Non-linear pricing as a means of differentiating the product: residential electricity markets in the UK

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Abstract

In the last five years, retail residential electricity markets in the UK have been opened to competition, and in most regions consumers have had the choice of up to 15 suppliers, when previously they had had to buy from their regional incumbent. The electricity market in the UK is divided into 14 separate regional areas. Although the product is, of course, homogenous, this paper argues that firms have effectively differentiated their brands by offering alternative price structures, with considerable variance in the standing charge (a fixed rate paid by all consumers, independent of their energy usage) and price(s) per unit. Drawing an analogy with a Hotelling model of horizontal product differentiation, with consumers distributed along a line defined by their electricity consumption, this paper explores some familiar questions about the effects of liberalisation, but in a novel context, using the tariffs charged by each firm in each of the regions over the first five years of the market's operation.

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1. Introduction

The UK was one of the first countries to open up its energy markets to competition, but many others are following its example. In particular, choice of supplier is being offered in many States of the US (Joskow, 2005) and the European Commission has issued directives that all markets should be opened by 2007. The UK experience, often held as an example of best practice, is valuable to inform both policy development there and initiatives in other countries. The emergence of six large players raises questions about whether the resultant deregulated oligopoly is an improvement on the regulated monopolies which this market replaces.

Choice of supplier was extended to all residential consumers between 1996 and 1999, so the market has experienced five years of full competition. Some commentators were dubious in advance about the potential benefits (see for example Green and McDaniel, 1998) and early examination of benefits which consumers have made from the change have suggested these may be small, relative to the costs both of opening the markets, and of firms in recruiting switchers (Giulietti, Waddams Price and Waterson, 2006). Giulietti, Otero and Waterson have explored changes in price levels as the market opened, and found little evidence of price convergence patterns which might be expected if competition was effective. Here for the first time we explore in detail the behaviour of the firms in terms of their pricing behaviour over these initial five years, both in terms of level and structure of price. We interpret structure in terms of product differentiation, i.e. that firms are using the structure of the tariff to focus on particular market segments, where these are defined by level of consumption. In this way firms may have been able to soften competition and so overcome one of the apparently unattractive features of entering such an industry, which supplies a homogeneous product, but has positive entry costs. Firms entering such markets need to be confident that the costs incurred are recoverable, and that prices would not be driven down to marginal costs by Bertrand competition. When the markets were opened it was widely predicted that the initial large

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2 There is no system in the UK to allocate consumers amongst different firms when markets are opened, as in some US States; each entrant needs to persuade consumers to switch away from the incumbent to them.
number of entrants (around 15) would be reduced to ‘a handful’ of long term players (Centrica 2001). Our analysis suggests that, initially, competition appears to have been active, but that, as the number of major players has been reduced to 6, there is clear evidence of a subsequent softening of competition.

This paper is the initial stage of an extensive exploration of how companies use tariff structures in the newly opened market. It identifies the evolution of price cost margins in the competitive market, and focuses on how entrants positioned themselves when they entered the markets, both in terms of price level and price structure; in particular, whether differentiation of price structures has increased or decreased. We describe the relation of firms to a ‘least cost’ frontier for consumers, to explore whether each offers the best buy for at least some consumers; and how that frontier shifts with new entry and with consolidation within the industry. The behaviour of the same companies with respect to price structure is compared in regions where they are incumbent and where they are entrants. The role of the main national entrant, who was incumbent in the gas market and now supplies more electricity consumers nationwide than any other company, is explored to identify whether it adopts different strategies from the traditional electricity companies. How far does variety of tariff structure serve to confuse consumer choice, leaving the original incumbents largely untouched by the forces of competition? Do the companies offer different tariff structures in markets which are differentiated by payment method? While the current paper deals only with one payment method, subsequent work will be extended to others.

We will also be able to identify the effect of regulation; all remaining price caps were withdrawn from the market which we analyse in this paper roughly midway through the period of observations. Since it was withdrawn earlier from another payment method we will be able to analyse the effect on firms’ price behaviour. We can extend this analysis by examining the gas market, where the same firms operate, and where de-regulation followed a slightly different pattern.
This paper uses a classic analysis of variance to identify stylised facts and developments in the market. It extends this focus on variance around the mean of the observations to identify how the different firms define the frontier, in the sense that they offer the best deal for consumers at a particular consumption level. Most firms are dominated (i.e. some other firm offers consumers a ‘better’ deal) at all levels of consumption, and we explore the development of these patterns as the markets have developed and been deregulated.

The next section explains the structure of the UK industry and evolution of the market since it was opened to competition, and the players in the electricity markets. Section 3 outlines our basic model, and section 4 the data. Section 5 reports our findings on analysis of variance, and section 6 on the ‘best buy’ frontier. Section 7 concludes and identifies areas for continuing research.

