Dual Fuel Competition in the British Energy Retail Markets

Richard Green*

University of Hull Business School
University of Hull
Hull HU6 7RX

Tel: 01482 465720
Fax: 01482 466216
Email: R.J.Green@hull.ac.uk

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Abstract
This paper studies interaction between companies selling both gas and electricity to households in Great Britain. British Gas is the former monopoly in the gas market, while five companies now own the former regional electricity monopolies. Switching costs give these incumbents a degree of market power. The paper models competition between these companies, and shows that the incumbents retain large market shares despite charging higher prices than their rivals.

Keywords: Electricity prices, retail competition, gas – electricity interactions
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1. Introduction

For the past five years, all British households have been able to choose which company they buy their gas or electricity from. Full retail competition was part of the plan for the electricity restructuring implemented in 1990, with an original target date of April 1, 1998. Delays in producing the IT systems required, and the desire to phase in the market opening over time, meant that the first households did not get a choice until September 1998, and the last in May 1999. Full retail competition in gas was not adopted as a policy until 1993, but the pilot scheme began in April 1996, and the whole country[1] was open to competition by April 1998.

In 1994, all domestic customers bought their gas from British Gas, and their electricity from their local Public Electricity Supplier. There were fourteen of these regional monopolies: the twelve former Area Electricity Boards in England and Wales, and two vertically integrated companies in Scotland. At the time of writing, these companies have an average market share of roughly three-fifths in their home areas (with some regional variation), and approximately half of households have switched supplier at least once – some have switched away, and then back to their local incumbent. In the regulator's view, this degree of switching compares well with a number of other markets where customers normally buy from a single company at a time, such as banking, telecoms and insurance.

Electricity and gas are homogeneous products, and changing supplier does not mean that you change the company that delivers the product – that is still the task of a regulated network company. While some companies offer special features such as air miles or green electricity, it seems natural that competition would mostly be based upon price. The Bertrand model does not seem to apply, however – the former monopolies (the incumbents) are significantly more expensive than their rivals in nearly every market segment. These price differentials give a motivation for switching, although the number of consumers who manage to switch to a more expensive supplier[2] shows that (actual) differentials cannot be the only motivation.

Another possible motivation is the convenience from buying both gas and electricity from the same company, and receiving a single bill. Ofgem (2004, p. 160)

[1] The subject of this paper is the energy market in Great Britain (England, Scotland and Wales), as Northern Ireland has no retail competition in electricity, and very few gas customers.
[2] Waddams Price (2004) shows that almost 40% of low-income customers who had switched supplier in 2000 had moved to a more expensive tariff than they were receiving from their previous supplier.

reports that 80 per cent of consumers who switch move on to a "dual fuel" deal. British Gas is now the largest supplier in the household electricity market, while the incumbents in electricity are the only other companies with large market shares in gas. While Ofgem does not publish the relevant regional data, intuition surely implies that they will have their largest shares of the gas market in the areas where they are the electricity incumbent. Typically, a company will stress the low price it can offer for its non-traditional fuel, while avoiding the subject of the high price it is still charging as an incumbent. The low price in the non-traditional market may not leave much of a profit margin (which is not to say that it is actually predatory), but has the great advantage of helping to retain customers in the traditional market, where margins remain much higher.

Despite the importance of the interactions between gas and electricity, and an increasing literature on the British retail markets, I am not aware of any academic work which studies dual fuel competition. This paper is an attempt to fill that gap. The next section gives more information on the market, and on the academic literature to date. Section 3 outlines a simple duopoly model, to illustrate the key trade-offs in a tractable model with analytical solutions. Section 4 moves to a more complicated model without analytical solutions, which nevertheless shows the interaction of incumbents and entrants across several markets. Section 5 compares the predictions of the models with data from the markets. Section 6 concludes.

2. Overview of the markets

There are 24 million household electricity customers in Great Britain, and 21 million gas customers – many households in rural areas, and some in towns, are not connected to the gas mains. The gas and electricity industries started in the nineteenth century with a mix of private and municipal ownership, and were nationalised in 1949 and 1948 respectively. In both cases, distribution and sales were organised on a local basis, with fourteen Area Electricity Boards and twelve Area Gas Boards. The British Gas Corporation was formed in 1972 to oversee the task of converting the country from coal gas to natural gas, and the Area Gas Boards lost their separate identities.

British Gas was privatised in 1986, with relatively light regulation, and (notional) competition to sell gas to large customers. This competition proved ineffective, since British Gas could set both prices to customers and the transmission charge any rival would have to pay it in order to compete with it. Pressure from the

Office of Fair Trading and an inquiry by the Monopolies and Mergers Commission made competition in the industrial market more effective, but the need to set a price control for gas transmission and distribution led to a second MMC inquiry in 1992-93. This inquiry recommended that British Gas should be split into a pipeline company and a retailing company, in order to ensure a level playing field for other retailers, and that once the split had taken effect, competition should be introduced in retailing to households. The government decided to introduce household competition on a faster timetable than that recommended by the MMC, and not to split up British Gas, in case this delayed competition. In practice, British Gas chose to split itself in two shortly afterwards. BG plc owned the pipelines[3] and most of the exploration and production assets, trading abroad as British Gas, while Centrica plc took over the supply business, trading in the UK as British Gas. From this point onward, I will use "British Gas" to refer to Centrica.

