Pricing behaviour under competition in the UK electricity supply industry *

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Abstract

This paper investigates the evolution of electricity prices for domestic customers in the UK following the introduction of competition. The empirical analysis is based on a panel data set containing detailed information about electricity supply prices over the period 1999 to 2006. The analysis examines the pricing patterns and draws inferences concerning the benefits of incumbency and the gains from search. The econometric analysis of persistence and price dispersion provides only limited support for the view that the market is becoming more competitive and also indicates that there remain significant potential benefits to consumers from searching alternative suppliers.

Keywords: electricity supply, price competition, convergence, dynamic panels, cross-sectional dependency.

JEL classification: L43, L13, L94, C22, C23

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1. Introduction

On 1st July 2007, EU energy markets became fully open, as a result of Directives 2003/54/EC (electricity) and 2003/55/EC (gas). This final stage, amongst other things, opened the European residential markets fully for the first time. At the same time, whilst some member governments have eagerly embraced the process, others have not. Competition in UK energy supply has arguably proceeded further than in any other country. Not only have *all* UK consumers been able to choose their electricity supplier since May 1999 but around half have done so. Additionally, since March 2002 there has been *no* supply price regulation. Therefore, an experiment of at least European significance is taking place, concerning the behaviour of consumers and their suppliers in relation to a key product. As one manifestation of this, firms from many other countries are participating in the market in order to gain experience of retail competition in energy; US, German, French and Spanish firms have taken significant stakes in the UK supply industry. What are the effects of this competition?

The focus of this paper is on the development over time of tariff structures for supply to domestic customers. Here, one null hypothesis is that, as a result of competition, prices for a product as homogeneous as electricity would converge together quickly. An alternative is that prices would remain somewhat dispersed, as a consequence of firms exploiting significant search and switching costs and creating product differentiation. Under this alternative, we might expect that particular events would trigger changes in the distribution of prices; for example the freeing of a particular class of consumers from price regulation, or input price changes arising from changes in supply source (e.g. in 2004 the UK started importing gas from Norway) may have influenced the price vector consumers face. By investigating the pattern of prices and changes in this pattern over time, we aim to tease out information about the influence of search costs and switching costs and examine the extent to which the market is or is becoming competitive in practice.

As a background to this study, we should note a number of important institutional features that facilitate the development of competition in the market in question. When the electricity market was broken up into generation, transmission, distribution and supply, the link between supply and distribution was broken. Transmission and distribution remain regulated, but any competent potential supplier may obtain a licence. Thus, by knowing the (regulated) prices for transport, and by writing contracts for wholesale electricity, a supplier is enabled to design a tariff to attract consumers away from their incumbent supplier. They can also purchase ancillary services, such as meter reading, on the market, but suppliers retain responsibility for billing, in a single bill to cover all vertical levels. A standardised system of identifying a customer by their meter number facilitates their accurate transfer between suppliers.

As industry regulator, OFGEM is charged with overseeing the development of competition. Energywatch, a related body, has a duty to provide consumers with information regarding suppliers. Amongst other measures, they provide regularly updated price comparison sheets on their website, covering every active supplier. In addition, they provide comparative information such as numbers of complaints about particular suppliers. Commercial companies may also provide price comparison services, so long as these cover the market and do not favour suppliers selectively, and this has developed into a significant business. They provide facilities to "click through" in order to switch supplier through their intermediation (indeed, this is the means by which they make money). The typical consumer is thus able to make an informed choice amongst six or more suppliers. However, all the major companies also engage in their own marketing activity, commonly using a sales force that moves from door to door within an area. The sales pitch focuses on price, with a secondary emphasis on service (but in both cases tends to be untailored and non-specific). At time of writing, almost half of all customers are supplied by a firm that is not their incumbent supplier.[1]

The competitors in electricity supply are of three main types. Before liberalisation, supply was a regionally-based activity, and prices generally differ as between the 14 regions still (costs also differ, as a result of transport cost differences).[2] Thus one category of competition comes from suppliers extending their activities across regions (usually, maintaining a differential in prices). A second category comes from companies engaged previously in the supply of gas. Prime amongst these is British (in Scotland, trading as Scottish) Gas, which provided a national integrated service for the supply of gas, but other gas supply companies, some associated in part with oil companies, also entered the electricity market.[3] The third force is independent suppliers; contrary to some expectations, these have tended not to be companies with a strong knowledge of mass market consumer activity or billing.

Our period of analysis runs from February 1999 to December 2006, spanning eight years of price data. During the sample period important strategic and institutional changes in

[1] The gross rate of switching is higher, because some people switch back and indeed there is significant "churn".
[2] That is, the price you can buy at depends upon where you live, i.e. your postcode.
[3] The gas market was opened to competition earlier. In some ways, though, it is less interesting analytically, since it is national not regional in nature, so that there is less variation to observe. British Gas remains the most important operator in the gas market.

electricity prices have occurred. For example, in April 2002 the energy regulator, OFGEM, removed all price controls for all residential consumers. Furthermore, perhaps as early as the Spring of 2002 we observed a worldwide trend of increasing oil and fuel costs which was reflected in substantial increases in fuel costs in the UK. The potential impact of these changes is taken into account in our empirical analysis.

Besides differentiation by region, in particular between in-area and out-of-area customers in the case of the existing electricity supplier, scope exists for companies to differentiate between various broad customer classes. There are three main ways of paying, namely by (monthly) direct debit, by quarterly bill (paid in arrears) and by prepayment meter. These involve different supply costs, direct debit being the cheapest and prepayment the most expensive. Since all suppliers' tariffs are at least two-part, companies can also differentiate between low and high consumers of electricity.[4] There is also a distinction between completely online offerings and tariffs that are available to consumers signing up through a range of possible approaches and, latterly, some distinctions relating to contract length.

In the last few years, as the internet has grown as a means for consumer purchases, there has been considerable interest amongst economists in whether it reduces the impact of search costs on consumer purchases and therefore perhaps makes markets more competitive.[5] Our study is unique in examining the effect on prices as the market under study is opened up to competition, in a context where a *complete* listing of prices is available on the internet. Thus additional quotes are available to internet users at zero additional charge. It is also relevant that shipping costs, which complicate or even bedevil price comparisons in other areas, are always included here and that "bait and switch" tactics are unlikely. Moreover, the product is a significant part of most consumers' lives, consuming a non-trivial fraction of their income. The savings from shopping around can be, though are not always, considerable.

The paper proceeds as follows. We start by developing a framework in section 2, followed by a description of the data and the econometric procedure used in the empirical analysis in section 3. Section 4 contains a discussion of the main results on price spreads and develops some interpretations, while section 5 offers some concluding remarks on the competitive process.

[4] In this paper we are concerned only with domestic consumers. Pricing to other consumer types is not transparent to the outside observer. We also will not consider at present "dual fuel" deals and the (increasingly less important) "Economy 7" tariffs; see Green (2005) on dual fuel.
[5] See e.g. Ellison and Ellison (2005) for a thoughtful survey.

2. Developing the Framework: Magnitudes and Theory

The initial switch that we are concerned with here is from an incumbent to an entrant player in the market. We want to examine the time path of the premia that incumbents can maintain and also to investigate the extent to which prices differ between entrant offers. Our approach is essentially descriptive rather than attempting to test precise hypotheses, for reasons that will become apparent below, since the range of potential models does not allow a one-to-one correspondence between empirical result and underlying model.

Pro-competitive actions by the regulator have facilitated the switching process, but studies of consumers (e.g. Giulietti et al, 2005) have shown that nevertheless, some consumers remain reluctant to switch, even in the face of substantial financial benefits. The incumbent can therefore charge a premium over entrant suppliers without losing all its custom, and it faces a trade-off between a higher premium, with fewer customer retentions, and a lower premium, with more customers.[6] We may expect the incumbent's price to be above an entrant's for two reasons. First, a customer faces a search cost in finding an alternative supplier. Second, having found a potential alternative, there is a cost in switching to that firm. Again, entrants may seek to attract a large proportion of those who encounter them, by pricing very competitively, or shade prices less but make more from each customer.

Our underlying assumption in this analysis is that firms set prices conscious of consumer reactions; they will need to assess the competitiveness of their tariffs and adjust them over time in response to consumer behaviour in order to capture a segment of the market. Thus tariffs reveal firms' views about the nature of the market. We also assume that within an area, for each class of consumer, marginal costs are the same for each player. We examine differences between tariffs offered rather than tariff levels themselves.[7]

In terms of magnitudes, the pure advantage to an incumbent can be measured by the difference between the price charged by the incumbent and the price charged by the median entrant (difference IM), which is the price that a customer would obtain by picking an entrant randomly from the set of suppliers. In the initial phase of competition, where all consumers

[6] The mechanism for charging a premium is that the firm differentiates in price (relative to cost) between electricity regions where it is an incumbent and where it is an entrant.
[7] The implication of our approach is that we analyse not margins, but *differences* between margins across firms. It is possible to relax the marginal cost assumption so that the incumbent's marginal costs are different (for example lower) than entrants', but the wholesale market, whilst extensive, is far from transparent, making examinations of margins somewhat complex.

moving supplier move from the incumbent to an entrant, this is also the nearest measure to the gain from switching, stripped as much as possible from the element due to search.

There are two possible measures relating solely to search, at least in this initial phase. First, the difference between the median price and the lowest price on offer (ML) is a measure of the gain from exhaustive search. Thus, considering the whole difference between the price charged by the incumbent and that available from the lowest price entrant (IL), the natural break is at the median entrant price. Second, the difference between the highest entrant price and the lowest (HL), given that all prices are "real", is a measure of the extent to which firms can range prices due to limited search.

Once consumers engage in subsequent searches, matters become more complex.[8] The value IM, although no longer a pure measure of switching cost, remains of independent interest as a measure of incumbency advantage. The values HL and ML remain of interest as a measure of the gain from search of someone who has never switched, but for other consumers then incorporate some element of switching costs as well as search costs, since a consumer may switch from one entrant to another. Indeed, "churn" is a significant feature of the market.

Turning to guidance offered by theory, Farrell and Klemperer (2006) distinguish various possible frameworks within which to examine switching costs. Their core model, which assumes firms cannot commit to future prices, is a good fit with our situation. Also, due to regulatory restrictions, firms cannot explicitly discriminate between cohorts of customers. In this case, modelling suggests that some firms specialise in selling to new customers and others in holding on to old customers. One plausible equilibrium outcome is a steady state in which prices in the newer firms rise over time, as they retain more old customers to service, and prices converge to a single intermediate price that incorporates a trade-off between attracting new customers and keeping old ones. This convergence likely leads to stable industry dynamics. Farrell and Klemperer also note that none of the empirical studies they survey models the dynamic effects of switching costs. From our perspective, new entrant suppliers are likely to shade price below marginal cost in an attempt to capture consumers, whom they can later exploit, implying that we cannot infer from the gap IL the true extent to which the incumbent is able to raise price above its marginal costs. However, if these

[8] As early as 2001, only 68% of consumers who made a switch of supplier were moving for the first time from their incumbent to an entrant supplier (Source: OFGEM 2003, based upon J D Power consumer survey data).

dynamic switching cost effects are present and no new entrants arrive, quantity IL should shrink over time, on their view.

Incumbents naturally face a trade-off between setting high prices relative to non-incumbents, thereby earning healthy margins, and those high prices driving some consumers away.[9] If, as a result of observing switchers' experiences, consumers who have not yet switched perceive switching costs as falling over time, then IM will fall over time.[10] On the other hand, if consumers as a group face psychic costs of switching that are arrayed on a distribution, we conjecture that those with the lowest perceived switching costs switch first. If so, then after the process has been underway for some time, the average switching cost for those who remain is higher than in the population of consumers as a whole. Hence companies seeking to gain share at the expense of the incumbent face having to provide increasingly attractive (introductory) offers over time to capture increasingly intransigent consumers.

One common theme in the search cost literature, following Burdett and Judd (1983) and Stahl (1989), involves assuming that some consumers are uninformed and face positive search costs for each additional search. In Stahl's paper, a subset of consumers is assumed to be fully informed. This leads to mixed strategy equilibria in which there is price dispersion. Stahl shows that as the proportion of customers with complete information increases, the price distribution shifts downward, so improvement in consumers' average information levels reduces average prices and, possibly, prices for the uninformed consumers, improving market competitiveness. If search costs are negligible, non-incumbents will all set the same price. If not, search cost theory suggests that price dispersion will remain and that the identity of the lowest price suppliers will change over time (Varian, 1980; Baye and Morgan, 2001). This leads to the prediction that increased internet usage will make markets more competitive,[11] although it need not reduce price dispersion.

Empirically, although results are somewhat mixed, Brown and Goolsbee (2002) for example have convincingly shown that the introduction of internet trading for term life insurance reduced premiums on average, by a significant 8-15%. However in this case, dispersion initially increased. Brynjolfsson and Smith (2000) find cross-sectionally that internet price levels are lower, but dispersion is not necessarily lower.

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[9] This trade-off is explored in Giulietti et al (2005).

[10] See Battisti et al (2006) for a discussion of the role of "word-of-mouth" in promoting (or encouraging) switching behaviour in the UK residential gas market.

[11] Janssen and Moraga-González (2004) argue that in what they term "low search intensity equilibria", this result does not hold. Examining relative magnitudes suggests that these are unlikely in our case.