2. The industry

The residential electricity industry comprises four vertical stages: generation/supply; national high voltage transmission; regional and local low voltage distribution; and the retail function of sales and billing to final consumers. Key dates in the reform process are shown in table 1. Electricity was privatised in 1990/91, when the industry in England and Wales was restructured by separating generation from transmission. Full operating separation of distribution from retail was not enabled until 2001 by license separation. Electricity distribution and retail has traditionally been separated into 14 geographical regions – 12 in England and 2 in Scotland (the supply chain in the two Scottish regions remains vertically integrated). In 2004 analysis by the Regulator, Ofgem, confirmed separate regional markets rather than a single national market (Ofgem, 2004). At the end of 2004 the company which is the incumbent supplier in each of the fourteen regions also owned the (monopoly) distribution system in eight of the fourteen areas, although they are operated and accounted for separately.
Figure 1: The Regional Electricity Markets of England and Wales
Each household electricity market was opened to competition between August 1998 and May 1999 (phased merely for operational purposes). Since the product itself was homogeneous, competition focused on price rather than service, and the process was widely seen as determining which of the many entrants would survive in the medium term.

Table 1 Key dates in Retail Electricity Market Reform

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Privatisation</td>
<td>1990/91</td>
</tr>
<tr>
<td>Separation of generation from transmission</td>
<td>1990/91</td>
</tr>
<tr>
<td>Separation of distribution from retail</td>
<td>2001</td>
</tr>
<tr>
<td>First consumers can choose suppliers</td>
<td>Sept 1998</td>
</tr>
<tr>
<td>All consumers can choose suppliers</td>
<td>May 1999</td>
</tr>
<tr>
<td>Last price caps removed from incumbents</td>
<td>April 2002</td>
</tr>
</tbody>
</table>

Residential consumers pay for energy in one of three ways. The traditional method is to await a quarterly meter reading, from which a bill is generated, and pay in arrears, known as ‘standard credit’. It is these tariffs, used by about 45% of consumers, which are the focus of this paper. However because of the poor state of the British housing stock and the potentially large bills generated by such infrequent billing, especially after a winter quarter, prepayment had been introduced for some consumers, requiring them to charge a card or key at a local payment outlet and insert it into the meter to release a flow of energy. This method was introduced chiefly to enable continued supply to those in debt to the retail company without increasing their indebtedness, or for consumers with poor credit ratings, and so are used predominantly by low income households. About 15% of electricity consumers use prepayment (Ofgem, 2004). The third method of payment is by monthly automated debit from a customer’s bank account, known as direct debit, and as competition was introduced, retail companies have introduced discounts for direct debit payers (about 40% of retail consumers). Of the three methods of payment, automated direct debit is cheapest for the companies and prepayment is the most expensive because it involves the cost of handling frequent cash payments.
In the residential market, consumers have a direct relationship with their retailers, who arrange for purchase of the fuel, its transmission and distribution, and for the retailing functions (e.g. meter reading, billing). Each retailer must publish a tariff for each payment method and is effectively obliged to serve all consumers who seek to purchase at that tariff. There is a limit on how often tariffs can be changed, and no special deals can be struck with individual consumers. The bill contains information about how the total is composed of fixed rate, per unit charges and tax, but do not itemize the constituent parts of the retailer’s costs; the retailer therefore carries the risk (and benefits) from changes in upstream costs, including generation. A comparison of the costs of consuming energy, based on these tariffs, is published by the energy consumer body, Energywatch, as part of its statutory duties.

Before competition was introduced, tariff structures largely reflected those established by the incumbents’ nationalised predecessors, namely a fixed rate per consumer for being attached to the distribution system (a standing charge) and a single per unit charge for energy consumed. There were other structures: in the most common alternative the standing charge is replaced by a much higher per unit rate for the first units consumed, followed by a lower charge for subsequent units. Sometimes such a two part tariff is combined with a standing charge. One effect of introducing competition was to increase the variety of tariffs.

When the companies were monopolies it was generally agreed that the standing charge did not cover all the consumer related costs. Indeed, as part of the argument to retain its monopoly, the incumbent gas supplier had argued that the standing charge would rise dramatically if competition were to be introduced (MMC, 1993). It is ironic that this same incumbent abolished its standing charge in the face of competition only seven years later. Incumbents in residential energy markets were subject to price caps immediately after privatisation, but entrants were not. As consumers started to switch supplier, regulation was gradually withdrawn, and the final markets were fully deregulated in April 2002.
2.1 The Players

The main entrants into each electricity market have been incumbents from other areas and the incumbent in the national gas market. Some other companies entered in the early stages, mostly from other parts of the energy industry, such as Calor gas, oil and coal supply companies. Other small companies have entered over the years, but few survived. By 2003, six big players had emerged in both the gas and electricity markets; one is the gas incumbent and the other five are merged electricity incumbents. Of these, two are owned by German companies, one by the French Government, and the other two are British plcs. A very small number of niche players remain, each with a tiny market share. Any entrant must offer the full range of payment methods in any market where supplies are offered.