Supply competition started with a pilot scheme in the southwest of England in April 1996. It was gradually extended to the rest of the country during 1997 and 1998, so that every gas customer was able to choose their supplier by May 1998. From the earliest days, the most effective competitor to British Gas appeared to be the local electricity company in each region, which was a cause of some tension, given that the electricity market was not yet open to competition.

The electricity industry was privatised after the gas industry. The area boards, now known as Regional Electricity Companies (RECs) were privatised in 1990, while two large generators, National Power and PowerGen, and two Scottish companies were sold in 1991. Partly in response to the problems that had followed gas privatisation, the electricity scheme had split transmission from the rest of the industry, introduced explicit regulation for distribution network charges, and set a timetable for introducing full competition in supply. The first phase of market opening, for large industrial customers, was relatively smooth, but the second phase, for medium-sized customers, was a fiasco. Customers were allowed to change supplier before they had the necessary metering and communications equipment in place and registered, and many therefore received incorrect bills. It was clear that the industry had not had an appropriate forum to design systems that would work, given the number of companies that expected to lose from the introduction of competition.

[3] These were subsequently also split off, and are now owned, together with the electricity transmission grid, by National Grid Transco.

To prevent a similar fiasco when the markets were opened to domestic customers, the regulator took control of a large-scale program that was to cost about £¾ billion. To ensure that the IT systems could cope, each company would open its market in stages over six months, starting with an area containing ten per cent of its customers (based on post codes (zip codes), so that the boundaries would be clear to all). None of the companies' IT systems were ready in time (there were rumours that some companies had expected the Labour government elected in 1997 to stop the program, and had delayed spending money accordingly). The first markets were opened in September 1998, and the final ones in May 1999.

By that time, the industry's corporate structure was starting to change. Scottish Power had bought Manweb, one of the RECs, in 1995. Hydro-Electric merged with Southern Electric in 1998, forming Scottish and Southern Electricity. National Power and PowerGen had tried to merge with RECs in 1995, and were blocked by the government, but were allowed to do so in 1999. Eastern Electricity, later known as TXU after its takeover by a US firm, had integrated into generation and bought the supply business of Norweb. Scottish and Southern bought Swalec, the supply business serving the south of Wales. Electricité de France bought London Electricity, then the SWEB supply business from the south-west of England, then Seeboard. National Power split itself into two, with the predominantly UK-based business taking the name Innogy and trading as npower. Innogy later took over two more REC supply businesses, Northern and Yorkshire. Innogy was itself taken over by RWE of Germany, while PowerGen was taken over by E.On. Finally, PowerGen took over the supply businesses and power stations owned by TXU, when the US parent withdrew from most of its European operations. Table 1 summarises these amalgamations, while figure 1 shows the areas concerned.

Table 1: Native customer numbers, by area and company

Name now	Area(s)	Native Customers (million)			
		1994	1999	2001	2003
British Gas	All GB	21	21	21	21
EdF Energy	Exporter to GB	0	1.8	3.0	4.8
	London	1.8			
	SWEB	1.2	1.2		
	Seeboard	1.8	1.8	1.8	
PowerGen	Generator	0	2.1	2.1	7.0
	E Midlands	2.1			
	Eastern	2.9	2.9	4.9	
	Norweb	2.0	2.0		
npower	Generator	0	2.0	3.9	5.3
	Midlands	2.0			
	Yorkshire	1.9	1.9		
	Northern	1.4	1.4	1.4	
Scottish and Southern Energy	Southern	2.4	3.0	3.9	3.9
	Scottish Hydro	0.6			
	Swalec	0.9	0.9		
Scottish Power	S Scotland	1.6	2.8	2.8	2.8
	Manweb	1.2			

Source: Ofgem (2004). Note that the figures reflect mergers, but not growth in total customer numbers over time.

Once their markets opened, the incumbents in both industries started to lose customers. Their prices were initially regulated, with price caps set in relation to their average costs. In both industries, the companies had entered into long-term wholesale purchase contracts at prices above those subsequently ruling, and so it was easy for competitors to undercut them on the basis of current wholesale prices. In the electricity industry, the most important competitor was British Gas, while in the gas industry, the most important competitor in each region was the incumbent electricity company. Regional market shares are not published, however, and so table 2 can only

give market shares for a typical electricity region on the basis of figures for the incumbents' shares in their own regions, and British Gas' share of the market as a whole.