In our context, access to information via the internet can be argued to have increased significantly over time. For example, the National Statistics Omnibus Survey reports that whilst in the three months to October 2000 (the earliest date they list), 36% of consumers used the internet for buying or ordering goods or services, and by 2006 over 60% did. The proportion of people using it to find information about goods and services rose from 70% to nearly 90% over the same period. The proportion of consumers connected to the internet rose 38% between March 2001 (the earliest date given) and March 2006, and whilst essentially all were on dialup connection in 2001, over 70% were on broadband connection in 2006.

Fast internet access allows consumers to search all suppliers at once using their own consumption details using one of the many comparison sites, together with click-through to the chosen site. If more consumers do this, the search literature suggests that average prices will fall, and eventually price dispersion will decrease. However there is evidence that although the proportion of searchers using the internet specifically for this purpose has increased over time, from 4% in 2001 to 30% in 2005, it is still less popular as a means of gaining information than from a representative who called the consumer's home (see OFGEM, 2006, Appendix figure 15).

If falls in search cost leads to better informed consumers over the period we study, the reduction in average price would have the effect of narrowing ML, the gap between median and lowest price over time. However, other forces apart from this convergence tendency[12] may be at work, as we will see. Also relevant is the effect on HL. In this market, all prices are actively used in transactions and consumer numbers are very large compared with the number of prices on offer. Hence the range HL across non-incumbents is a relevant measure of price dispersion. Although some theories predict dispersion should fall as consumers become more knowledgeable, at some basic level dispersion is non-monotonic in the proportion of people with full information, since in situations with either perfect or with zero information, prices are uniform.

[12] We use the term "convergence" in the sense of Baye and Morgan (2001), to mean prices moving towards each other. An alternative terminology is to use convergence to mean stationarity in the time series econometric sense of reverting to a particular value after a shock. We will attempt to distinguish by calling the latter stationarity, but in our empirical work we take account of both.

An alternative approach, deserving some consideration in our market context, is the Anderson- de Palma (2005) model of Passive Search. Their consumers do not incur search costs because they do not actively engage in search. However, when the opportunity presents itself, for example in our context, if a salesman turns up on the doorstep, you may choose to buy although you have little experience of the range of prices on offer in the market. They show that this yields a pure price equilibrium, with dispersed prices.

What is the effect of the number of suppliers on the average price paid/offered, primarily as a result of search costs? Here there are (at least) two forces and predictions depend quite delicately upon the nature of the model (see Janssen and Moraga-González, 2004). Consider the position as firms enter in a Stahl-type model. The "business stealing" effect of charging lower prices to capture more consumers strengthens, but so too does the "surplus appropriation" effect of earning a high surplus from uninformed consumers. Morgan et al (2006) find that as the number of firms increases, informed customers pay lower prices whilst the uninformed face higher prices. In the Anderson- de Palma framework, the dispersion of prices rises and the average price falls as the number of firms rises. Barron et al (2004) consider a broad range of models and show that, dependent upon the nature of the underlying model, the number of sellers and average price can be either negatively or positively correlated and, in addition, the number of sellers and price dispersion can be either positively or negatively correlated![13]

In sum, although an obvious null is that over time the differences in prices (a) between incumbent and entrants and (b) across entrants would shrink, there are several reasons why this need not happen. Hence it becomes important to examine what the actual price paths look like, as a precursor to attempting some interpretation of the patterns emerging.

3. Data and econometric procedure

3.1 Data

Our analysis of the changes in electricity retail prices since the introduction of competition takes into account geographical, product market and temporal dimensions. Our data set consists of a balanced panel of 48 bimonthly price observations for each firm active in the market over the period February 1999 to December 2006. Over this period the number of

[13] There is one (of four) prediction in Barron et al's Table 1 that is unambiguous, but this is not easily examined with our data.

firms operating in the market ranges between 18 and 6 suppliers. Data were obtained from the Consumers' Association website initially and, later, from the OFGEM and Energywatch websites. All price offers by suppliers are public, in this sector.

As discussed before, electricity retail prices for domestic consumption in the UK differ by payment method and geographical location. As a result of this, our data set comprises 84 cross-sectional units corresponding to the fourteen supply regions[14], three payment methods namely direct debit (DD), quarterly bills (QB) and prepayment meters (PP), and two levels of consumption, namely "high" and "low". We distinguish between high (4950 KWh per year) and low (1650 KWh per year) consumption in order to reflect the at least two-part nature (commonly a higher unit rate for the first *x* KWh than for subsequent KWh) of electricity tariffs. This allows us to consider six different products whose prices are set by residential energy suppliers. All the companies for which data have been collected and all the tariffs they offered (including internet-only tariffs) are used in the calculation of the variables ML, HL, IM and IL. In constructing these variables we calculated average yearly bills for customers on low and high consumption levels for each of the main types of payment methods.

Some sample illustrative charts are shown in Figures 1 to 4, based on data at the national level. The price pattern observed at the regional level, however, is not dissimilar to the one observed at the national level. Although these charts all relate to one particular class of consumer, namely direct debit consumers, they are enough to show that a simple pattern of convergence to a single price does not exist.

We investigate the time trends in the series ML, HL, IM and IL. A positive and significant time coefficient on, say, ML, would suggest rejecting the hypothesis that average price is declining over time as a result of increased internet usage However, in order to do so, we first need to examine whether a trend can legitimately be identified.

3.2 Stationarity

In examining the evolution of electricity tariffs in the eight years since the introduction of competition we need to incorporate the approach in the literature on adjustment to the 'law of one price'. Here several empirical tests of price convergence (what we refer to as stationarity)

[14] These regions are Eastern (EA), East Midlands (EM), London (LD), Midlands (MD), Manweb – Greater Manchester (MW), Northern (NT), North Western (NW), South Eastern (SE), Scottish Hydro – North of Scotland (SH), Scottish Power – Southern Scotland(SP), Southern (ST), South Wales (SA), South West (SW) and Yorkshire (YK).

have been carried out, particularly in the international trade area (Frankel and Rose, 1996), but also with reference to consumer price indices across US cities (Cecchetti et al., 2002) and car prices across European countries (Goldberg and Verboven, 2005).

Recent contributions in these areas rely on the econometric theory of unit root testing in order to provide evidence of price adjustment to a 'common' average in the sense of mean reversion. A number of alternative procedures have recently been proposed to test for the presence of unit roots in dynamic heterogeneous panels, see for example, Im, Pesaran and Shin (2003) and Maddala and Wu (1999). These authors test the null hypothesis of a unit root against the alternative of a least one stationary series, by using the (Augmented) Dickey-Fuller (ADF) statistic across the cross-sectional units of the panel.

By contrast, Hadri (2000) proposed an *LM* procedure to test the null hypothesis that the individual observed series are stationary, either around a mean or around a trend, against the alternative of a unit root in the panel. These tests are denoted Z_μ and Z_τ, respectively. The *LM* tests proposed by Hadri (2000) are the panel version of the test developed by Kwiattowski et al (KPSS) (1992). The Monte Carlo experiments of Hadri (2000) demonstrate that these tests have good size properties for *T* and *n* sufficiently large. However, Giulietti et al. (2008) show that even for relatively large *T* and *n* the Hadri (2000) tests suffer from severe size distortions in the presence of cross-sectional dependence, the magnitude of which increases as the strength of the cross-sectional dependence increases. This finding is in line with the results obtained by Strauss and Yigit (2003) and Pesaran (2007) on both the Im, Pesaran, Shin and the Maddala and Wu panel unit root tests. In order to correct the size distortion caused by cross-sectional dependence, Giulietti et al. (2008) apply the bootstrap method and find that the bootstrap Hadri tests are approximately correctly sized.

To implement the bootstrap method in the context of the Hadri tests, we start off by resampling the residuals from either a regression of y_i on a constant for the Z_μ test, or on a constant and a trend for the Z_τ test. As suggested by Maddala and Wu (1999, p.646), we resample the residuals with the cross-section index fixed, so that we preserve the cross-correlation structure of the error term.

With time dependent data, a further refinement in the bootstrap described above can be obtained by applying the idea of bootstrapping overlapping blocks of residuals rather than the individual residuals, also known as the moving block bootstrap approach.[15] This approach requires the researcher to choose the block size, i.e. the number of contiguous residuals to be resampled with replacement. The choice of the block size is based on the values suggested by the inspection of the correlogram of the series, which involves identifying the smallest integer after which the correlogram becomes negligible, as suggested by Künsch (1989; p.1226). In particular, the results shown in Table 1 are based on 1,000 bootstrap replications used to derive the empirical distribution of the Z_τ statistics, for alternative block sizes of 4, 6 and 8 bi-monthly residuals. Although the smallest integer we identified is around four, we also allowed for larger blocks in order to ensure the robustness of the results for longer block sizes.

During the sample period covered in our analysis, an important institutional change in price setting was introduced in April 2002, when the energy regulator, OFGEM, removed all price controls for residential consumers. Furthermore, starting from the Spring in 2002 we observe a substantial increase in fuel costs as illustrated in Figure 5. Thus, to account for the potential impact of these changes for our empirical analysis, the dataset is split into two periods- before and after April 2002.

Applying the Hadri tests for panel stationarity to our dataset over the two sample periods, we find that all the series analysed are stationary around a trend, independently of the selected block size, as reported in Table 1. Given this result, we now turn attention to the trends in price spreads.

3.3 Econometric Approach

Our four estimating equations have the following form:

$$\Delta Y_{rpc,t} = \alpha_{rpc} + \alpha_{rpc} * Tr + \beta Y_{rpc,t-1} + \sum_{k=1}^{K} \gamma_l \Delta Y_{rpc,t-k} + \delta\, NFIRMS_{r,t} + \varepsilon_{rpc,t}\,, \quad (1)$$

where *Y* refers to the variables ML, HL, IM, IL, being the price spread variables discussed in section 2, while *r*, *p*, *c* and *t* identify a region, product, consumption level and time period, respectively. Δ indicates the first difference operator, so that $\Delta Y_{rpc,t} = Y_{rpc,t} - Y_{rpc,t\text{-}1}$. The first *K* differences in the lagged dependent variable are included on the right hand side to account

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[15] For a discussion of the moving block bootstrap see Künsch (1989), Maddala and Kim (1998) and Berkowitz and Kilian (2000). Lee and Wu (2001) use this approach within the context of the Im, Pesaran and Shin panel unit root test. Details on the implementation of the moving block bootstrap can be found in these references, and so are not presented here to save space.

for potential serial correlation in the error term.[16] The inclusion of five lags of these first differences reduces the number of available time observations to be used for estimation to 42, so that the total number of observations available is 3528 ($T = 42, n = 84$), 1512 of which are used for estimation during the first sample period (February 1999 to April 2002), while the remaining 2016 observations are used for the second sample period (June 2002 to December 2006).[17]

The specification in (1) allows us to assess the speed of any process of reversion to a trend based on the sign and size of the estimated β coefficient, keeping in mind that we expect a negative sign on β if the process is stationary, while $\beta = 0$ indicates that the effect of a shock on prices is permanent. The estimated value of β can be used to calculate the approximate half-life of a shock on the dependent variable, based on the formula $-\ln(2)/\beta$.

In order to control for region and product-specific factors that might affect the companies' pricing behaviour, regional, product and consumption level dummies (α_{rpc}) are included in the estimating equation. Furthermore, the inclusion in equation (1) of the number of firms operating in the different regional markets ($NFIRMS_{r,t}$), which varies by region and time only, is aimed at controlling for the effects of changes in market structure and the nature of competition as firms enter or exit the market.

However, for the purpose of our analysis of price dispersion over time, the sign and magnitude of the coefficients associated with the interactions between fixed effects (the α's) and the time trend *Tr* are the most relevant, because they enable us to investigate the presence, or absence, of convergence in the sense discussed in the previous section.[18] The presence of a significant positive (negative) deterministic trend term would provide evidence in support of an increasing (decreasing) gap or range (ML or HL) in average bills over time for the relevant region, product and consumption level, reflecting the underlying evolution of consumers' search costs as a result of competition. At the same time, the presence of a deterministic trend in the bill differentials between the median or lowest-priced entrant firm

[16] We chose five lags based on a general-to-specific approach, having started with K= 6 lags.

[17] Alternatively it would have been possible to use the whole sample period for estimation purposes, but including a dummy variable that takes the value of one after June 2002 (along with its interactions). However, we find that splitting the sample period makes the interpretation of the coefficients more straightforward. From a statistical point of view, the two approaches yield the same results.

[18] Alternative approaches to test price dispersion in the presence of search costs, applying maximum likelihood estimation techniques on price data alone, have been considered recently by Hong and Shum (2006) and Moraga-González and Wildenbeest (2006).

and the incumbent (IM or IL) assists examination of the evolution of customers' switching costs in this market and their estimated variation over time.

All the equations are estimated using the Least Squares Dummy Variable estimator that has been shown to provide efficient and unbiased estimates for balanced panels of dimensions close to ours (Judson and Owen, 1999). As mentioned earlier we also include five lags of the dependent variable to account for potential residual serial correlation. The *t*-statistics calculated for all the estimated coefficients are based on White's heteroskedasticity-consistent standard errors and covariances.

4. Results and Interpretation

4.1 Discussion of Results

Our empirical analysis starts with fairly general specifications of equation (1) explaining price dynamics. The detailed information available about electricity prices allows us to distinguish between the movements of prices across geographical, payment method and consumption level dimensions. In order to account for all possible sources of cross-sectional variation in the trend we considered all possible interactions between the different cross-sectional dimensions. The interaction coefficients between the time trend and the fixed effects give an indication of the increases or decreases in our indexes of price dispersion over time.