We can thus distinguish two types of firm. Majors consist of the 14 original electricity incumbents (12 firms as two firms each owned 2 incumbents). By December 2004, mergers had reduced this to only 5 separate firms. In any given region, there are two types of major, the incumbent and the entrants. Virtually all the majors offer supplies in all the regions.

The second type of firm is independents, who were not in the electricity market before it was opened. These consist of British Gas, the incumbent in the national gas market, and up to five others. Again, there are two types of independent: the genuine de novo entrants (typically low price but with a very poor survival rate) and the diversifying incumbent in gas who now supplies more electricity customers than any single major.
Table 2 List of Firms

(a) Majors (original incumbents)

<table>
<thead>
<tr>
<th>Region</th>
<th>Original incumbent</th>
<th>Current owner (date of acquisition)</th>
</tr>
</thead>
<tbody>
<tr>
<td>London</td>
<td>London</td>
<td>London (EDF)</td>
</tr>
<tr>
<td>SWEB</td>
<td>SWEB</td>
<td>EDF (Sep 99)</td>
</tr>
<tr>
<td>Seeboard</td>
<td>Seeboard</td>
<td>EDF (Jul 02)</td>
</tr>
<tr>
<td>Southern</td>
<td>Southern</td>
<td>S&amp;S (Sep 98)</td>
</tr>
<tr>
<td>ScottishHydro</td>
<td>ScottishHydro</td>
<td>S&amp;S (Sep 98)</td>
</tr>
<tr>
<td>Swalec</td>
<td>Swalec</td>
<td>S&amp;S (Aug 00)</td>
</tr>
<tr>
<td>Midlands</td>
<td>MEB</td>
<td>N Power</td>
</tr>
<tr>
<td>Northern</td>
<td>Northern</td>
<td>N Power (May 02)</td>
</tr>
<tr>
<td>Yorkshire</td>
<td>Yorkshire</td>
<td>N Power (Feb 01)</td>
</tr>
<tr>
<td>Scottish Power</td>
<td>Scottish Power</td>
<td>Scottish Power</td>
</tr>
<tr>
<td>Manweb</td>
<td>Manweb</td>
<td>Scottish Power (Oct 95)</td>
</tr>
<tr>
<td>East Midlands</td>
<td>East Midlands</td>
<td>Powergen (Jul 98)</td>
</tr>
<tr>
<td>Eastern</td>
<td>Eastern (TXU)</td>
<td>Powergen (Jul 03)</td>
</tr>
<tr>
<td>Norweb</td>
<td>Norweb (TXU Aug 00)</td>
<td>Powergen (Jul 03)</td>
</tr>
</tbody>
</table>

(b) Independents

<table>
<thead>
<tr>
<th>Firm</th>
<th>Period in market</th>
<th>Fate</th>
</tr>
</thead>
<tbody>
<tr>
<td>British Gas</td>
<td>Throughout</td>
<td>Survivor</td>
</tr>
<tr>
<td>Amerada</td>
<td>Oct 00 - Sep 02</td>
<td>Acquired by Powergen</td>
</tr>
<tr>
<td>Atlantic</td>
<td>Apr 01 – Aug 04</td>
<td>Acquired by S&amp;S</td>
</tr>
<tr>
<td>Utility Link/Basic Power</td>
<td>Jun 00 – Dec 04 (Basic from Aug 01)</td>
<td>Survivor</td>
</tr>
<tr>
<td>Independent</td>
<td>Feb 00 – Aug 00</td>
<td>Bankrupt, Acquired by N Power</td>
</tr>
<tr>
<td>Northern Energy</td>
<td>Apr 99 – Apr 01</td>
<td>Unknown</td>
</tr>
</tbody>
</table>
Table 3 Number of separately owned firms active in the market\textsuperscript{1}

<table>
<thead>
<tr>
<th></th>
<th>Majors</th>
<th>Independents</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feb 99</td>
<td>12</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>Oct 99</td>
<td>12</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>Jun 00</td>
<td>11</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>Dec 00</td>
<td>9</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>Jun 01</td>
<td>9</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>Dec 01</td>
<td>7</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>Jun 02</td>
<td>7</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>Dec 02</td>
<td>7</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>Jun 03</td>
<td>5</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Dec 03</td>
<td>5</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Jun 04</td>
<td>5</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Dec 04</td>
<td>5</td>
<td>2</td>
<td>7</td>
</tr>
</tbody>
</table>

Note 1. Not all firms necessarily active in all 14 regional markets.
3. The model

3.1 The tariff structure frontier

We begin by deriving a simple graphical device which helps us to understand how non-linear pricing may be used to differentiate an homogenous product.