Table 2: Market shares in a region, based on GB averages

Industry	Type of company	Market share			
		1994	Sep 1999	Sep 2001	Dec 2003
Gas	British Gas	100	75	67	61
	All entrants	0	25	33	39
Electricity	Incumbent	100	90	70	59
	British Gas	0	10	17	24
	All other entrants	0		13	17

Source: Ofgem (2004)

On this basis, the market still appears to be very concentrated, while the national market shares in table 3 and 4 imply a much more fragmented market structure.

Table 3: National market shares in household gas supply

Name now	Former company	Market share (per cent)			
		1994	Sep 1999	Sep 2001	Dec 2003
British Gas	British Gas	100	75	67	61
EdF Energy	EdF	0	n/a	2	5
	London	0			
	SWEB	0	n/a		
	Seeboard	0	n/a	2	
PowerGen	PowerGen	0	n/a	4	12
	E Midlands	0			
	Eastern	0	3	6	
	Norweb	0	2		
npower	National Power	0	n/a	6	9
	Midlands	0			
	Yorkshire	0	n/a		
	Northern	0	n/a	2	
Scottish and Southern Energy	Southern	0	3	5	7
	Scottish Hydro	0			
	Swalec	0	1		
Scottish Power	Scottish Power	0	n/a	5	6
	Manweb	0			
All others		0	n/a	1	1

a = too small to be separately reported by Ofgem, included in “all others”

Source: Ofgem (2004) for British Gas; various Ofgem merger consultations

Table 4: National market shares in household electricity supply

Name now	Former company	Market share (per cent)		
		1994	Sep 2001	Dec 2003
British Gas	British Gas	0	17	24
EdF Energy	EdF	0	10	14
	London	8		
	SWEB	5		
	Seeboard	8	6	
PowerGen	PowerGen	0	8	21
	E Midlands	9		
	Eastern	12	15	
	Norweb	9		
npower	National Power	0	14	15
	Midlands	8		
	Yorkshire	8		
	Northern	6	5	
Scottish and Southern Energy	Southern	10	14	14
	Scottish Hydro	2		
	Swalec	4		
Scottish Power	Scottish Power	7	10	11
	Manweb	5		
All others		0	1	1

Source: Ofgem (2004) and author's estimates

Table 5: National market shares in household energy supply, December 2003

Company	Gas		Electricity		
	As the Incumbent	As an Entrant	As the Incumbent	As an Entrant	Total
British Gas	61	0	0	24	24
EdF Energy	0	5	12	2	14
Npower	0	9	12	3	15
PowerGen	0	12	16	5	21
Scottish & Southern	0	7	11	3	14
Scottish Power	0	6	7	4	11
All others	0	1	0	1	1
All companies	61	40	58	42	100

Source: Author's estimates from Ofgem data

Table 5 breaks down these national market shares into the customers which a company supplies as an incumbent, and those supplied as an entrant: the former electricity incumbents have been far less successful than British Gas in attracting electricity consumers from outside their traditional areas, individually, and even as a group. It is not possible to break down the second column of the table to divide the electricity companies' gas customers into those living where the company is the electricity incumbent, and those where the company is an entrant for both fuels. It would be surprising, however, if the electricity companies did not find most of their gas customers in the areas in which they are incumbents.

There has been a substantial amount of academic work on the UK residential energy markets, although almost all of it looks either at gas or at electricity, rather than taking a dual fuel perspective. Furthermore, there has been little work on market shares, and most authors concentrate on the pattern of prices and of discounts, relative to incumbents, and the switching costs that may explain these.

Otero and Waddams Price (2001) explored the pattern of prices across payment types shortly after the electricity market was opened to competition. Entrants generally undercut incumbents' direct debit tariffs, but were (on average) more expensive for prepayment customers. In many cases, of course, an entrant in one region is an incumbent elsewhere, and these companies' prepayment tariffs were

closer to their direct debit tariffs where they were incumbents than where they were entrants. Otero and Waddams Price suggest that this is due to price discrimination, and in particular to political pressure to keep prepayment tariffs down, relative to the costs involved in serving prepayment customers. Entrants were unwilling to compete hard for prepayment customers at those price levels, and while they were offering better prices for direct debit customers, customer inertia allowed the incumbents to retain high market shares despite higher prices.

Salies and Waddams Price (2004) show that incumbents continued to charge higher prices for direct debit and standard credit customers in 2002, while their charges for prepayment customers were not significantly different from entrants' charges. Regional differences in transmission and distribution costs were translated almost one-for-one into the tariffs for direct debit and standard credit customers, while the relationship between these costs and prepayment charges was much weaker. Salies and Waddams Price interpret this as reflecting weaker competition in the prepayment sector.

Giulietti et al (2004) show that electricity prices remained dispersed, and customers were able to gain from switching to a new supplier, several years after the markets were opened to competition. They suggest that this shows that consumers still have significant switching costs.