We refer to the most general specification reported in Table 2 as the unrestricted model. Based on the results from the stationarity tests reported in Table 1, the unrestricted model is estimated over two sample periods, before and after June 2002. Splitting the sample period in such a way allows us to deal with stationary series and at the same time to account for the potential effect of exogenous changes due to the international markets and institutional changes mentioned earlier.

To assess variability across the fourteen electricity regions, we carried out a series of Wald tests on the estimated coefficients from the unrestricted models of Table 2. The results are reported in Table 3. It is clear that for the dependent variable IL, no real simplification is possible, but that in the other three cases (ML, HL, IM) the model can be simplified. For these, independently of the sample period, for low consumption users we observe no statistically significant regional differences in the tariffs for all payment methods, as the Wald tests for the null hypothesis that the estimated coefficients are the same across regions are not rejected (see lines 4 to 6, 8, 13 to 15 and 17). Furthermore, for the sample period until April 2002 the hypothesis that the estimated coefficients are not significantly different between tariffs for high and low consumption levels (line 9) is not rejected for all payment methods. The corresponding hypothesis for the sample period starting in June 2002 is rejected, at least at the 10% significance level (line 18). Focussing again on the second sample period, for high consumption users the Wald tests reveal regional variations in the estimated coefficients referring to the switching cost variables but not to the search cost variables (lines 10 to 12).

Based on the previous hypothesis tests, we have proceeded to estimate a restricted version of the model, where we make no distinction between high and low levels of consumption. The chosen specification is such that all the dependent variables bar IL are regressed on the same set of regressors. The resulting restricted models for the two sample periods are reported in Table 4. There is considerable concordance on the results *within* periods.

The results in Table 4 for the first sample period indicate negative and statistically significant trend coefficients for both ML and HL across all regions for DD and QB bill types, but not for PP. On the other hand, the variable related to incumbency advantage (IM) shows a positive and statistically significant trend across all regions and payment methods. Given the early stage of the market, these results are consistent with search costs falling in the first period, but with switching costs rising, perhaps because those consumers who were switching were increasingly reluctant switchers.

The results for the second sample period show that the negative trend in ML and HL turns positive and statistically significant across regions and payment methods, while the positive trend in incumbency advantage becomes negative and statistically significant across regions and payment methods. It is difficult to imagine that search costs are increasing, which is one possible implication of the first finding. More likely is either that suppliers have become more successful at differentiating their products from other suppliers, so that the search takes on less of a commodity nature, or that entrant firms have regard not only to capturing new customers but increasingly also to retaining, or even milking, those they have gained. The result that incumbency advantage is shrinking may arise either because consumers are becoming more used to switching, or because past price hikes emanating from cost increases mean that greater absolute money amounts are at stake so prompting more switching, or finally, because incumbents wish to regain some of the consumers they have lost, or slow their departure. The ramifications of switching being not solely from incumbent to an entrant are discussed below. The upshot is that in neither sub-sample does the overall spread decline, so throughout the period there is no monotonic increase in competitiveness amongst suppliers. This can also be seen in the results for IL in Table 2, where the trend is positive not negative across both periods, for higher consumption.

The general trend in the price indexes of interest is also partly reflected in the estimated effect of changes in market structure, measured here by the number of firms operating in the market. Throughout the period under examination, (non-incumbent) firm numbers have been declining regularly. The estimated positive coefficients on the number of firms variable for ML and HL over both sample periods might therefore be taken to indicate that as the number of firms reduces, search costs decline. The positive association with dispersion is broadly consistent with both Morgan et al (2006) and Anderson- de Palma (2005), although these two papers use very different frameworks. On the other hand, for the second part of the sample only we estimate a significantly negative coefficient on firm numbers for IM.

It is also of some interest to discuss the variables' speed of adjustment to exogenous shocks or innovations, which involves examining the estimates of the coefficient β from (1). Our results in Table 2 indicate that all the variables analysed are trend stationary processes. The estimated speed of adjustment (lagged dependent variable) coefficients all have negative sign and are significantly different from zero, as required for stability. The speed of adjustment is relatively slow in the first period, as indicated by estimated coefficients in Table 4 ranging from -0.07 to -0.27, implying a half life ranging from 20 to 3 months. In the second period the speed of adjustment is slightly faster, as the estimated coefficients range from -0.11 to -0.40, resulting in a half life ranging from 12 to 4 months.[19]

Finally, we should consider two possible caveats relating to the development of the market. One recent trend has been for tariffs that are more complex than those listed on the Energywatch website to become available from suppliers. The most popular example is a tariff involving a price fixed for a period.[20] The impact of this is that there will be occasions

[19] The reported estimated speed-of-adjustment coefficients were obtained from a specification that assumes homogeneity at the national level; i.e. the coefficient associated to the lagged dependent variable in equation (1) is β. However, they are very similar in magnitude to those obtained by averaging the coefficients of a model that allows for heterogeneity across the different regions; i.e. the coefficient associated to the lagged dependent variable in equation (1) is β_r. See Pesaran and Smith (1995) for a discussion on estimating convergence in dynamic panels with a large number of time observations.

[20] This is a very recent development. Where a consumer chooses a fixed price tariff, the period of fix is normally around a year. The product was unknown before 2003 but by March 2006 had around 8% of the

when some consumers are able to achieve lower prices than we have measured. Therefore, if anything we have latterly underestimated "L" in our variables ML, HL, IL. Hence if anything this will strengthen our conclusions regarding the movements of these magnitudes over time. The second development, which has captured a significant proportion of switching consumers, is a "dual fuel" type of tariff where the parties contract for consumer requirements of both electricity and gas to come from the same supplier. Broadly speaking, the results for relevant magnitudes on dual fuel show substantial similarities with those we report in detail here; in particular there is no tendency for them to shrink. Appendix 1 discusses the issue in somewhat more detail.

4.2 Some Interpretations

The results on the trend in prices over time are clearly unable to support a naïve Bertrand-type explanation for the price differences experienced in this industry- prices are not converging to a single value. They demonstrate a continuing incumbency advantage in line with the general prediction of switching cost models, although not a more specific prediction of declining gap between the incumbent price and lowest available price (IL).

The less straightforward finding is the pattern of prices between entrant firms within an area. Here the first issue to consider is whether price patterns relate more closely to a pure strategy equilibrium along Anderson- de Palma lines, or a Stahl-type mixed strategy equilibrium. The basic prediction of either Anderson- de Palma or the several mixed strategy variants, of a *ceteris paribus* positive relationship between the number of firms and the spread of prices, is borne out by the results shown in Tables 2 and 4. However, the evidence on price behaviour over time more generally is much more consistent with the mixed strategy explanation.[21]

Here, we follow Lach (2002) in taking various cuts of the data.[22] Specifically, we carry out two data exercises. In the first, we examine entrant firms' prices in terms of the proportion of time for which they are above or below the median value. The details on this are reported in Appendix 2. Summarising briefly, it is remarkably seldom that a firm is a "good" or "bad"

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market (OFGEM, 2007) and was growing rapidly. "Green" tariffs, which are an important element in some European countries, have not proven very popular in the UK.

[21] One peculiarity of the Anderson- de Palma model is that there is an inverse relationship between the price a firm charges and its level of profit. What appears unresolved in their model is how the lower profit (higher price) firms respond in a multi-period context. Thus, in a single period game, their model has a pure strategy equilibrium, but the model remains silent as to the relationship between this equilibrium and firm identities over time.

[22] Lach considered *inter alia* the identity of firms occupying quartiles of the price distribution. With only six players at the end of our period, this would clearly be inappropriate – we focus instead on above and below median players.

buy over the period- the clearest message from the table is that firms spend some time in both positions. To gain a more quantitative impression, and again following Lach's approach, we calculated Spearman rank correlations between February 1999 price and price at time *t* based on the price ranks of the six companies that survived over the whole period: British Gas, Power Gen, Npower, London (EDF), Scottish and Southern, and Scottish Power.[23] The critical value is 0.771 at 5% significance level (Gibbons and Chakraborti, 1992, Table M). Taking as an example the East Midlands region, low or high consumption, with payment by direct debit, our results identify no significant correlation beyond a period of one year for low consumption, and six months for high consumption. In sum, there is little evidence that price advantages for one firm persist for long periods, rather the prices appear to follow a pattern *consistent with* mixed strategy equilibrium.

A central proposition within the Stahl mixed strategy framework, verified empirically several times, is that as the proportion of customers who become well informed increases, average prices fall; see for example Sorensen (2000) and Brown and Goolsbee (2002). It is also commonly found (in Sorensen, but *not* Brown and Goolsbee) that the spread of prices decreases. However, in our context, both of these predictions are in doubt. We cannot fully address the first question, since we are not attempting in this paper to measure costs, but the positive trend in ML speaks against a fall in average prices. The positive trend in HL in the second period goes against the common view on price spread. This suggests that a pure search cost explanation for the observed pricing patterns across entrants is incomplete.

The missing element, we argue, is that this market is one where considerable re-switching takes place. For example in 2005, of the 4.5 million total switches, only 38.6% were from incumbent to an entrant. Nearly 40% were churn amongst entrants and 22.7% of switchers actually moved back to their incumbent! (Source, OFGEM, 2006). In this context, an entrant player will trade off a number of different and somewhat opposing influences. At any price, it earns revenue streams from (a) existing customers it has captured earlier who decide against moving again, (b) existing customers who, having searched other suppliers, decide to remain, (c) switchers to it from the incumbent and (d) switchers from other entrants. The lower the price set, the higher the proportion of customers of types (b) to (d) will be achieved, but the lower the revenues per customer from each source. The parameters of this trade-off will vary as the proportion of customers of each type is available; for example if a large base of customers has been gained already, they are likely to weigh relatively heavily in the decision.

[23] These results are not reported here for brevity, but are available from the authors upon request.

In order to examine this issue more closely, a model of the trade-off function facing a particular entrant was developed; the model is sketched in Appendix 3. We then engaged in some simulations by making a particular distributional assumption (the lognormal) and experimenting with some parameterisation of the model. Two examples from the resulting distributions are illustrated in Figures 6 and 7. Figure 6 shows a range of distributions where the number of players involved is 6, whilst Figure 7 is similar except that the number of players is 15; these firm numbers correspond to the typical number of suppliers at the end and at the start of our time period respectively. The meaning of any one cumulative distribution function (cdf) is that this is the distribution from which each firm will pick its price in a mixed strategy equilibrium. From these cdf's we can read off the median (as an estimate of the sample median) directly and get an impression of the likely empirical range of prices considered. The parameter which varies within the figures is the proportion of customers retained by the incumbent, λ. Hence, at the start of the experiment, λ is one. By the end of our period, it is on average around 0.5. Comparing across the figures, if λ remained at 1, the fall in the number of suppliers, N, would have reduced median price, in line with our empirical finding (Table 4) on the effect of firm numbers on ML. But of course, all other things are not equal, and as λ declines, median price rises, holding N constant. Even allowing for falls in N, the simulation indicates that median price will rise. The other finding is that the price range increases, in line with our finding regarding HL in the second period. It is also worth noting from our empirical results that the second period positive trend in HL outweighs the negative trend in the earlier period. In sum, once we allow for significant reswitching, the empirical results we uncover accord more closely with theoretical expectations.

5. Conclusions

On one view, electricity supply is a homogeneous good market in which consumers quickly learn through their own or others' experience how easy it is to switch suppliers in order to save money. As a result, companies aiming to capture new business would need to price competitively and companies wanting to retain business would need to ensure their offer did not move too far out of line with entrants' offers. Hence as companies learnt more about their competitors' moves, differences in the trend values of prices would tend to shrink. To some extent this has happened in the UK, but although a large proportion of consumers has switched there has until now been no comprehensive, substantive analysis of the prices consumers face. Our finding that there is a persistent incumbency advantage of almost 10%

is significant but not completely surprising. The more surprising and significant finding is that it remains worthwhile for some non-incumbent suppliers to quote, and do business at, prices that are very significantly non-competitive, in the face of evidence that internet usage has increased greatly over time.

Of course, during the first half of the sample period we are observing, price controls were operative on incumbent players. However removal of these controls has, if anything, led to the gains from switching supplier away from the incumbent to grow over time. Thus, whilst the market has not seen major anticompetitive moves by established players by any means, and whilst innovation in products has been observed, a fully competitive market has not emerged. Indeed competitive pressures seem somewhat damped. This conclusion is reinforced by the fact that retail electricity prices overall are somewhat insensitive to movements in wholesale prices over the period since a market has developed (OFGEM, 2004).

Why have prices not converged across suppliers? Although the decline in supplier numbers would by itself suggest a lesser dispersion (albeit with a higher average price), as time passes those firms that previously were entrants have an increased incentive, when setting their prices, to consider not only the benefits from winning new customers but also the benefits of making money from those they have previously gained. The implication for consumers is, unfortunately, that a company which was once a "good buy" may slip significantly in the rankings. As an illustration of what may be this phenomenon at work, British Gas gained a deserved reputation in the early years for being a good buy for electricity, and managed to obtain a large share of the electricity market. However, as a result of price rises, over the course of 2006 it became a markedly poor buy, as Figure 8 illustrates.[24] Our results therefore suggest that consumers' periodic renewed search for a supplier is likely to be worthwhile; the correlations over time reported in section 4.2 imply this should be as frequently as annually, in the current market.

[24] Admittedly, this ranking improved significantly in 2007, outside our estimation period, as a result of customers leaving the company.