In the standard credit market, incumbents inherited from their nationalised predecessors a very simple, two part tariff, non-linear price structure. This consisted of a standing charge, SC, and a price per unit, PU. So, for a consumer with consumption X, expenditure is E:

\[ E = SC + PU \cdot X \]

(1)

Consider first a world in which there is an incumbent monopolist (I), with a given price structure, and 3 consumers, with consumptions X₁, X₂ and X₃ (X₁ > X₂ > X₃).

![Figure 2. Pre-liberalisation, incumbent monopolist selling to three consumers](image)

Figure 2 in \{SC, PP\} space shows the monopolist’s tariff as a single point, representing its standing charge and per unit price. For a consumer with any particular level of consumption (X₀), there is a straight line through this point which represents his
expenditure \((E_0)\). This, we shall refer to (obviously) as an iso-expenditure line. Rewriting (1), it has the equation:

\[
SC = E_0 - PU \cdot X_0
\]  

(2)

where, given the monopolist’s price structure, the vertical intercept denotes his expenditure, the horizontal intercept is his average expenditure per unit consumed \((E_0/X_0)\), and the slope of the line denotes the quantity consumed. Thus, each of the three lines in figure 2 corresponds to one of the three different consumption levels and expenditures referred to above – steeper lines depict higher quantities of consumption \((X)\).

Now suppose a second firm \((E)\) enters. Does it locate close to the same point, and engage in cut-throat pricing? If so, with perfectly informed consumers and zero switching costs, Bertrand pricing will presumably push that point in towards the origin. Or, alternatively, does the second firm differentiate its offer by price structure?

Figure 3 depicts the case where the entrant selects an alternative price structure (with lower standing charge and higher price per unit). As drawn, this effectively segments the market. Consumer 1 continues to buy from I (because this provides him with his lowest iso-expenditure line, but consumer 3 now switches to the entrant, whose price structure allows this consumer to achieve a lower iso-expenditure line\(^3\). As drawn, consumer 2 is indifferent between the two price structures\(^4\), and he is therefore the marginal consumer.

\(^3\) For graphical simplicity here, we assume consumers have price-inelastic demand.

\(^4\) Geometrically, the slope of the line joining to the two firms’ price points is identical to \(X_2\).
This segments the market: figure 4 is a generalisation showing a large number of firms, each with different price structures, in a world of many consumers. Assuming that no firm offers a structure which is dominated by that of another firm, i.e. will be the ‘best buy’ for at least one consumer (consumption level), the price points effectively sketch out a ‘best buy’ frontier.
As drawn, figure 4 depicts a case where firms spread themselves out along the frontier - each sells to a different volume segment of the market. The analogy with Hotelling’s familiar linear city is fairly obvious. On the consumer side, there is a density function, \( f(X) \), describing the number of consumers at each consumption level (X). Of course, we would not expect this to be the uniform distribution in most textbook treatments – in fact, there are good reasons to expect some positively skewed (say lognormal) distribution amongst residential consumers, and, to anticipate, this is what we actually find in section 4.

Once the Hotelling analogy is recognised, some obvious (and familiar) questions arise. In particular, does liberalisation and entry lead to market sharing by firms spreading themselves along the frontier, or is there cut-throat competition at some central point (perhaps near the original incumbent)? But also, how, if at all, does the incumbent relocate?

Finally, so far, we have assumed that all firms choose to locate on the frontier. In a world of a genuinely homogenous product, this is reasonable so long as consumers are perfectly informed, with no search or switching costs. However, as we shall see, this turns out not to be the case, and figure 4 also shows an additional point - above the frontier. This would refer to a firm whose price structure is not the best buy for any consumer. In these circumstances, it is helpful to have some measure of the firm’s ‘distance from frontier’. The most convenient such measure is the horizontal distance between the point and the frontier. This depicts the minimum distance from the frontier in the following sense. Although this firm may not be a best buy for any consumer (value of X), there will nevertheless be some consumer for whom the excess price is smallest. As noted earlier, the horizontal intercept for any iso-expenditure line for a given consumption level is (E/X). It follows that the horizontal distance between any off-frontier price point and the frontier is the **excess average price** it entails for a consumer with consumption level denoted by the corresponding slope of the frontier at that point. This is the consumption level at which the firm offers its ‘least bad buy’. To put it another way, any consumer buying from an off-frontier firm, pays more, per unit consumed, than he needs do, but this distance measures the excess price at its minimum.
Insofar as we actually observe firms lying off-frontier at such points, a number of other empirical questions are raised. For example, do off frontier firms tend to cluster in certain segments of the market – where, perhaps consumers are inert in switching? Over time, as the effects of competition unfold, do we observe a gradual movement towards the frontier? Does the incumbent feel able to locate off-frontier, relying on ‘incumbent loyalty’ to retain a significant market share, in spite of offering an uncompetitive price structure?