Giulietti et al (2003) assess the extent of switching costs in the gas industry, and the factors affecting them. They show that British Gas could increase its prices significantly relative to entrants' prices (and its costs) while still retaining many of its customers, and that to do so would be profit maximising. They calculate what this implies for social welfare, given the gains to consumers who switch, the losses to those who do not, and the costs that companies incur in persuading consumers to switch. Overall, several of their scenarios imply that gas competition has reduced welfare. Their estimates of the profit-maximising mark-ups are similar to those of Green (2000), who uses a calibrated theoretical model to calculate electricity companies' best responses to utility-maximising customers with switching costs.

Sturluson (2003) differentiates between search and switching costs, and estimates both empirically for Swedish data. He also shows how these conceptually different costs can have different impacts upon companies.

While all of these papers are based on utility-maximising, rational, consumers, Waddams Price (2004) shows that, remarkably, many among a sample of low-income

customers from 2000 who had switched had actually made themselves worse off, paying more after they switched to a new supplier than they would have done, had they stayed with their former supplier. While some consumers may have switched to a supplier that was cheaper at the time that the decision was made, but had subsequently raised its prices, twenty four out of thirty nine gas customers who had just arranged to switch suppliers were making themselves worse off, as were twelve out of twenty nine electricity customers. At the very least, these results imply that we should expect to find that non-price factors are important in consumers' decisions about energy suppliers.

None of these papers considers the role of "dual fuel" competition, in which customers buy gas and electricity from the same supplier. Such competition has steadily grown in importance, however, and Ofgem now estimate that 80 per cent of switching consumers do so with a dual fuel deal – either buying a second fuel from a company that already supplies them, or buying both fuels from the same (new) company. British Gas' success in electricity supply has been driven by the company's ability to sell power to its existing customers, while table 5 reveals how (relatively) unsuccessful the electricity companies have been in selling electricity to customers in other areas. While the data are not published, it seems obvious that their much greater success in the gas market must come from the same kind of cross-selling. The effects of such cross-selling on consumer choices and company behaviour are the subject of this paper.

3. A simple model

We will start to explore the impact of gas-electricity interactions with a deliberately simple model, which gives analytical solutions. We will assume that there are only two active companies in any given region – British Gas and the electricity incumbent. Normalising the size of the population to one, a proportion of consumers, α, buy just one unit of electricity, while $(1-\alpha)$ buy both γ units of gas and one unit of electricity. (There are no gas-only customers.)

The electricity company's price for electricity is p_e. British Gas' price for gas is p_g. The electricity company sells gas at a price of p_g^e, while British Gas sells electricity at a price of p_e^g. The subscript refers to the product, the superscript (where

present) to the main product of the selling company. The companies' marginal costs of gas and electricity are given (in the same order) by c_e, c_g, c_g^e and c_e^g. With a liquid wholesale market and common carriage on the networks, we would expect the cost of actually serving the customer with a given product to be very nearly the same for both companies, but the cost of acquiring a customer is likely to make the entrant's overall cost higher than the incumbent's in each industry. We treat the customer, rather than the kWh, as the marginal unit, and so it is appropriate to treat these acquisition costs as marginal.

While gas and electricity are homogeneous products, we move away from pure price competition by assuming that each customer has a relative preference between British Gas and the electricity company – this may reflect their past experience with the two companies, or the effectiveness of the companies' marketing and advertising activities. We will model this as a variable β, which reflects the relative preference for British Gas, uniformly distributed on [–1, +1]. A consumer who switches one of their fuel supplies to British Gas will add β to their utility, while a consumer who switches to the electricity company will subtract β from their utility. (If they prefer the electricity company, of course, their value of β will be negative, and so this will raise their utility.) A customer who buys both fuels and switches one of them incurs a switching cost of s. A customer who buys only electricity and switches to British Gas incurs a switching cost of $t \geq s$. Their switching cost may be larger because they will be moving to a company that they may not have dealt with before; β is now a measure of the customer's attitude to the electricity company, and to advertising by British Gas, rather than to the company's past performance in serving this particular customer.

A customer who buys both gas and electricity will have the following utility:

$$\begin{array}{ll} v - \gamma p_g - p_e & \text{if they buy both products from the incumbent suppliers} \\ v - \gamma p_g - p_e^g + \beta - s & \text{if they buy both products from British Gas} \\ v - \gamma p_g^e - p_e - \beta - s & \text{if they buy both products from the electricity company} \end{array} \quad (1)$$

Simple utility maximisation implies that the electricity company will sell both gas and electricity to customers with values of $\beta \leq \gamma\left(p_g - p_g^e\right) - s$, that British Gas will sell both fuels to customers with values of $\beta \geq s - \left(p_e - p_e^g\right)$, and that customers with

intermediate values will buy gas from British Gas and electricity from the electricity company.