Figure 1. Difference between entrant median and lowest bills - Direct Debit

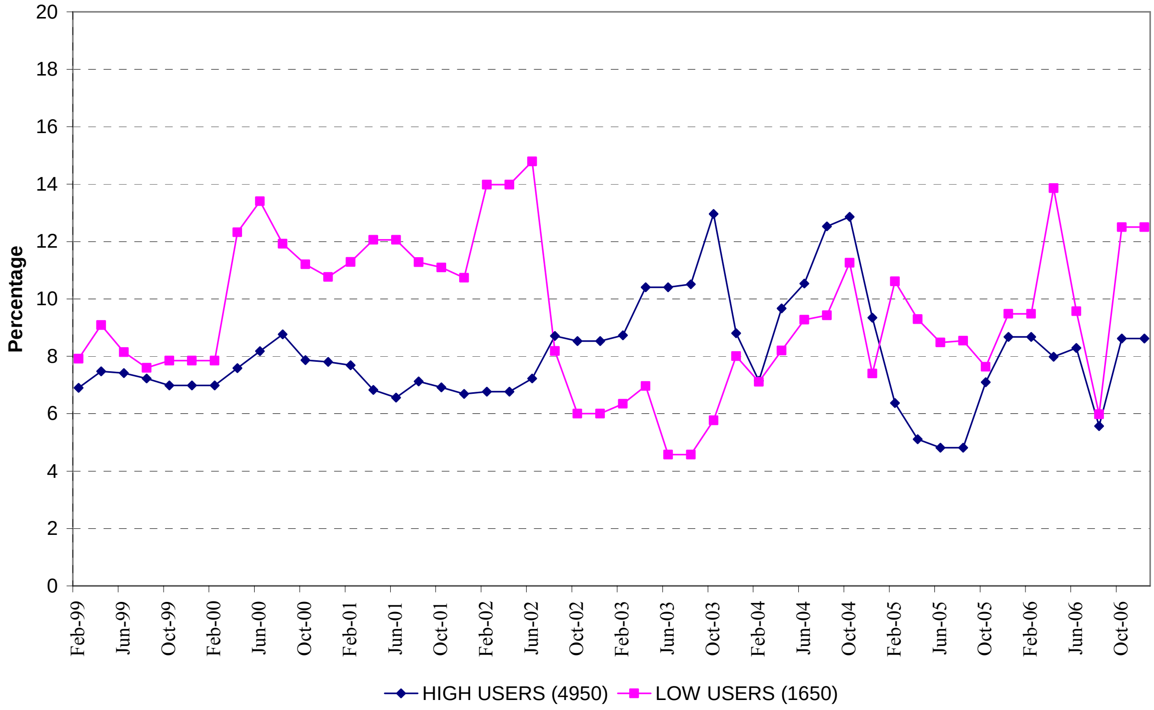


Figure 2. Bill range (excluding incumbent) - Direct Debit

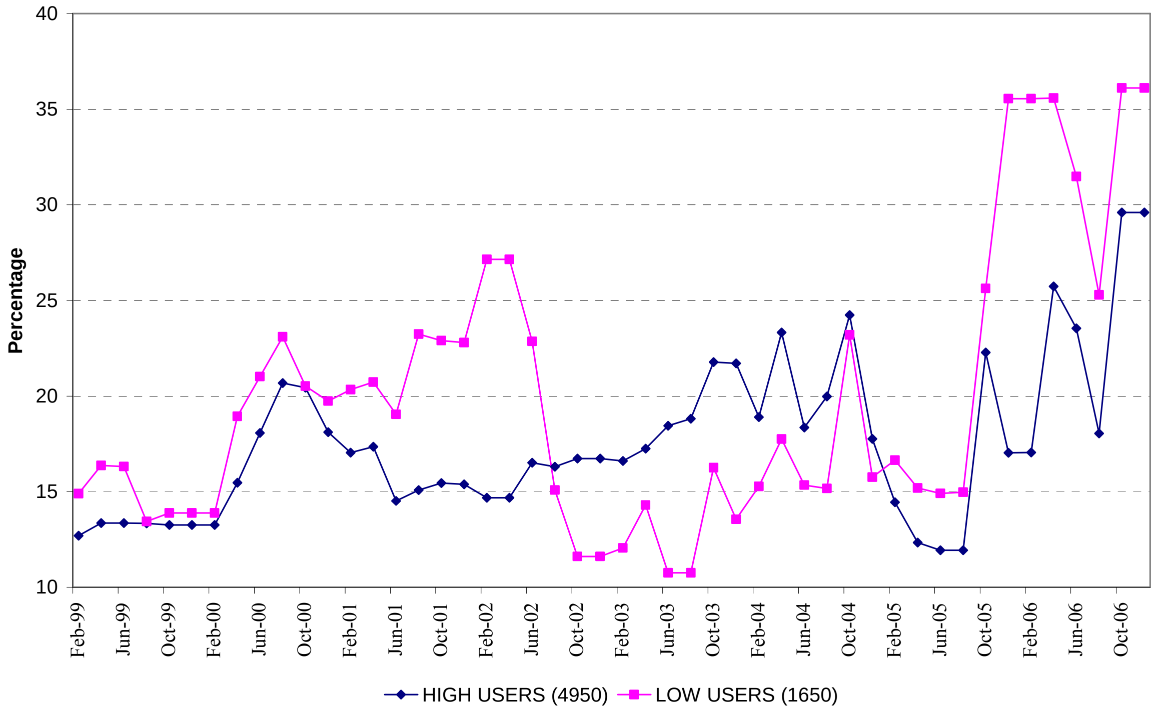


Figure 3. Incumbency advantage - Direct Debit high users (4950 KWh)

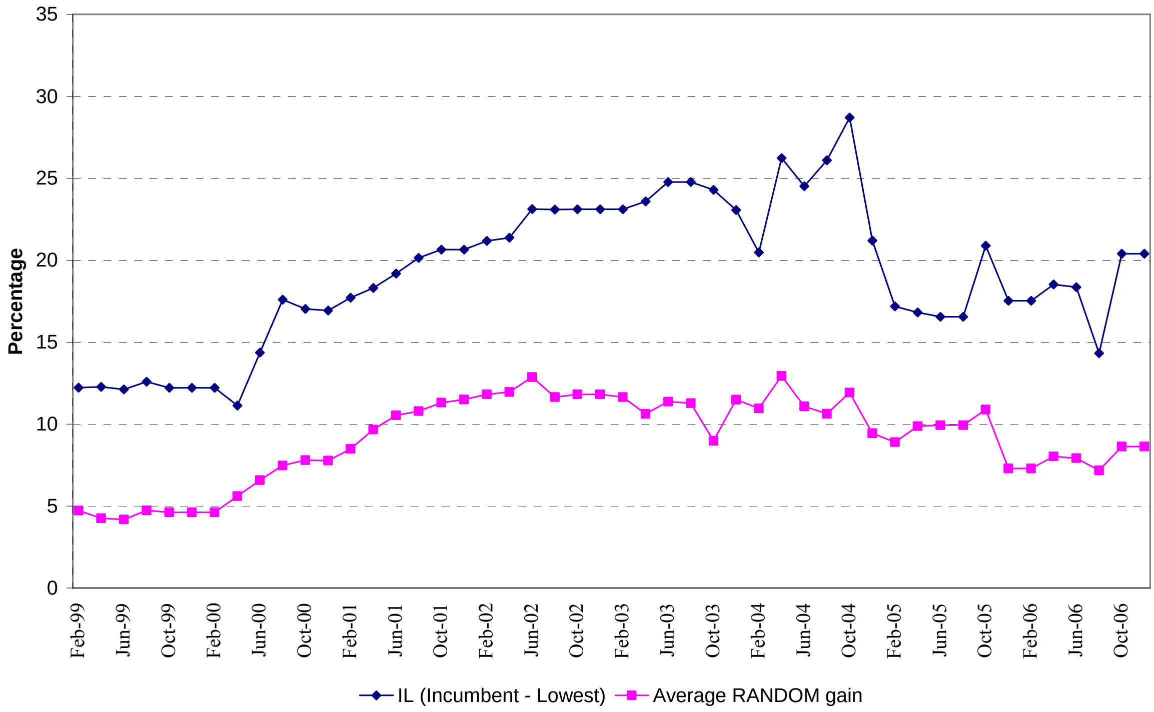


Figure 4. Incumbency advantage – Direct Debit low users (1650 KWh)

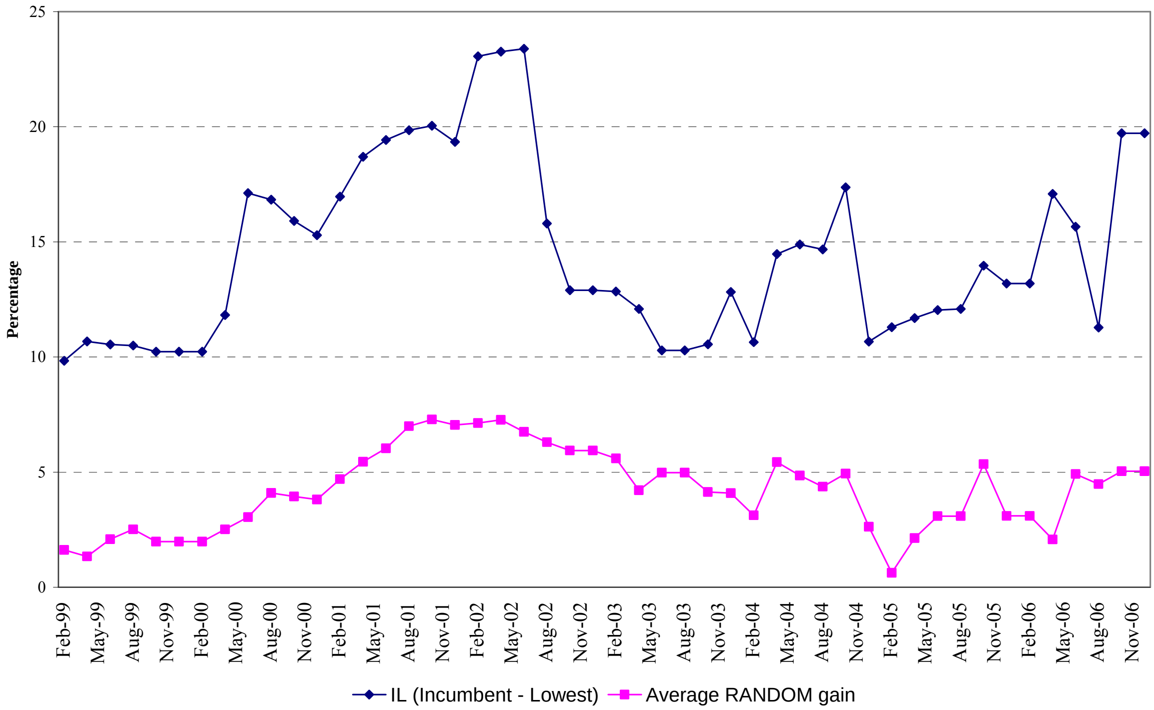
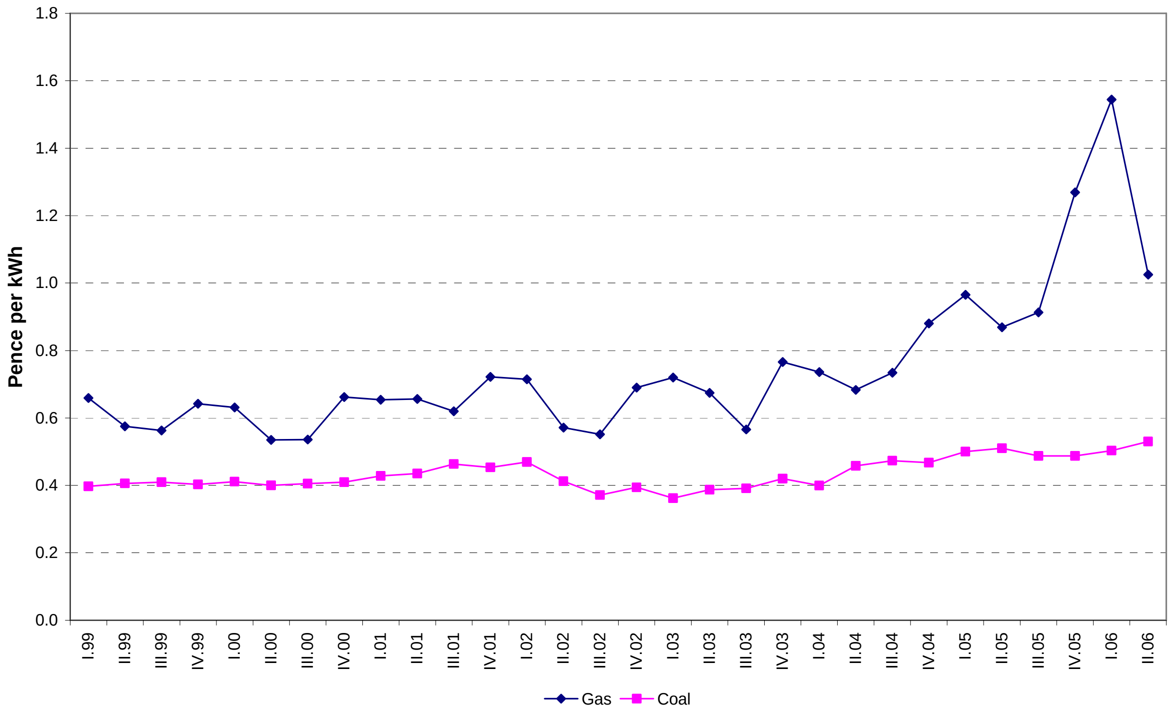


Figure 5. Fuel input prices for electricity producers



Source: UK Department of Trade and Industry. Quarterly Energy Prices Tables – December 2006 (Table 3.2.1).