3.2 The average price frontier

Although the tariff structure frontier is a useful pedagogic device, in this paper it is more convenient to work empirically in terms of a closely related concept which we refer to as the average price frontier. In this context, average price is the average price per unit consumed \((E/X)\), defined in a world of two part tariffs as:

\[
P = \frac{E}{X} = \frac{F}{X} + PU
\]  

(3)

This frontier is constructed by first drawing, for each firm, its average price \((E/X)\) schedule at different levels of consumption, \(X\). The frontier is then formed by the lower envelope of these schedules, which then shows the ‘best buy’ (i.e. lowest average price) on offer for each level of consumption. Any firm on the price structure frontier must also lie on the average price frontier.
This switch to the average price frontier is necessary for two reasons:

(i) as the market has evolved, some firms have begun to introduce more complex (more than two-part) tariff structures, for example with different per unit rates according to the level of consumption (effectively three parts, if a standing charge is included as well). All of these tariff structures can be captured by an analysis of average prices, but not in a \{SC, PU\} diagram

(ii) some of the raw data we have are in this form, rather than direct observations on SC and PU.

In this case, the equivalent of the horizontal distance between the off-frontier point and the frontier in figure 4 is the minimum vertical distance between a given off-frontier firm’s schedule and the frontier shown in figure 5.

We can pose exactly the same the questions for the average price frontier as for the tariff structure frontier: do firms ‘spread out’, each occupying different segments of the frontier, or do they congregate at the same point? Where does the incumbent locate? Is there a movement towards the frontier over time?
4. Data

To investigate these questions, we have assembled a database with two parts.

The first is for average prices. More precisely, we have concentrated on standard credit electricity, bought as a single fuel (i.e. without a corresponding gas purchase from the same company). This is the ‘basic’ tariff, used by almost half of residential electricity consumers. We have initially focussed on 6 annual (December of each year) observations of prices charged in each area by each firm.

Starting with the tariffs, we have computed the firm’s average price for nine different quantity levels. These levels correspond to the boundaries between the deciles of the UK distribution of consumption levels for residential consumers using standard credit single fuel tariffs. We derived this distribution from the Expenditure and Food Survey (a stratified representative national sample) for the year April 2002-April 2003. For each region we calculated the average price at each of three levels of consumption, which are used by the consumer watchdog in publishing comparative prices. This was a weighted average, using tariffs in August 2002, and allowing for the percentage of the market retained by the incumbents (around two thirds at that time). The price which corresponded to the quantity closest to each decile was then used to identify the consumption associated with each expenditure decile. A further iteration, using the average price at the consumption level of each consumption decile boundary was then undertaken. Although regional deciles were calculated from information about regional expenditure and tariffs in each market, we have used national deciles divisions for the analysis reported in this paper.

The distribution is shown in figure 6 in cumulative form - as expected, it is positively skewed, approximately lognormal. The average price of each firm is then computed at the 9 boundaries between deciles. Since in the average year there are roughly 9-10 firms in each regional market, a crude expectation if firms spread themselves equally across
consumers would be that each firm would be at the boundary at one decile of the distribution (i.e. offering the best buy for about 10% of consumers).

Our database is for 6 years (1999-2004 inclusive), across 14 regions. For each, we have observations on

**P: average price per unit consumed, for each firm, at the nine decile boundaries.**

Thus, for each region year, we have a matrix of 9*N observations on P, where N=1…15, depending on the region and year.

The second part of the database is a cost index for retailers, constructed from information about generating and distribution costs. Generating costs constitute about 40% of the residential bill, and information was obtained on the average costs of the main component parts of this: coal, gas, and nuclear. Only a small proportion of electricity was generated from oil. The fuel index was constructed from information about the average cost of each of these fuels, and the proportion used by the major electricity generators (DTI, 2005). While the exact change in cost varies according to the generation mix, this index provides an average measure of fuel costs. Distribution costs account for about 30% of the final residential bill, and are regulated. An index for each region was calculated from changes
enforced through the last regulatory price review in 1999. 3% of the bill is attributable to transmission costs (also regulated), but these have changed little over the last six years. An overall cost index was constructed from weighting the generation and distribution indices, assuming that the other 30% of retailers’ costs did not change.

5. Analysis of Means & Variances

Given the largely exploratory nature of the present paper, our main emphasis here is to search for stylised aggregate facts, which will help guide future, more analytical, work. While future work will exploit the micro nature of the data (on average price of firm i, for decile d, in region j, at time t), here, we concentrate on a more aggregate descriptive analysis. To avoid tedious repetition, we concentrate on the London region, which is typical of the general pattern.