A customer who buys only electricity will have the following utility:

$$\begin{array}{ll} v - p_e & \text{if they buy from the electricity company} \\ v - p_e^g + \beta - t & \text{if they buy from British Gas} \end{array} \qquad (2)$$

In this case, British Gas will attract customers with values of $\beta \geq t - \left(p_e - p_e^g\right)$. Aggregating across both types of customer, we get the following sales figures:

$$\begin{array}{ll} \text{The electricity company sells:} & \\ q_e = \dfrac{(1-\alpha)\left[1+s-\left(p_e - p_e^g\right)\right] + \alpha\left[1+t-\left(p_e - p_e^g\right)\right]}{2} & \text{units of electricity and} \\ q_g^e = \dfrac{\gamma(1-\alpha)\left[1-s+\gamma\left(p_g - p_g^e\right)\right]}{2} & \text{units of gas} \\ \text{British Gas sells:} & \\ q_e^g = \dfrac{(1-\alpha)\left[1-s+\left(p_e - p_e^g\right)\right] + \alpha\left[1-t+\left(p_e - p_e^g\right)\right]}{2} & \text{units of electricity and} \\ q_g = \dfrac{\gamma(1-\alpha)\left[1+s-\gamma\left(p_g - p_g^e\right)\right]}{2} & \text{units of gas} \end{array} \qquad (3)$$

This set-up gives us convenient demand curves, which are linear in the two companies' prices for the fuel. There are no cross-fuel effects, however. The model in the next section allows for the possibility that British Gas (for example) might cut the price of electricity in order to retain more gas customers. Adding a sub-group of consumers who have no switching costs would change the demand curves so that the quantity of each fuel depended upon all four prices. In equilibrium, however, this changes the level of prices, but not the pattern of price differentials, which only depend upon the parameters specific to each market. While we could add other complicating factors (such as a non-uniform distribution of β) to get a richer pattern of price differentials, it is better to stick with the simpler model for the present section.

British Gas' profits are given by $\pi_g = \left(p_g - c_g\right)q_g + \left(p_e^g - c_e^g\right)q_e^g$, while the electricity company's profits are given by $\pi_e = \left(p_e - c_e\right)q_e + \left(p_g^e - c_g^e\right)q_g^e$. If we differentiate with respect to each price in turn, we get reaction functions:

$$p_e = \frac{1 + p_e^g + c_e}{2} + \frac{(1-\alpha)s + \alpha t}{2} \text{ and } p_g^e = \frac{1 - s + \gamma\left(p_g + c_g^e\right)}{2\gamma} \text{ for the electricity company,}$$

$$\text{and } p_e^g = \frac{1 + p_e + c_e^g}{2} - \frac{(1-\alpha)s + \alpha t}{2} \text{ and } p_g = \frac{1 + s + \gamma\left(p_g^e + c_g\right)}{2\gamma} \text{ for British Gas} \qquad (4)$$

We can combine the reaction functions and solve to get:

$$p_e = 1 + \frac{2c_e + c_e^g}{3} + \frac{(1-\alpha)s + \alpha t}{3} \text{ and } p_e^g = 1 + \frac{2c_e^g + c_e}{3} - \frac{(1-\alpha)s + \alpha t}{3} \text{ for electricity,}$$

$$\text{and } p_g = \frac{1}{\gamma} + \frac{2c_g + c_g^e}{3} + \frac{s}{3\gamma} \text{ and } p_g^e = \frac{1}{\gamma} + \frac{2c_g^e + c_g}{3} - \frac{s}{3\gamma} \text{ for gas} \qquad (5)$$

We thus find that the price differentials depend upon the differences in cost between the entrant and the incumbent, and the average switching cost in each market:

$$\begin{aligned} p_e - p_e^g &= \frac{2}{3}\left(s + \alpha(t-s)\right) - \frac{c_e^g - c_e}{3} && \text{for electricity, and} \\ p_g - p_g^e &= \frac{2s}{3\gamma} - \frac{c_g^e - c_g}{3} && \text{for gas} \end{aligned} \qquad (6)$$

Note that the amount of gas bought relative to electricity enters into equation (6), but is basically a scaling factor – the difference in gas bills (as opposed to prices) will equal one third of the difference in costs, plus two-thirds of the switching cost for that market, just as in electricity. As argued above, the entrants are likely to have higher marginal costs than the incumbents, once we include customer acquisition costs, and so the equations are written to make the final fractions positive. From equation (6), we can derive quantities for each firm:

The electricity company sells :

$$q_e = \frac{1}{2}\left[1 + \frac{\left(c_e^g - c_e\right)}{3} + \frac{(1-\alpha)s + \alpha t}{3}\right] \quad \text{units of electricity and}$$

$$q_g^e = \frac{\gamma(1-\alpha)}{2}\left[1 - \frac{\gamma\left(c_g^e - c_g\right)}{3} - \frac{s}{3}\right] \quad \text{units of gas} \qquad (7)$$