Figure 6. Price cdf for several λ values. N = 6 firms, lognormal (1,4)

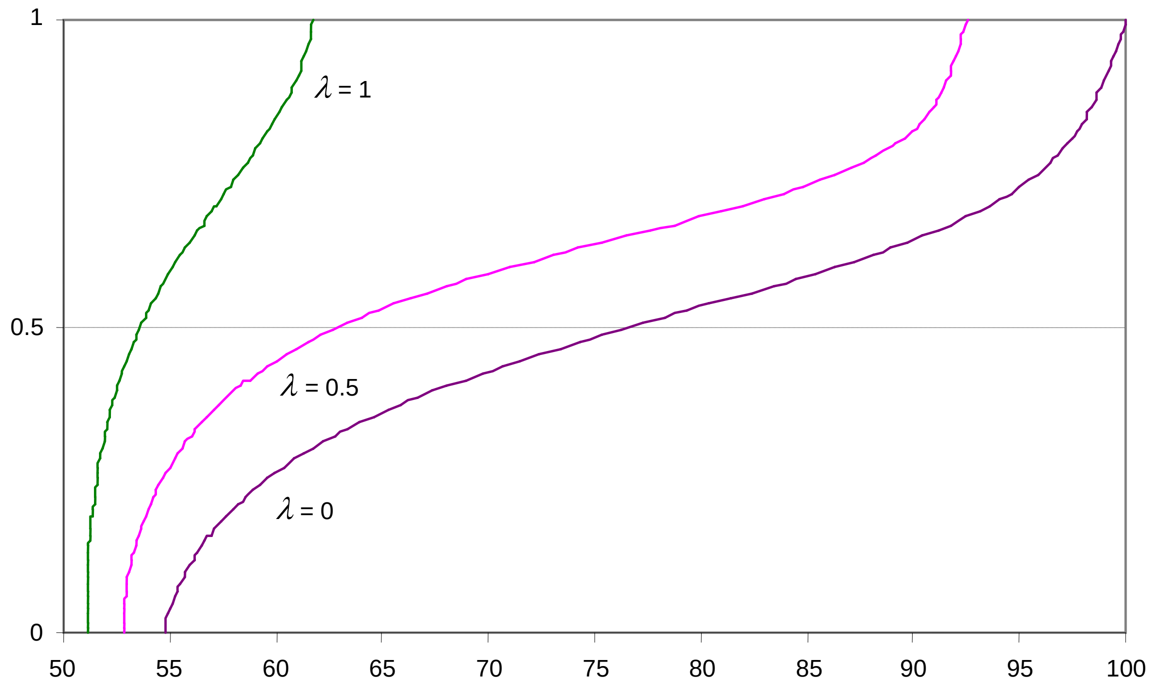


Figure 7. Price cdf for several λ values. N = 15 firms, lognormal (1,4)

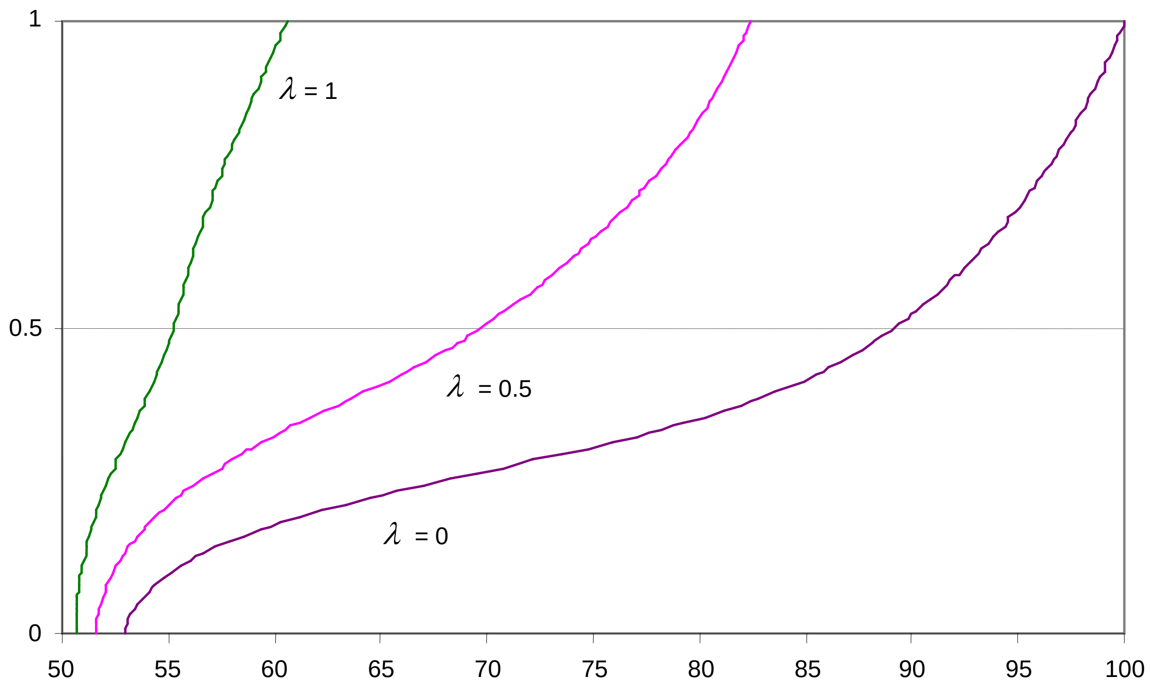


Figure 8. Incumbency advantage relative to British Gas - Direct Debit

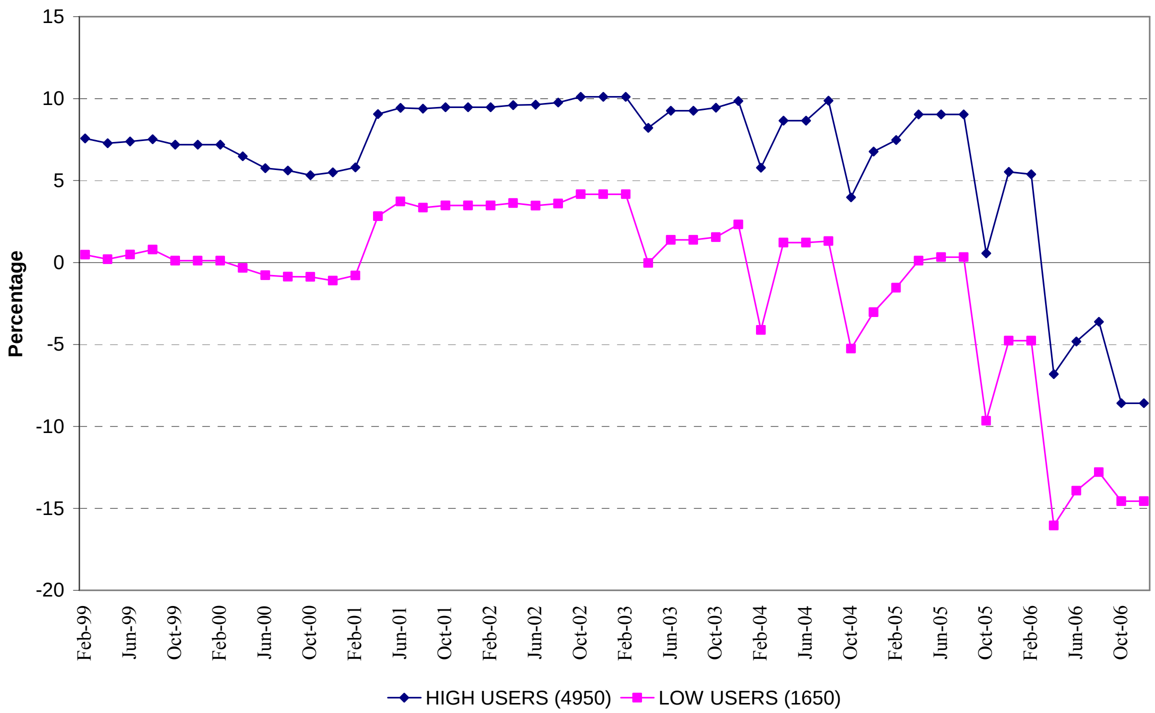


Table 1 – The bootstrap Z_τ Hadri test

Series	Block size	Feb. 1999 – Apr. 2002 Test stat.	Feb. 1999 – Apr. 2002 *p*-value	Jun. 2002 – Dec. 2006 Test stat.	Jun. 2002 – Dec. 2006 *p*-value
	4		0.53		0.48
ML	6	10.27	0.53	11.16	0.47
	8		0.46		0.41
	4		0.45		0.41
HL	6	10.78	0.45	11.28	0.43
	8		0.41		0.40
	4		0.77		0.48
IM	6	9.12	0.71	10.89	0.48
	8		0.62		0.43
	4		0.47		0.46
IL	6	10.74	0.48	11.06	0.44
	8		0.42		0.40

Notes: We first calculate individual KPSS test statistics using a lag truncation parameter equal to six, which accounts for potential residual serial correlation in the series. The average of the individual KPSS statistics is subsequently standardised, using mean and variance given by Hadri (2000), to obtain the Hadri test statistic. To do the block bootstrap, we regress $Y_{rpc,t}$ on a constant and a trend for the Z_τ test. Then, overlapping blocks of residuals (of size 4, 6 and 8) from these regressions are resampled keeping the cross-section index fixed, so that the cross-correlation structure of the error term is preserved. The *p*-values reported in the table are based upon 1,000 bootstrap replications.

Table 2. Unrestricted model. Trend interaction by region, products and consumption levels

Regressors	ΔY = ΔML				ΔY = ΔHL				ΔY = ΔIM				ΔY = ΔIL			
	Feb. 99–Apr. 02		Jun. 02–Dec. 06		Feb. 99–Apr. 02		Jun. 02–Dec. 06		Feb. 99–Apr. 02		Jun. 02–Dec. 06		Feb. 99–Apr. 02		Jun. 02–Dec. 06	
	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat
Y(-1)	-0.33	-8.63	-0.52	-12.30	-0.18	-6.29	-0.25	-7.06	-0.20	-3.69	-0.31	-9.94	-0.47	-9.96	-0.30	-10.34
NFIRMS	0.10	1.69	0.66	7.06	0.35	3.19	1.19	8.05	0.09	2.55	-0.27	-2.38	0.14	2.35	0.54	3.69
Group 1																
Tr*EA*DD	-0.13	-4.76	0.08	3.61	-0.19	-3.12	0.34	8.16	0.15	3.44	-0.01	-0.20	0.22	5.89	0.11	3.11
Tr*EM*DD	-0.09	-2.30	0.08	3.45	-0.17	-2.28	0.31	7.33	0.13	3.35	0.00	-0.06	0.23	4.85	0.11	3.18
Tr*LD*DD	-0.06	-1.95	0.10	4.24	-0.19	-2.74	0.32	6.94	0.12	3.68	-0.03	-0.96	0.22	5.09	0.10	2.27
Tr*MD*DD	-0.10	-3.46	0.08	3.50	-0.20	-3.32	0.32	7.72	0.16	3.45	0.03	1.44	0.29	6.77	0.16	4.35
Tr*MW*DD	-0.10	-3.26	0.10	3.49	-0.19	-2.83	0.31	7.25	0.15	3.01	-0.05	-2.13	0.27	6.20	0.07	1.99
Tr*NT*DD	-0.03	-1.19	0.08	3.62	-0.13	-1.80	0.38	7.59	0.19	3.54	0.07	2.40	0.47	8.12	0.22	5.55
Tr*NW*DD	-0.12	-4.28	0.08	3.39	-0.24	-4.13	0.35	5.00	0.16	3.42	0.01	0.52	0.27	6.41	0.14	4.11
Tr*SE*DD	-0.12	-3.54	0.09	4.13	-0.20	-3.21	0.33	7.03	0.17	3.62	-0.01	-0.44	0.27	6.05	0.11	2.61
Tr*SH*DD	-0.01	-0.46	0.09	3.02	-0.16	-3.64	0.29	7.21	0.12	2.98	-0.12	-3.90	0.31	6.55	-0.01	-0.25
Tr*SP*DD	-0.13	-5.00	0.14	3.99	-0.19	-3.36	0.34	6.30	0.16	3.33	-0.07	-2.72	0.24	4.97	0.09	2.02
Tr*ST*DD	-0.12	-4.87	0.13	4.54	-0.22	-3.48	0.35	7.79	0.16	3.89	-0.07	-2.46	0.25	6.60	0.07	1.88
Tr*SA*DD	-0.03	-1.11	0.09	3.80	-0.20	-3.53	0.32	7.37	0.09	2.29	-0.09	-3.18	0.18	4.14	0.01	0.40
Tr*SW*DD	-0.14	-5.53	0.09	4.63	-0.20	-3.70	0.33	7.86	0.15	3.66	-0.02	-0.67	0.19	4.93	0.10	2.75
Tr*YK*DD	-0.06	-1.86	0.08	3.50	-0.14	-2.27	0.35	8.02	0.18	3.72	0.05	1.65	0.39	7.88	0.19	4.73
Group 2																
Tr*EA*PP	0.02	0.41	0.13	5.17	0.08	0.91	0.36	6.91	0.00	0.17	-0.07	-2.81	0.09	1.34	0.08	2.08
Tr*EM*PP	0.05	0.55	0.15	4.85	0.11	0.69	0.36	8.24	-0.03	-0.89	-0.08	-2.20	0.04	0.42	0.08	2.53
Tr*LD*PP	-0.01	-0.12	0.15	5.22	-0.01	-0.12	0.37	6.60	0.00	0.04	-0.10	-3.26	0.01	0.27	0.06	1.48
Tr*MD*PP	0.04	0.83	0.13	5.56	0.01	0.05	0.38	8.33	0.01	0.64	0.01	0.21	0.13	2.20	0.17	4.90
Tr*MW*PP	0.06	1.21	0.12	5.51	-0.11	-1.81	0.39	8.14	0.01	0.26	-0.06	-2.22	0.13	2.16	0.08	2.39
Tr*NT*PP	0.09	1.38	0.16	6.27	-0.05	-0.64	0.43	7.63	0.04	1.64	0.01	0.50	0.26	3.11	0.21	5.60
Tr*NW*PP	0.05	1.11	0.17	5.50	0.08	0.62	0.40	6.73	0.02	0.71	-0.06	-2.17	0.15	2.38	0.11	3.18
Tr*SE*PP	0.07	1.27	0.12	4.78	0.01	0.18	0.36	6.80	0.03	1.45	-0.07	-2.68	0.23	3.10	0.06	1.58
Tr*SH*PP	-0.10	-3.81	0.10	4.01	-0.05	-0.40	0.35	7.77	0.09	3.25	-0.13	-4.02	0.02	0.57	0.00	-0.01
Tr*SP*PP	-0.11	-3.79	0.15	5.44	-0.18	-3.32	0.46	8.40	0.05	1.80	-0.07	-2.48	-0.06	-1.61	0.10	2.78
Tr*ST*PP	0.02	0.34	0.12	2.99	-0.03	-0.29	0.38	5.29	0.07	2.98	-0.07	-2.29	0.20	3.16	0.07	1.21
Tr*SA*PP	0.03	0.77	0.13	5.14	-0.18	-2.12	0.39	8.23	0.03	1.24	-0.11	-3.77	0.12	2.75	0.04	0.84
Tr*SW*PP	-0.03	-0.77	0.15	5.10	-0.14	-2.07	0.39	7.18	0.02	1.01	-0.08	-3.10	0.03	0.58	0.07	1.88
Tr*YK*PP	0.08	1.33	0.17	5.84	0.00	0.00	0.43	9.27	0.00	0.09	0.01	0.20	0.17	2.45	0.21	5.24