5.1 Explaining the methodology

We begin by conducting a traditional analysis of means and variances. At any point in time for a given region, there is an overall mean, P, and variance, VP, of average prices (across deciles and firms). By tracking how these have changed over time, we begin to describe some of the key tendencies over this period.

The analysis of means will be straightforward and requires no prior explanation. For the variances, we employ a classical decomposition analysis of the overall variance, and a preliminary explanation of notation and expectations is helpful.

To establish notation, we first write down two basic decompositions:

\[ VP = \text{INTRA-D} + \text{INTER-D} = \text{INTRA-F} + \text{INTER-F} \]  

\[ (4) \]

\(^5\) Such work will be within what might be loosely referred to as the New Empirical Industrial Organisation paradigm (see Slade (1987) and Bresnahan (1989)).
Thus, for a given region, at a given point in time, VP is the overall variance across the 9 decile quantity points, and over up to (depending on the year) 15 firms. This overall variance can be decomposed either in terms of the deciles or the firms.

In terms of deciles,

INTRA-D = average variance of firms’ prices within deciles
INTER-D = variance between the mean prices for each deciles

Alternatively, in terms of firms,

INTRA-F = average variance within firms (i.e. the average firm variance across deciles)
INTER-F = variance between firms (in their means across deciles)

Simplified examples

Each of these sources of variance should reveal something about the nature of the variability in the data, and how it is changing over time. This can be illustrated in a simplified form with five alternative cases, and figure 7.

Figure 7. cases (b) and (c)
Case (a): monopolist without non-linear pricing

This is a trivial base point, not shown in the figure. With only a single firm selling at a uniform price, there is just a single point, with no variance:

\[ VP = 0 \]
Case (b): monopolist (firm A) with non-linear prices
But now suppose non-linear pricing by the monopolist. This immediately introduces a variance between its prices at different deciles, and, equivalently, the same variance in ‘mean’ firm price across deciles:

\[ VP = INTER-D = INTRA-F > 0 \]

This establishes a key point: in itself, non-linear pricing means positive variances within firms and between deciles. These sources of variance carry over to the three remaining cases. On the other hand, in this case, because there is only one firm, there is no variance either within deciles or between firms, i.e. INTRA-D = INTER-F = 0

Notice also that both INTER-D and INTRA-F will be higher the steeper is the schedule (in the case of the two-part tariff, the larger relatively is SC).

Case (c): two firms, with identical price structures and levels
Here, although we now have two firms, because their price structures are identical, there is still no variance within deciles, or between firms, thus it remains true that

\[ VP = INTER-D = INTRA-F > 0, \text{ but} \]
\[ INTRA-D = INTER-F = 0 \]

In other words, the decomposition is invariant with respect to firm numbers if the firms are symmetric.

The next two cases introduce different types of asymmetry between the firms: they set prices which are different from each other’s, as well as different between deciles.
Case (d)  two firms, equally ‘efficient’, but specialising on different quantity consumers.

Here, firm B targets low quantity consumers by setting a relatively shallow schedule (low SC, but high PU), while firm A targets high quantity consumers (high SC, low PU), with a steeper schedule. Compared to case (c), we now have both sources of decile variance: INTRA- as well as INTER-. And, when decomposing by firms, as before, non-linear pricing ensures a positive INTRA- variance. However, there need not necessarily be any INTER- variance. Indeed, as drawn, these schedules would exhibit roughly equal means for the two firms: INTER-F = 0.

Case (e)  two firms, parallel structures, but B uniformly less ‘efficient’

By uniformly less ‘efficient’ we mean that B’s price is higher than A’s by a uniform amount at each decile. In this case, the comparison with case (c) looks quite different. While both INTER-D and INTRA-F are unchanged compared to symmetric firms, we now have INTER-F > 0 (reflecting the difference between the two firms’ average prices), and it follows that INTRA-D must also increase by the same amount.

Summary

These simple comparisons, while lacking rigour, alert us to broad tendencies which may become apparent in the analysis of variance:

- Non-linear pricing, in itself, introduces a ‘core’ of inter-decile and intra-firm variance. These variances will tend to increase (decrease) if firms tend to opt for pricing schedules which are more (less) non-linear.
- If firms increasingly differentiate their pricing structures from each other, by targeting certain parts of the market, intra-decile variance will tend to increase.
- On the other hand, to the extent that firms increase how ‘competitively’ they price and move nearer to the frontier, this will be reflected in lower variances within deciles, and even more so, in a lower inter-firm variance.
5.2 Applying the methodology
We now apply this methodology to the London region as an illustration.

Analysis of means
Figure 8 plots the evolution of mean prices over the six years. For each of the three series shown, the ‘mean’ relates to an average over the 9 decile points. The incumbent refers to London Electricity; ‘average’ refers to the average across all firms operating in the region; and ‘minimum’ refers to the lowest prices at each of the decile points.