British Gas sells :

$$q_e^g = \frac{1}{2}\left[1 - \frac{\left(c_e^g - c_e\right)}{3} - \frac{(1-\alpha)s + \alpha t}{3}\right] \quad \text{units of electricity and}$$

$$q_g = \frac{\gamma(1-\alpha)}{2}\left[1 + \frac{\gamma\left(c_g^e - c_g\right)}{3} + \frac{s}{3}\right] \quad \text{units of gas}$$

The results of the model can be summed up in

Proposition 1:

An increase in the level of switching costs for consumers taking both fuels will raise the incumbents' prices and market shares, and reduce the entrants' prices and market shares. An increase in the level of switching costs for customers taking only electricity will raise the electricity company's price and market share in electricity (and reduce those of British Gas). An increase in the proportion of customers taking only electricity will raise the electricity company's price and market share in electricity. An increase in the incumbent's costs will raise both companies' prices and reduce the incumbent's market share. An increase in the entrant's costs will raise both companies' prices and increase the incumbent's market share. An increase in the cost differential between the two companies in either market (assuming the incumbent to have the lower costs) will reduce the price differential between them, and raise the incumbent's market share.

Proof: From inspection, or differentiation, of equations (5) to (7).

This model was deliberately kept simple, but shows the key role played by consumers' switching costs (real or perceived) and cost differences between companies. The ratio of gas to electricity consumers varies across Great Britain, and this will allow us to test proposition 1 in the penultimate section of the paper. First, however, we will move to a less simplified model of the markets, but one that does not allow for analytical solutions.

4. A numerical model

The model of section 3 was kept simple, to ensure analytical solutions, but only included two companies. While British Gas and the incumbent electricity company typically serve around three-quarters of the households in each region, and the other companies' individual market shares are much smaller, their collective market share is sufficient to justify building a model that includes them. In this section of the paper, we use a logit model of consumer choice to explore how prices and market shares vary with switching costs and other market characteristics.

We follow Besanko et al's (1990) derivation of the logit model, but assume that there is no "outside option" – all consumers will buy energy from the suppliers that we model. We assume that there are *m* companies, and that number 1 is the electricity incumbent. The consumers' utilities are similar to those given by equations (1) and (2), in that consumer *i* receives a utility of $v - p_k^d - s_k^d + \eta_k^{di}$ if she buys electricity and gas from company *k*, where *v* is a common symmetric value gained when buying energy from any of the companies, p_k^d is company *k*'s dual-fuel price for gas and electricity combined, s_k^d is the cost (to any consumer) of switching to company *k*, and η_k^{di} is a consumer- and company-specific valuation of buying from company *k*. If the consumer buys both fuels separately from the incumbents, however, her utility will be $v - p_1^e - p_g + \eta_0^{di}$, where p_1^e is the incumbent electricity company's price for electricity alone, p_g is British Gas' price for gas alone, and η_0^{di} is the customer-specific valuation of buying from the two incumbents. In this case, of course, no switching costs are incurred.

For customers who only purchase electricity (which is an exogenous decision, as all customers connected to the gas mains are assumed to buy gas), the utility from buying from the incumbent is given by $v - p_1^e + \eta_1^{ei}$ where η_1^{ei} is the utility from buying electricity (alone) from the incumbent. A customer who buys electricity from an entrant, *k*, receives a utility of $v - p_k^e - s_k^e + \eta_k^{ei}$, where p_k^e is that company's price for electricity, s_k^e is the cost of switching to that company for electricity alone, and η_k^{ei} is the idiosyncratic valuation of buying electricity from that company.

We assume that the idiosyncratic valuations are identically and independently distributed according to a type-1 extreme value distribution. This has location parameter zero and scale parameter θ. The distribution and density functions are given by

$$\begin{aligned} F(x) &= \exp\left\{-e^{-x/\theta}\right\} \\ f(x) &= \theta^{-1}e^{-x/\theta}F(x) \end{aligned} \tag{8}$$

Besanko *et al* interpret θ as a measure of diversity, or the extent to which consumers' idiosyncratic valuations affect their purchase decisions. With a low value of θ, consumers place relatively little weight on company-specific factors, and more weight on price and switching cost. A high value of θ corresponds to a case in which company-specific factors are important.

In this application, it makes more sense to think of θ as a measure of the effectiveness of marketing and sales campaigns in reducing consumers' switching costs. When we calibrate the model, the best match to the data for 2003 comes from setting relatively high levels of switching costs – so high that no consumer would switch on price savings alone. If we interpret θ as a measure of the companies' ability to reduce these switching costs (typically by contacting customers with details of the savings on offer), then we will find that in areas with high values of θ, customers are more responsive to such contacts, and more switching takes place.