Table 2 (Contd.) Unrestricted model. Trend interaction by region, products and consumption levels

Regressors	ΔY = ΔML				ΔY = ΔHL				ΔY = ΔIM				ΔY = ΔIL			
	Feb. 99–Apr. 02		Jun. 02–Dec. 06		Feb. 99–Apr. 02		Jun. 02–Dec. 06		Feb. 99–Apr. 02		Jun. 02–Dec. 06		Feb. 99–Apr. 02		Jun. 02–Dec. 06	
	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat
<u>Group 3</u>																
Tr*EA*QB	-0.09	-1.83	0.10	4.54	-0.21	-3.04	0.33	7.98	0.11	2.98	-0.04	-1.32	0.19	2.92	0.09	2.55
Tr*EM*QB	-0.06	-1.24	0.09	4.28	-0.12	-1.60	0.31	7.91	0.11	3.04	-0.03	-1.02	0.20	3.29	0.10	2.73
Tr*LD*QB	-0.04	-0.78	0.13	4.38	-0.13	-1.87	0.33	7.64	0.09	3.04	-0.08	-2.55	0.18	3.14	0.07	1.65
Tr*MD*QB	-0.08	-1.80	0.11	4.46	-0.16	-2.42	0.32	7.51	0.12	2.97	0.00	-0.06	0.26	4.70	0.15	4.08
Tr*MW*QB	-0.08	-2.69	0.10	3.80	-0.19	-3.00	0.32	7.66	0.12	3.05	-0.04	-1.54	0.24	4.88	0.09	2.58
Tr*NT*QB	0.01	0.35	0.14	5.51	-0.11	-1.41	0.37	7.65	0.15	3.56	0.01	0.54	0.44	6.60	0.20	5.18
Tr*NW*QB	-0.08	-2.10	0.09	3.81	-0.23	-3.97	0.34	5.48	0.13	3.45	-0.02	-0.87	0.25	4.80	0.11	3.10
Tr*SE*QB	-0.07	-1.49	0.12	4.83	-0.15	-2.18	0.34	7.87	0.14	3.32	-0.06	-1.86	0.28	4.90	0.08	1.81
Tr*SH*QB	-0.07	-2.30	0.10	3.63	-0.16	-3.47	0.30	7.73	0.13	3.49	-0.11	-3.73	0.25	4.64	0.01	0.31
Tr*SP*QB	-0.15	-5.73	0.11	3.65	-0.20	-3.99	0.33	6.93	0.14	3.10	-0.05	-1.84	0.16	3.72	0.10	2.52
Tr*ST*QB	-0.07	-1.75	0.10	4.04	-0.16	-2.59	0.32	8.32	0.15	3.82	-0.08	-2.62	0.29	4.86	0.04	1.07
Tr*SA*QB	-0.05	-1.11	0.11	4.64	-0.16	-2.28	0.32	7.66	0.13	3.70	-0.11	-3.52	0.29	5.37	0.02	0.44
Tr*SW*QB	-0.09	-2.60	0.08	3.40	-0.19	-3.38	0.32	7.42	0.12	3.40	-0.06	-2.43	0.20	4.90	0.05	1.55
Tr*YK*QB	-0.01	-0.21	0.15	5.76	-0.08	-1.22	0.34	7.78	0.13	3.40	-0.01	-0.21	0.37	5.68	0.17	4.47
<u>Group 4</u>																
Tr*EA*DD*Low	0.05	0.87	0.01	0.58	-0.04	-0.43	0.04	0.93	-0.06	-1.77	-0.02	-0.68	-0.04	-0.71	0.00	-0.04
Tr*EM*DD*Low	0.00	0.02	0.07	2.58	-0.05	-0.37	0.10	2.15	-0.12	-3.13	-0.06	-1.77	-0.26	-3.30	-0.01	-0.21
Tr*LD*DD*Low	0.04	0.69	0.02	0.74	0.00	-0.01	0.03	0.71	-0.08	-2.36	-0.05	-1.65	-0.16	-2.05	-0.05	-1.07
Tr*MD*DD*Low	0.07	1.19	0.00	0.12	0.01	0.09	0.03	0.58	-0.13	-3.68	-0.11	-4.04	-0.19	-2.97	-0.14	-3.32
Tr*MW*DD*Low	0.02	0.36	-0.03	-1.02	-0.05	-0.52	0.00	0.08	-0.05	-1.12	-0.02	-0.92	-0.05	-0.57	-0.04	-1.65
Tr*NT*DD*Low	0.07	1.12	0.02	0.74	0.06	0.55	-0.03	-0.67	-0.07	-1.74	-0.11	-3.92	-0.01	-0.16	-0.14	-3.19
Tr*NW*DD*Low	0.04	0.64	0.01	0.61	0.03	0.32	0.06	0.67	-0.07	-2.08	-0.05	-1.33	-0.12	-1.81	-0.04	-0.83
Tr*SE*DD*Low	0.11	1.45	0.02	0.92	0.02	0.19	0.05	0.95	-0.19	-2.66	-0.05	-1.72	-0.30	-3.50	-0.04	-0.92
Tr*SH*DD*Low	-0.03	-0.63	0.01	0.46	-0.01	-0.20	0.06	1.73	0.04	1.21	0.04	1.17	0.06	1.17	0.05	1.45
Tr*SP*DD*Low	0.06	1.94	-0.03	-0.85	0.02	0.46	0.00	-0.08	-0.04	-0.89	-0.01	-0.41	0.02	0.40	-0.03	-0.71
Tr*ST*DD*Low	0.08	1.76	0.00	-0.12	0.01	0.13	0.03	0.77	-0.01	-0.22	0.01	0.29	0.14	2.11	0.01	0.36
Tr*SA*DD*Low	0.00	0.03	-0.01	-0.25	0.01	0.09	0.03	0.78	-0.03	-0.69	-0.01	-0.19	-0.06	-0.96	-0.01	-0.16
Tr*SW*DD*Low	0.05	1.49	0.03	1.64	0.00	-0.03	0.03	0.85	-0.11	-3.02	-0.05	-1.57	-0.12	-2.54	-0.04	-1.05
Tr*YK*DD*Low	0.04	0.79	0.02	0.69	-0.02	-0.19	0.03	0.64	-0.08	-2.50	-0.13	-4.33	-0.13	-2.23	-0.15	-3.62

Table 2 (Contd.) Unrestricted model. Trend interaction by region, products and consumption levels

Regressors	ΔY = ΔML				ΔY = ΔHL				ΔY = ΔIM				ΔY = ΔIL			
	Feb. 99–Apr. 02		Jun. 02–Dec. 06		Feb. 99–Apr. 02		Jun. 02–Dec. 06		Feb. 99–Apr. 02		Jun. 02–Dec. 06		Feb. 99–Apr. 02		Jun. 02–Dec. 06	
	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat
Group 5																
Tr*EA*PP*Low	-0.06	-1.02	0.00	0.06	0.05	0.51	0.07	1.12	0.01	0.32	-0.03	-0.91	-0.17	-2.34	-0.03	-0.70
Tr*EM*PP*Low	-0.08	-0.78	0.04	1.37	0.05	0.27	0.15	2.99	-0.03	-0.77	-0.05	-1.34	-0.20	-1.85	-0.04	-1.23
Tr*LD*PP*Low	-0.02	-0.25	0.01	0.25	0.03	0.29	0.02	0.29	0.00	-0.31	-0.03	-0.87	-0.07	-1.15	-0.04	-0.97
Tr*MD*PP*Low	-0.12	-2.23	0.01	0.86	0.06	0.45	-0.05	-0.94	-0.01	-0.80	-0.03	-1.64	-0.21	-3.33	-0.04	-1.11
Tr*MW*PP*Low	0.00	0.07	0.02	1.29	0.13	2.20	0.09	2.12	-0.02	-0.86	-0.01	-0.59	-0.06	-1.07	-0.01	-0.15
Tr*NT*PP*Low	-0.04	-0.69	0.00	0.18	0.01	0.08	-0.08	-1.63	-0.03	-0.83	-0.02	-0.97	-0.14	-1.80	-0.03	-1.09
Tr*NW*PP*Low	0.02	0.31	0.03	1.30	0.02	0.08	0.04	0.55	-0.02	-0.80	-0.06	-2.03	-0.06	-1.13	-0.04	-1.20
Tr*SE*PP*Low	0.05	0.58	0.03	0.90	0.17	2.22	0.08	0.88	-0.07	-1.21	-0.04	-1.16	-0.32	-4.07	-0.02	-0.51
Tr*SH*PP*Low	0.03	1.74	0.00	0.10	0.06	0.28	0.04	1.32	-0.04	-1.67	0.02	0.48	-0.04	-1.40	0.02	0.54
Tr*SP*PP*Low	0.10	2.97	0.00	0.09	0.19	4.05	0.00	0.04	-0.03	-1.55	0.00	0.10	0.06	1.87	0.00	0.00
Tr*ST*PP*Low	0.00	-0.02	0.03	0.83	0.00	-0.01	0.04	0.58	-0.01	-0.27	0.00	0.09	-0.05	-0.96	0.02	0.37
Tr*SA*PP*Low	-0.04	-1.10	0.01	0.51	0.20	2.53	0.07	1.74	-0.01	-0.81	0.01	0.21	-0.11	-2.55	0.01	0.30
Tr*SW*PP*Low	0.08	1.46	0.02	0.66	0.20	2.43	0.02	0.37	-0.03	-1.71	-0.05	-2.00	0.02	0.43	-0.05	-1.33
Tr*YK*PP*Low	-0.02	-0.25	0.00	-0.08	-0.01	-0.11	-0.06	-1.50	0.00	0.07	-0.04	-1.47	-0.03	-0.44	-0.06	-1.91
Group 6																
Tr*EA*QB*Low	-0.06	-1.05	0.07	2.49	-0.01	-0.11	0.09	1.90	-0.05	-1.72	-0.06	-1.67	-0.23	-3.05	0.00	-0.04
Tr*EM*QB*Low	-0.02	-0.30	0.09	3.29	-0.08	-0.78	0.13	3.40	-0.09	-2.83	-0.07	-2.12	-0.22	-2.84	0.00	-0.07
Tr*LD*QB*Low	-0.04	-0.81	0.05	1.60	-0.05	-0.66	0.08	1.58	-0.07	-2.27	-0.04	-1.14	-0.22	-3.89	-0.01	-0.27
Tr*MD*QB*Low	0.07	1.28	0.07	2.46	0.02	0.26	0.08	2.03	-0.17	-3.76	-0.09	-3.97	-0.30	-5.03	-0.07	-1.73
Tr*MW*QB*Low	0.01	0.23	0.01	0.38	-0.02	-0.21	0.02	0.43	-0.07	-2.60	-0.03	-1.02	-0.15	-2.54	-0.02	-0.66
Tr*NT*QB*Low	0.01	0.18	0.02	0.56	0.02	0.22	0.01	0.18	-0.04	-1.65	-0.08	-3.26	-0.03	-0.41	-0.09	-2.31
Tr*NW*QB*Low	0.01	0.14	0.05	1.96	0.06	0.81	0.10	1.17	-0.07	-2.83	-0.05	-1.44	-0.18	-2.90	-0.01	-0.19
Tr*SE*QB*Low	0.04	0.61	0.10	3.23	-0.06	-0.72	0.08	1.43	-0.12	-3.34	-0.07	-2.28	-0.21	-2.87	-0.01	-0.31
Tr*SH*QB*Low	0.00	0.05	0.03	0.90	-0.05	-0.89	0.05	1.71	-0.03	-1.04	-0.01	-0.22	-0.06	-1.22	0.01	0.25
Tr*SP*QB*Low	0.06	1.53	0.04	1.01	0.00	-0.01	0.04	0.96	-0.06	-1.67	-0.01	-0.38	-0.04	-0.91	0.01	0.45
Tr*ST*QB*Low	-0.01	-0.23	0.04	1.33	-0.04	-0.46	0.07	1.55	-0.04	-1.68	-0.02	-0.77	-0.12	-1.76	0.00	-0.07
Tr*SA*QB*Low	0.02	0.30	0.00	-0.17	-0.04	-0.51	0.05	1.53	-0.09	-2.42	-0.03	-0.95	-0.20	-3.39	-0.03	-0.69
Tr*SW*QB*Low	-0.01	-0.23	0.07	2.38	0.00	-0.03	0.08	2.05	-0.10	-3.63	-0.05	-1.87	-0.23	-4.53	0.00	-0.06
Tr*YK*QB*Low	-0.03	-0.46	0.03	1.27	-0.13	-1.50	0.07	1.89	-0.05	-2.00	-0.10	-3.59	-0.12	-1.70	-0.09	-2.14