Focussing first on the average for all firms, this declines in the first two years after liberalisation, increases slightly in the following two years, before increasing rapidly in 2004. The incumbent’s price, on the other hand, begins at a slightly lower than average level in 1999, but shows little change in the following four years, before also increasingly noticeably in 2004. Note that, with the exception of 1999, the incumbent always prices above the average. Finally, the minimum price is always significantly below both the average and the incumbent, with no tendency for the average or incumbent to move towards the minimum.

Figure 9, re-expresses these three series relative to the index of costs, and bases at 1999 levels = 100. As can be seen, in all three series, margins are squeezed over most of the
period before rising dramatically in 2004. Indeed, by 2004, price cost margins have recovered all the lost ground in the intermediate years, and, for both the incumbent and the average, were higher than at the onset of liberalisation.

These tendencies are all borne out, to a greater or lesser extent, for all the other regions (albeit with some intriguing inter-regional differences). Thus the general picture to emerge on average price (recalling that this reflects the average movements at 9 different points on the distribution, rather than for just the average consumer is as follows:

- Liberalisation led to falling prices in the early years, up to 2001 or 2002.
- Thereafter, there has been a sharp recovery in prices, such that, typically, they are now in excess of the starting level.
- Price movements are not just a reflection of cost changes: the decreases in the early years can not be accounted for by reduced costs, nor can the recent increases be explained in terms of sharply rising costs.
- Relating these price trends to the firm numbers in Table 3, one explanation would be that the relatively high numbers in the early years were the driver of intense competition, pushing margins to a level which was unacceptably low. In turn, this
led to a shake out, with some independents exiting the industry and the majors engaging in merger activity amongst themselves.

- The incumbent in most regions at most points in time consistently prices higher than the average, with no tendency for the gap to close.
- The average itself shows no discernible tendency to move towards the minimum

**Analysis of variance**

Figure 10 and 11 focus on the variance in prices. Figure 10 shows the time series for the overall variance and the four constituents discussed earlier. As an initial point of reference, the figure also shows for 1998, the variance in prices of the original incumbent – this reflects the inherent variability which can be accounted for by non-linear pricing.

![Figure 10 London Time series on sources of variance](image)

Again, the time period breaks down into two sub-periods. Between 1999 and 2001, the overall variance declines, largely as a result of reductions in intra-firm variance and inter-decile variance. This could be due to a tendency for firms to reduce the non-linearity in their pricing structures (i.e. reducing SC). However, the picture changes noticeably between 2001 and 2004, when the variance, and all constituent parts, increase sharply.
More insights are provided by Figure 11, which shows the proportions in the overall variance accounted for by intra-decile variance or inter-firm variance. Both show a sharply increased share. Relating this back to the summary of the previous section, an increased share in the total variance for intra-decile variance can be explained by either a trend towards more specialisation in firms’ pricing structures, or increased inefficiency (a general movement away from the frontier), or both. An increased share for inter-firm variability is also indicative of increased inefficiency. Since intra-decile variance increases its share rather more than inter-firm variance, it seems likely that both causal influences are at work: increased inefficiency and increased specialisation.

![Figure 11 London time series on variance proportions](image)

These patterns are consistently found for all other regions. Especially in the later years in the period, intra-decile variance and inter-firm variance increase their shares in total variance, as total variance itself is increasing. Although not conclusive, these tendencies suggest that, with falling firm numbers towards in the later years, firms have drifted away from the frontier on average, and moved towards more specialised pricing. The former is indicative of reduced competitive pressures, the latter of firms locating further away from each other on the frontier.
6. Analysis of the frontiers

The previous section suggests a number of intriguing possibilities, but, by its nature, it can not be conclusive. In this section, we focus more deliberately on the firms operating at the frontier, and the relative locations of off-frontier firms. Results are summarised, again with London as the example, in Table 4.

Table 4 Observations on and off the frontier

<table>
<thead>
<tr>
<th></th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Number of Firms</td>
<td>15</td>
<td>14</td>
<td>11</td>
<td>10</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Number on frontier</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Deciles at which firms on Frontier</td>
<td>1-3</td>
<td>1-3</td>
<td>1-3</td>
<td>1-3</td>
<td>1-3</td>
<td>1-6</td>
</tr>
<tr>
<td></td>
<td>4-9</td>
<td>4-9</td>
<td>4-9</td>
<td>4-9</td>
<td>4-7</td>
<td>7-9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8-9</td>
<td></td>
</tr>
<tr>
<td>Number off frontier</td>
<td>13</td>
<td>12</td>
<td>9</td>
<td>8</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Number with their best decile at:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#3</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#4</td>
<td>5</td>
<td>9</td>
<td>7</td>
<td>8</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>#7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>#8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>#9</td>
<td>6</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average distance from frontier at best point</td>
<td>0.33</td>
<td>0.38</td>
<td>0.33</td>
<td>0.4</td>
<td>0.34</td>
<td>0.45</td>
</tr>
</tbody>
</table>