Returning to the details of the model, each consumer will choose to buy from the company that offers her the greatest level of utility, taking price, switching cost, and idiosyncratic component together. Following Besanko *et al*, market shares of dual-fuel customers are

$$\begin{aligned} x_k^d(\mathbf{p},m) &= \exp\left\{\left(v - p_k^d - s_k^d\right)/\theta\right\}/D \qquad \text{for customers who switch} \\ x_0^d(\mathbf{p},m) &= \exp\left\{\left(v - p_1^e - p_g\right)/\theta\right\}/D \qquad \text{for customers who stay with both incumbents} \end{aligned}$$

where (9)

$$D = \sum_{k=1}^{m} \exp\left\{\left(v - p_k^d - s_k^d\right)/\theta\right\} + \exp\left\{\left(v - p_1^e - p_g\right)/\theta\right\}$$

The market shares of electricity-only customers are given by

$$x_k^e(\mathbf{p},m) = \exp\left\{\left(v - p_k^e - s_k^e\right)/\theta\right\}/E \qquad \text{for customers who switch}$$
$$x_1^e(\mathbf{p},m) = \exp\left\{\left(v - p_1^e\right)/\theta\right\}/E \qquad \text{for customers who stay with the incumbent}$$

where (10)

$$E = \sum_{k=2}^{m} \exp\left\{\left(v - p_k^e - s_k^e\right)/\theta\right\} + \exp\left\{\left(v - p_1^e\right)/\theta\right\}$$

Given the size of each market, and the variable costs of supply, it is straightforward to write down the profit functions for each firm:

$$\pi_1 = \left[p_1^d - \left(c^e + c^g\right)\right]x_1^d(\mathbf{p},m)(1-\alpha) + \left[p_1^e - c^e\right]\left(x_0^d(\mathbf{p},m)(1-\alpha) + x_1^e(\mathbf{p},m)\alpha\right) \tag{11}$$

The incumbent electricity company earns the difference between its dual-fuel price and the cost of supplying two fuels, on its share of the dual-fuel customers; together with the difference between its electricity-only price and cost, on the customers who take both fuels and do not switch, and its share of the electricity-only customers.

$$\pi_g = \left[p_g^d - \left(c^e + c^g\right)\right]x_g^d(\mathbf{p},m)(1-\alpha) + \left[p^g - c^g\right]x_0^d(\mathbf{p},m)(1-\alpha) + \left[p_g^e - c^e\right]x_g^e(\mathbf{p},m)\alpha \tag{12}$$

The incumbent gas company earns the difference between its dual-fuel price and the cost of supplying two fuels, on its share of the dual-fuel customers; the difference between its gas-only price and cost, on the customers who take both fuels and do not switch; and the difference between its electricity-only price and cost, on its share of the electricity-only customers.

$$\pi_k = \left[p_k^d - \left(c^e + c^g\right)\right]x_k^d(\mathbf{p},m)(1-\alpha) + \left[p_k^e - c^e\right]x_k^e(\mathbf{p},m)\alpha \tag{13}$$

The other companies earn the difference between their dual-fuel price and the cost of supplying two fuels, on their share of the dual-fuel customers; together with the difference between their electricity-only price and cost, on their share of the electricity-only customers.

Besanko *et al* describe two solution concepts – monopolistic competition, in which firms take E as given, and the Nash equilibrium, in which firms take account of

the impact of their prices on *D* and *E*. One feature of their monopolistic equilibrium is that all firms have the same mark-up, which is definitely not a feature of the British energy market. We therefore calculate the Nash equilibrium, which has to be done numerically.

To calculate such an equilibrium, we need to calibrate the model. The consumer protection body energywatch publishes data on the prices charged in each of the fourteen regional markets by each company, for electricity, gas, and a dual-fuel package, at each of three consumption levels[4] and for three payment types. The payment types are standard credit, for consumers who receive a bill every three months and then pay it; direct debit, for consumers who pay with an automatic bank transfer each month (typically a fixed amount throughout the year, based on an estimate of their consumption); and prepayment, for consumers who have to charge their meter, usually with an electronic card, before taking any fuel. Direct debit is the cheapest payment method (it involves the lowest costs for the companies) and prepayment the most expensive.[5] Using prices for April 2003, we calculate the price in each region for each payment type as the average of the total bills at the three consumption levels. We assume that there are only seven possible outcomes for dual-fuel customers: buying both fuels from the original incumbents, buying both from British Gas, or buying both from one of the five remaining large electricity companies. This involves two simplifying assumptions: firstly, three fringe suppliers (with a collective market share of under one percent) are ignored, and second, we cut down the number of permutations by assuming that all switchers move to a dual fuel deal.

The Department of Trade and Industry publishes the incumbent's quarterly market share in each of the fourteen electricity regions, and in each of British Gas' twelve operating regions, for each payment type. Using data for gas consumption in each local government area, and assuming that the proportion of customers switching within a British Gas region is uniform across local government areas, we can estimate the number of gas customers, and the proportion who switch, in each electricity region.