Table 2 (Contd.) Unrestricted model. Trend interaction by region, products and consumption levels

Regressors	ΔY = ΔML				ΔY = ΔHL				ΔY = ΔIM				ΔY = ΔIL			
	Feb. 99–Apr. 02		Jun. 02–Dec. 06		Feb. 99–Apr. 02		Jun. 02–Dec. 06		Feb. 99–Apr. 02		Jun. 02–Dec. 06		Feb. 99–Apr. 02		Jun. 02–Dec. 06	
	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat
R-squared	0.17		0.28		0.14		0.22		0.18		0.23		0.22		0.25	
Adjusted R-squared	0.12		0.25		0.08		0.18		0.13		0.19		0.17		0.21	
S.E. of regression	2.70		3.26		5.47		6.22		1.84		3.45		3.14		4.84	
F-statistic [*p*-value]	3.23	[0.00]	8.35	[0.00]	2.50	[0.00]	6.02	[0.00]	3.51	[0.00]	6.34	[0.00]	4.37	0.00	6.90	0.00

Notes: The regressions include constant and five lags of the dependent variable to account for potential serial correlation; also region dummies for Eastern (EA), East MiLands (EM), London (LD), Midlands (MD), Manweb (Greater Manchester) (MW), Northern (NT), North Western (NW), South Eastern (SE), Scottish Hydro (West Scotland) (SH), Scottish Power (East Scotland) (SP), Southern (ST), South Wales (SA), South West (SW) and Yorkshire (YK); product dummies for Direct Debit (DD), Quarterly Bills (QB) and Prepayment Meter (PP); and consumption dummies for low consumption levels (L). Tr denotes a linear trend term. t-statistics are based on White heteroskedasticity-consistent variance-covariance matrix.

Table 3 – Unrestricted model. Tests of hypotheses

	Dependent variable							
	ΔML		ΔHL		ΔIM		ΔIL	
Feb. 1999 – Apr. 2002								
1. DD High (Group 1)	3.09	[0.00]	0.35	[0.98]	0.67	[0.80]	5.20	[0.00]
2. PP High (Group 2)	2.46	[0.00]	1.32	[0.20]	3.73	[0.00]	2.57	[0.00]
3. QB High (Group 3)	2.24	[0.01]	0.58	[0.87]	0.80	[0.66]	2.78	[0.00]
4. DD Low (Group 4)	0.43	[0.96]	0.10	[1.00]	1.18	[0.29]	2.40	[0.00]
5. PP Low (Group 5)	1.29	[0.21]	0.81	[0.65]	0.52	[0.91]	2.11	[0.01]
6. QB Low (Group 6)	0.49	[0.93]	0.35	[0.98]	0.97	[0.48]	1.72	[0.05]
7. DD High = PP High = QB High	1.54	[0.02]	0.67	[0.95]	1.36	[0.07]	2.95	[0.00]
8. DD Low = PP Low = QB Low	0.66	[0.95]	0.92	[0.61]	0.79	[0.82]	1.82	[0.00]
9. DD Low = PP Low = QB Low = 0	0.73	[0.90]	0.95	[0.57]	0.78	[0.84]	2.50	[0.00]
Jun. 2002 – Dec. 2006								
10. DD High (Group 1)	0.60	[0.86]	0.49	[0.93]	6.17	[0.00]	3.95	[0.00]
11. PP High (Group 2)	1.38	[0.16]	1.09	[0.36]	4.70	[0.00]	4.93	[0.00]
12. QB High (Group 3)	1.21	[0.26]	0.37	[0.98]	3.97	[0.00]	3.44	[0.00]
13. DD Low (Group 4)	0.79	[0.68]	0.44	[0.96]	2.19	[0.01]	1.97	[0.02]
14. PP Low (Group 5)	0.28	[0.99]	1.45	[0.13]	0.62	[0.84]	0.49	[0.93]
15. QB Low (Group 6)	1.20	[0.27]	0.64	[0.82]	1.12	[0.34]	0.74	[0.72]
16. DD High = PP High = QB High	1.63	[0.01]	1.21	[0.17]	3.50	[0.00]	2.92	[0.00]
17. DD Low = PP Low = QB Low	1.02	[0.44]	0.89	[0.68]	1.11	[0.30]	0.94	[0.57]
18. DD Low = PP Low = QB Low = 0	1.59	[0.01]	1.33	[0.08]	1.67	[0.00]	1.15	[0.23]

Notes: The tests of hypotheses refer to Wald tests that test whether the estimated coefficients associated to the variables within a group (as defined in Table 2) are statistically the same. In lines 9 and 18, the hypotheses refer to whether the estimated coefficients in the relevant groups are all equal to zero. The tests are reported in their F-version, with probability values in parentheses.

Table 4 – Restricted model. Trend interaction by region and product.

Regressors	ΔY = ΔML		ΔY = ΔHL		ΔY = ΔIM	
	Before	After	Before	After	Before	After
	Coeff. (t-stat)	Coeff. (t-stat)	Coeff. (t-stat)	Coeff. (t-stat)	Coeff. (t-stat)	Coeff. (t-stat)
Y(-1)	-0.27(-9.16)	-0.40 (-10.3)	-0.16 (-6.04)	-0.16 (-7.09)	-0.07 (-2.65)	-0.13 (-6.34)
NFIRMS	0.09 (1.54)	0.64 (7.03)	0.34 (3.22)	1.17 (8.04)	0.13 (3.46)	-0.34 (-2.90)
Group 1						
Tr*EA*DD	-0.11 (-3.53)	0.09 (4.27)	-0.21 (-3.70)	0.33 (8.47)	0.05 (1.87)	-0.03 (-1.11)
Tr*EM*DD	-0.09 (-2.19)	0.10 (4.77)	-0.19 (-2.83)	0.34 (8.32)	0.04 (1.45)	-0.03 (-1.32)
Tr*LD*DD	-0.05 (-1.57)	0.11 (5.15)	-0.19 (-3.31)	0.32 (8.02)	0.05 (2.25)	-0.06 (-2.37)
Tr*MD*DD	-0.07 (-2.25)	0.08 (4.06)	-0.19 (-3.56)	0.32 (8.04)	0.03 (1.33)	-0.03 (-1.36)
Tr*MW*DD	-0.09 (-2.65)	0.08 (3.85)	-0.20 (-3.54)	0.30 (7.88)	0.05 (1.50)	-0.07 (-3.20)
Tr*NT*DD	-0.01 (-0.37)	0.09 (4.53)	-0.10 (-1.67)	0.33 (8.17)	0.07 (2.23)	-0.02 (-0.73)
Tr*NW*DD	-0.10 (-2.87)	0.09 (4.36)	-0.21 (-3.93)	0.36 (6.79)	0.06 (2.03)	-0.02 (-0.76)
Tr*SE*DD	-0.07 (-1.70)	0.10 (4.73)	-0.19 (-3.26)	0.33 (8.07)	0.05 (1.43)	-0.05 (-2.15)
Tr*SH*DD	-0.04 (-1.14)	0.09 (4.04)	-0.16 (-3.29)	0.31 (8.26)	0.07 (2.37)	-0.10 (-3.76)
Tr*SP*DD	-0.10 (-3.91)	0.12 (4.79)	-0.17 (-3.55)	0.32 (7.97)	0.07 (1.89)	-0.08 (-3.51)
Tr*ST*DD	-0.08 (-3.02)	0.12 (5.07)	-0.21 (-4.11)	0.35 (8.73)	0.08 (2.93)	-0.08 (-3.08)
Tr*SA*DD	-0.05 (-1.60)	0.09 (4.19)	-0.20 (-3.92)	0.33 (8.26)	0.05 (1.65)	-0.09 (-3.82)
Tr*SW*DD	-0.11 (-4.34)	0.10 (5.20)	-0.20 (-4.29)	0.33 (8.71)	0.04 (1.54)	-0.05 (-2.13)
Tr*YK*DD	-0.05 (-1.61)	0.09 (4.28)	-0.15 (-2.56)	0.34 (8.76)	0.07 (2.40)	-0.03 (-1.29)
Group 2						
Tr*EA*PP	-0.02 (-0.66)	0.13 (5.72)	0.09 (1.34)	0.35 (7.56)	0.02 (0.80)	-0.07 (-2.43)
Tr*EM*PP	-0.01 (-0.12)	0.16 (5.86)	0.10 (1.00)	0.38 (9.00)	-0.01 (-0.51)	-0.07 (-2.25)
Tr*LD*PP	-0.02 (-0.57)	0.14 (5.37)	0.00 (-0.04)	0.34 (6.42)	0.01 (0.46)	-0.09 (-3.37)
Tr*MD*PP	-0.03 (-1.02)	0.13 (6.09)	0.01 (0.13)	0.33 (7.27)	0.01 (0.31)	-0.03 (-1.20)
Tr*MW*PP	0.03 (0.95)	0.12 (5.73)	-0.06 (-1.15)	0.39 (9.03)	0.00 (0.18)	-0.07 (-2.73)
Tr*NT*PP	0.03 (0.89)	0.15 (6.91)	-0.06(-1.05)	0.37 (7.92)	0.02 (0.98)	-0.02 (-0.91)
Tr*NW*PP	0.03 (0.86)	0.17 (6.81)	0.05 (0.53)	0.37 (7.47)	0.01 (0.59)	-0.07 (-2.56)
Tr*SE*PP	0.05 (1.26)	0.12 (4.69)	0.08 (1.13)	0.34 (6.37)	0.05 (1.40)	-0.08 (-3.11)
Tr*SH*PP	-0.08 (-3.19)	0.10 (4.36)	-0.05 (-0.51)	0.35 (8.39)	0.06 (2.46)	-0.11 (-3.71)
Tr*SP*PP	-0.06 (-2.16)	0.14 (5.36)	-0.09 (-1.66)	0.42 (9.19)	0.03 (1.29)	-0.07 (-2.62)
Tr*ST*PP	-0.01 (-0.17)	0.13 (4.82)	-0.05 (-0.68)	0.37 (6.91)	0.06 (2.45)	-0.07 (-2.52)
Tr*SA*PP	-0.01 (-0.41)	0.13 (5.43)	-0.08 (-1.40)	0.38 (9.12)	0.02 (1.09)	-0.09 (-3.41)
Tr*SW*PP	-0.01 (-0.29)	0.14 (5.43)	-0.05 (-0.80)	0.36 (7.51)	0.02 (0.77)	-0.09 (-3.41)
Tr*YK*PP	0.04 (1.14)	0.15 (5.81)	-0.02 (-0.31)	0.36 (8.33)	0.00 (-0.01)	-0.02 (-0.95)
Group 3						
Tr*EA*QB	-0.11 (-2.99)	0.13 (5.28)	-0.20 (-3.52)	0.35 (8.40)	0.04 (1.50)	-0.06 (-2.13)
Tr*EM*QB	-0.07 (-1.93)	0.13 (5.34)	-0.16 (-2.54)	0.35 (8.73)	0.02 (1.07)	-0.06 (-2.14)
Tr*LD*QB	-0.06 (-1.99)	0.15 (5.78)	-0.15 (-3.02)	0.34 (7.87)	0.03 (1.32)	-0.09 (-3.35)
Tr*MD*QB	-0.05 (-1.63)	0.13 (5.64)	-0.14 (-2.62)	0.34 (8.47)	0.00 (0.22)	-0.05 (-2.17)
Tr*MW*QB	-0.08 (-2.67)	0.10 (4.25)	-0.19 (-3.44)	0.32 (8.27)	0.03 (1.33)	-0.07 (-2.64)
Tr*NT*QB	0.00 (0.11)	0.14 (6.10)	-0.09 (-1.46)	0.34 (8.41)	0.06 (2.16)	-0.05 (-1.93)
Tr*NW*QB	-0.08 (-2.42)	0.11 (4.82)	-0.20 (-4.05)	0.37 (7.48)	0.04 (1.85)	-0.05 (-1.89)
Tr*SE*QB	-0.06 (-1.63)	0.15 (5.94)	-0.17 (-3.21)	0.35 (7.61)	0.03 (1.09)	-0.09 (-3.28)
Tr*SH*QB	-0.07 (-2.24)	0.11 (4.41)	-0.17 (-3.58)	0.32 (8.35)	0.06 (2.28)	-0.11 (-4.05)
Tr*SP*QB	-0.11 (-3.60)	0.12 (4.53)	-0.19 (-3.95)	0.35 (8.38)	0.05 (1.71)	-0.07 (-2.66)
Tr*ST*QB	-0.08 (-2.38)	0.11 (4.94)	-0.17 (-3.37)	0.33 (8.03)	0.07 (2.71)	-0.10 (-3.66)
Tr*SA*QB	-0.05 (-1.57)	0.10 (4.58)	-0.17 (-3.59)	0.32 (8.61)	0.04 (1.49)	-0.11 (-4.33)
Tr*SW*QB	-0.09 (-3.25)	0.12 (4.71)	-0.18 (-4.10)	0.34 (8.46)	0.03 (1.27)	-0.08 (-3.46)
Tr*YK*QB	-0.03 (-0.89)	0.15 (6.48)	-0.14 (-2.61)	0.35 (8.76)	0.04 (1.49)	-0.05 (-2.17)
R-squared	0.16	0.26	0.13	0.20	0.14	0.21
Adjusted R-squared	0.13	0.24	0.10	0.18	0.12	0.19
S.E. of regression	2.69	3.29	5.42	6.23	1.86	3.47
F-statistic [*p*-value]	5.57 [0.00]	13.78 [0.00]	4.42 [0.00]	10.14 [0.00]	5.05 [0.00]	10.40 [0.00]
Tests of hypotheses						
Group 1	1.29 [0.21]	0.85 [0.61]	0.40 [0.97]	0.36 [0.98]	0.80 [0.66]	3.37 [0.00]
Group 2	2.21 [0.01]	1.55 [0.09]	1.45 [0.13]	1.01 [0.44]	3.24 [0.00]	3.52 [0.00]
Group 3	1.02 [0.43]	1.40 [0.15]	0.39 [0.97]	0.41 [0.97]	1.44 [0.13]	2.38 [0.00]