To interpret the table, consider the column for 1999. In that year, there were 15 firms in the market, of which only two were at the frontier – only these two firms offered tariffs which yielded minimum expenditures for consumers at any of the 9 decile points. All other suppliers’ pricing structures were dominated by these two firms, one of which was an incumbent from an adjacent region (Seebord, who was at the frontier for deciles 1-3), and the other a small independent entrant (Independent Energy, at the frontier for deciles 4-9).

The remaining firms were not at the frontier at any decile, but the lower rows of the table show the number closest to the frontier at each of the 9 deciles. Six were closest at the 9th
decile, 5 at the 4th and 2 at the 3rd. On average, firms were 0.33 pence from the frontier at their best points\(^6\) (average price was about seven pence).

In other words, in the year after liberalisation, most firms were offering ‘inefficient’ pricing structures, clustered in a bimodal manner in the low/middle #3-4 range or at #9.

A similar picture emerges for the following year, although the identities of the two frontier firms changed – Scottish and Southern replaced Seebord at the lower range, and N Power (another incumbent from another region) replaced Independent at the top range, Independent having exited the industry. There was no tendency for off-frontier firms to move closer to the frontier; again they are clustered at the low/middle or top range.

In the following years, Scottish and Southern continued to define the frontier in the first 3 deciles up to 2003, and also extended its dominance to deciles 4-6 in 2004. Npower was replaced by Basic Power (another Independent) from 2002 onwards, and briefly, in 2003, a third firm (Atlantic, another Independent moved to the frontier at deciles 4-7, before exiting).

Turning to the remaining off-frontier firms (including the incumbent in the region, London Energy), there is no trend for them to move closer to the frontier, even at their ‘best’ points as shown here – if anything, the reverse is true. They continue to be concentrated most near the frontier in a bimodal way.

Comparisons with the other 13 regions suggests that London may be an extreme case, in that the typical region, in the typical year has a frontier defined by three firms, and off-frontier firms tend to be a little more dispersed at their best points. Nevertheless, a fairly robust picture emerges, with the following stylised facts.

- In all markets, the frontier is defined by between 2 and 4 firms

\(^6\) This average includes the two firms on the frontier.
• These firms are most frequently the smaller independents, and Southern & Scottish and N Power (who appear to play almost a maverick role outside their own regions).

• Incumbents in their own regions are invariably off-frontier

• There is no tendency for off-frontier firms to move closer to the frontier over time. This is certainly true for incumbents in their regions of historical incumbency.

• Off-frontier firms tend not to disperse themselves across the deciles. In the typical region year, most are clustered nearest to the boundary at deciles 3-4 or 7-9 (but this varies in detail between regions).

7. Conclusions and directions for future research

Taking the findings of sections 5 and 6 together, we believe that descriptive statistics have provided some evidence on the ‘success’ or otherwise of the liberalisation programme, and some suggestive pointers for future research designed to uncover the nature of the oligopoly game being played out in this particular market.

On the effects of liberalisation, at best the judgement is not proven. On the plus side, in the early years entry occurred, seemingly driving price down across the board (i.e. for all deciles/segments of the market). This was particularly true for the most competitive suppliers (on the frontier), but on average, most firms, including incumbents, appear to have shaved their margins. However, within the last 3 years, and particularly in 2004, prices have tended to rise quite sharply relative to costs, alongside the exit of the independent entrants and consolidation amongst the original incumbents.

Rather surprisingly, even within the early years, most firms do not offer a price structure which makes them a ‘best buy’ at any level of consumption, and this is certainly true for incumbents. There is not even any discernible tendency for off-frontier firms to move
closer to the frontier. This is surprising if one expects liberalisation to tighten competitive discipline.

Turning to the nature of the oligopoly game, the evidence is, as yet, weak concerning our starting hypothesis. There is only patchy evidence that firms have attempted to differentiate their product by choosing price structures which will capture different parts of the market, segmented by the consumption levels of consumers. Instead, most firms seem content to offer price structures which are not only dominated by the few 'competitively pricing firms, but also close to those of their fellow inefficient rivals. Tentatively, we conclude that consumer inertia and switching costs may be more powerful sources of differentiation. However, a few firms do appear to have adopted more aggressive strategies. While these include a number of independents who have since exited the market, two of the original incumbents have frequently adopted this strategy outside their original regions of incumbency.

Future work will develop a more explicit model of pricing behaviour designed to pursue these issues, as well as extending the empirical analysis to other payment methods and the national gas market.
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