Notes: The tests of hypotheses refer to Wald tests that test whether the estimated coefficients associated to the variables within a group are statistically the same. The tests are reported in their F-version, with probability values in parentheses. The variables are defined in the notes in Table 2.

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Appendix 1: Dual fuel calculations[25]

The concept of purchasing electricity and gas from the same supplier at a discount to the separate electricity and gas tariffs that would be paid was popularised by British Gas in mid-2000. It has become a very common means of purchasing energy supplies, with around 1/3 of domestic consumers now purchasing their energy requirements this way.[26] Note that the concept of an incumbent loses some significance (or becomes more ambiguous) in the case of dual fuel supplies, since to be on a dual fuel tariff means you have switched at least one product away from your incumbent supplier. Therefore, probably the most direct comparison with trends in electricity prices discussed in the main body of the paper is the trend in HL. Here, so far as direct debit tariffs (the most popular) are concerned, there is no discernable trend in prices across the period between mid-2000 and mid-2006. For standard credit, the trend if anything is upward on average. As with the results in the main text, towards the end of the period under study, British Gas' prices were moving ahead of the average, so there is a definite positive trend between gas incumbent price and average price for the dual fuel offer. The number of suppliers has a very small impact on the dual fuel market (but there has been less change over time here than in the electricity market).

[25] We are grateful to Ruben Pastor Vicedo for carrying out the analysis written up here and reported in detail in his unpublished MSc thesis at the University of Warwick.

[26] At the same time, since around 1/5 of consumers are not connected to the gas network, and since prepayment is not an option here, it is not by any means available to all.

Appendix 2. Percentage of total time periods during which a company had a tariff above (and below) the median within a region
Direct Debit and High Consumption level

Company	Time Periods	Region													
		EM	EA	LD	MW	MD	NT	NW	SH	SP	SE	ST	SA	SW	YK
Amerada	14	71 (29)	0 (100)	29 (64)	79 (7)	29 (57)	57 (21)	100 (0)	0 (100)	0 (100)	0 (64)	7 (57)	100 (0)	0 (100)	21 (43)
Amerada online	16	0 (100)	0 (100)	0 (100)	0 (100)	0 (100)	0 (100)	0 (100)	0 (100)	0 (100)	0 (100)	0 (100)	0 (100)	38 (63)	0 (100)
Atlantic	22	5 (95)	5 (95)	5 (95)	5 (95)	5 (95)	9 (73)	5 (95)	5 (95)	5 (95)	5 (95)	5 (95)	5 (95)	9 (91)	5 (95)
Basic	29	28 (72)	34 (66)	21 (76)	17 (79)	28 (72)	28 (72)	21 (72)	n/a	n/a	24 (76)	21 (76)	7 (86)	21 (79)	24 (76)
British Gas	48	46 (42)	83 (15)	67 (27)	25 (69)	69 (27)	83 (15)	81 (17)	10 (83)	15 (85)	96 (0)	65 (17)	67 (19)	75 (15)	81 (17)
Energy Supplies	13	100 (0)	100 (0)	100 (0)	100 (0)	100 (0)	100 (0)	100 (0)	100 (0)	100 (0)	85 (15)	100 (0)	100 (0)	100 (0)	100 (0)
Independent	10	10 (90)	10 (90)	0 (100)	0 (100)	10 (90)	0 (100)	10 (90)	0 (100)	0 (100)	10 (90)	0 (100)	0 (100)	0 (90)	0 (100)
London	48	92 (2)	85 (10)	92 (6)	79 (10)	77 (13)	35 (52)	79 (17)	77 (10)	52 (35)	45 (45)	67 (29)	81 (13)	100 (0)	31 (52)
London online	3	0 (100)	0 (100)	n/a	0 (100)	0 (100)	0 (100)	0 (100)	0 (100)	0 (100)	0 100	0 (100)	0 (100)	n/a	0 (100)
Manweb	48	n/a	n/a	n/a	100 (0)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Northern	48	6 (82)	59 (29)	53 (47)	35 (65)	6 (82)	100 (0)	41 (53)	53 (47)	29 (71)	0 (100)	24 (65)	53 (47)	24 (71)	0 (94)
Norweb	48	44 (50)	20 (80)	6 (94)	44 (56)	13 (88)	44 (44)	100 (0)	69 (25)	19 (81)	50 (50)	31 (69)	6 (94)	94 (6)	50 (50)
Npower	48	31 (65)	31 (65)	42 (54)	29 (71)	100 (0)	29 (71)	40 (56)	29 (67)	46 (50)	54 (44)	27 (63)	35 (63)	52 (46)	20 (73)
Powergen	48	98 (2)	96 (4)	85 (6)	75 (13)	77 (21)	92 (6)	92 (8)	72 (24)	78 (13)	60 (23)	90 (6)	71 (23)	71 (21)	83 (17)
Scottish Hydro	48	38 (45)	14 (72)	21 (59)	21 (69)	24 (41)	28 (66)	31 (59)	81 (19)	62 (24)	17 (66)	n/a	70 (20)	24 (48)	48 (41)
Scottish Power	48	6 (85)	6 (81)	42 (50)	n/a	2 (94)	2 (98)	10 (85)	66 (17)	90 (0)	21 (75)	2 (98)	0 (95)	15 (77)	10 (88)
Scottish Power online	26	0 (92)	0 (96)	8 (88)	65 (4)	0 (100)	0 (100)	0 (100)	15 (65)	81 (19)	0 (100)	4 (96)	0 (100)	0 (100)	0 (100)
Seeboard	48	54 (42)	65 (35)	35 (65)	8 (85)	0 (85)	27 (54)	27 (54)	23 (62)	12 (85)	100 (0)	73 (23)	23 (69)	5 (95)	65 (31)
Southern	48	46 (38)	19 (65)	8 (65)	0 (100)	35 (35)	31 (58)	42 (31)	n/a	23 (77)	8 (81)	94 (6)	100 (0)	4 (65)	54 (23)
Swalec	48	57 (21)	50 (43)	50 (43)	64 (36)	57 (21)	57 (36)	50 (43)	n/a	n/a	57 (29)	80 (20)	90 (8)	50 (50)	64 (21)
Sweb	48	93 (7)	79 (14)	63 (38)	36 (57)	100 (0)	57 (43)	50 (50)	n/a	n/a	71 (29)	29 (71)	7 (64)	96 (0)	36 (64)
TXU	48	100 (0)	98 (2)	96 (4)	92 (4)	100 (0)	92 (8)	80 (20)	50 (46)	88 (8)	96 (4)	96 (4)	81 (15)	88 (8)	100 (0)
Utility Link	7	14 (86)	14 (86)	14 (86)	14 (86)	14 (86)	14 (86)	14 (86)	n/a	n/a	14 (86)	14 (86)	14 (86)	14 (86)	14 (86)
Yorkshire	48	40 (60)	93 (7)	93 (7)	60 (27)	73 (27)	67 (33)	7 (93)	100 (0)	87 (7)	93 (7)	47 (27)	93 (7)	93 (7)	100 (0)

Notes: The following acronyms are used to identify the different regions: Eastern (EA), East Midlands (EM), London (LD), Midlands (MD), Manweb (Greater Manchester) (MW), Northern (NT), North Western (NW), South Eastern (SE), Scottish Hydro (West Scotland) (SH), Scottish Power (East Scotland) (SP), Southern (ST), South Wales (SA), South West (SW) and Yorkshire (YK). The percentages of total time above (and below) the median tariff may not add up to 100% in those cases when a company's tariff is exactly equal to the median. The figures in the second column indicate the number of time periods when a company has been operating in at least of the regions.

Appendix 3. Implementation of the search model simulations

The search model simulations reported in Figures 6 and 7 were implemented using the computer software EVIEWS and are based on a MATLAB code which was kindly provided to the authors by Matthijs Wildenbeest; for a detailed description of the estimation of a sequential search model the interested reader is referred to Wildenbeest (2007, ch.5). In the simulations we assume that there is one incumbent firm, and N entrants. The incumbent firm has a proportion λ of customers, while all entrants together have the remaining $(1-\lambda)$ of customers; specifically, λ is assumed to take the values of 1, 0.5 and 0. Switching costs are zero, but some consumers do not switch either because their search costs are such that given the local price they are facing it is not profitable to start searching, or because they do not find a price lower than their local price. Consumers' valuation of the good is equal to $v=100$. The common marginal cost of producing this good is $r=50$. Consumers are characterised by their search costs, which are random draws from a distribution $G(c)$ with density $g(c)$, $c \in \mathbb{R}^+$. In particular, we assume that $G(c)$ follows a log-normal distribution with mean equal to 1 and variance equal to 4; simulations for other parameter values of the mean and variance were also undertaken and the findings were qualitatively similar. Let $H(\hat{p})$ denote the gains from searching after a consumer has observed a price $\hat{p}$, i.e.,

$$H(\hat{p},F)=\int_{\underline{p}}^{\hat{p}} F(p)\,dp\ ,$$

where $F(p)$ denotes the distribution of prices. The reservation price $\rho(c;F)$ of a consumer is defined as the price at which the gains from searching one more time are equal to the cost of searching one more time; that is, $\rho(c;F)$ is the solution to

$$H(\rho;F)-c=0\,.$$

Assuming the incumbent firm sets a price equal to v, then profits of the entrants are given by:

$$\pi_E(p) = (p-r)\left[\underbrace{\frac{1-\lambda}{N}\left(1-G\left(H(p)\right)\right)}_{\text{Locals accepting current price}} + \underbrace{\frac{1-\lambda}{N}\int_{H(p)}^{H(\bar{p})}\sum_{k=1}^{N-1}\left(1-F\left(\rho(c,F)\right)\right)^{k} g(c)\,dc}_{\text{Switchers from other entrants}}\right.$$

$$\left. + \underbrace{\frac{\lambda}{N}\int_{H(p)}^{v-E[p]}\sum_{k=1}^{N}\left(1-F\left(\rho(c,F)\right)\right)^{k-1} g(c)\,dc}_{\text{Switchers from incumbent}} + \underbrace{G\left(H(p)\right)\left(1-F(p)\right)^{N-1}}_{\text{Consumers with lower } \rho \text{ if lowest price}}\right]$$

In order to estimate the search cost distribution, let us assume that we have a data set with $M = 100$ different prices, which are sorted in ascending order $p_1 < p_2 < \ldots < p_M$. These prices can be used to estimate $F(p)$ non-parametrically by the empirical distribution function, i.e.

$$\tilde{F}(p) = \frac{1}{M}\sum_{i=1}^{M}\mathbf{I}(p_i < p)$$

where $\mathbf{I}$ is an indicator function.

Following Wildenbeest (2007), the differences between subsequent values of the search cost cumulative distribution function, denoted by γ_j, can be calculated as $\gamma_j = G\left(H\left(p_{j+1}\right)\right) - G\left(H\left(p_j\right)\right)$. The estimated values of γ_j in combination with the values of the search cost c_j then form a nonparametric estimate of the search cost distribution function $G(c)$. Thence, given marginal cost r, maximum price $\bar{p}$, number of firms N, search cost distribution function $G(c)$, and M initial search cost values c_j, equilibrium prices can be calculated as:

$$p_i = \frac{(\bar{p}-r)\gamma_M}{N\left(1-\sum_{j=i}^{M}\gamma_j\right)\left(1-\tilde{F}(p_i)\right)^{N-1} + \sum_{j=i}^{M}\gamma_j\sum_{k=1}^{N}\left(1-\tilde{F}(p_j)\right)^{k-1}} + r\,.$$