[4] energywatch defines low consumption as 1,650 kWh of electricity and 10,000 kWh of gas per year; medium consumption as 3,300 kWh of electricity and 20,500 kWh of gas per year, and high consumption as 4,950 kWh of electricity and 28,000 kWh of gas per year

[5] In practice, dual-fuel deals are not available for customers with pre-payment meters, and the companies' prices for separate supplies of gas and electricity were used instead.

We assume that the cost of switching varies between regions and between the types of companies, but that the ratio of costs between company types within a region does not generally change. By company type, we mean that the cost may depend upon whether the company already has a relationship with the customer, but will not depend upon the identity of that company. We allow the cost of switching electricity alone to be less than the cost of dual-fuel switching (and assume that British Gas has no switching cost advantage for these customers, with whom it has no existing relationship). In practice, the constraint that the electricity-only cost was less than or equal to the cost of dual-fuel switching turned out to be binding, while a constraint that dual-fuel switching to either incumbent was less costly than switching to a completely new company was not binding. Keeping the ratio of costs within a region the same across regions meant that the cost of switching to a non-incumbent company was always three times that of switching to the electricity incumbent, while the cost of switching to British Gas was generally two-thirds that of switching to the electricity incumbent. (These ratios were chosen by Microsoft Excel's solver, together with the switching cost and values of θ.) The exception was the cost of switching to British Gas in the Scottish Hydro region, where the lower proportion of gas customers was likely to place the company at a disadvantage compared to the electricity incumbent.

We assumed that the effectiveness of the companies' efforts to overcome switching cost was the same in each region, but varied with the customer's payment type. In practice, the values of θ for standard credit and pre-payment customers were similar (114 and 120), while the value for direct debit customers was 50% higher (172). The switching costs and effectiveness parameters were chosen to minimise the sum of squared deviations between the incumbents' actual market shares and their predicted shares for each payment type and each fuel. In most regions, the cost of dual-fuel switching to British Gas was around £80, to an electricity incumbent was around £120, and to a new company was roughly £360. The last figure also applies to electricity-only switching. These figures should be contrasted to annual bills for two fuels of between £480 and £690, and for electricity of between £200 and £330. Clearly, switching costs of this magnitude will ensure that customers stay with the incumbents unless suppliers can find ways of overcoming the costs by effective marketing.

Table 6 shows the estimated switching costs and the proportion of customers still with the incumbent companies, averaged across three payment types and two fuels, except for the Hydro-Electric region, where it is for electricity alone.[6] The regions are divided into three groups. There are three regions with particularly high levels of switching, all in the north of England, and these had relatively low switching costs. It is possible that the companies spend more on marketing in this part of the country, since the cost of transporting gas is relatively low, but the implicit revenues from selling gas are very close to those in other regions, implying higher profit margins.[7] The north of Scotland has the lowest level of switching. The estimated switching cost for electricity companies was higher than elsewhere, and the cost of switching to British Gas, which was allowed to vary from its normal ratio, was much higher.

[6] Gas switching figures are only published for Scotland as a whole, although switching behaviour in electricity differs dramatically between the north and the south. The calibration therefore matched the average of the figures calculated for the two regions to the national level of switching, for each gas payment type. The resulting figures were a close match for electricity, but would have appeared a poor match for gas in the north of Scotland.

[7] By implicit revenues from selling gas we mean the difference between a company's dual fuel tariff and its tariff for electricity alone. This point arose in discussion with Daniel Sgroi.

Table 6: Estimated switching costs and incumbent shares

	Switching costs			Incumbent shares	
	Elec. Inc.	BG	Other	actual	fitted
Low switching					
Scottish Hydro	170.0	249.7	507.9	74	76
Average switching					
Southern	137.6	87.3	411.1	67	67
London	137.0	86.9	409.2	66	66
SWEB	121.4	77.1	362.7	64	65
Scottish Power	126.1	80.0	376.7	64	64
Eastern	121.7	77.2	363.5	64	64
Swalec	124.4	79.0	371.6	64	64
Seeboard	120.4	76.4	359.6	63	63
Midlands	122.4	77.7	365.7	63	63
East Midlands	111.8	70.9	334.0	61	61
Manweb	116.0	73.6	346.5	61	60
High switching					
Norweb	104.1	66.1	311.1	59	59
Yorkshire	106.9	67.8	319.4	58	58
Northern	97.9	62.1	292.5	56	56

Having estimated the key parameters, we were then able to solve the model numerically. We modelled three regions – one with low effectiveness and switching, one with intermediate, and one with high effectiveness and switching. We assume each region has the same number of dual-fuel customers. The relative number of electricity-only customers also varied between regions, being highest in the low-switching region and lowest in the high-switching region. Companies were allowed to choose a dual-fuel and an electricity price for each region, but British Gas had a single nationwide price for gas-only customers, in line with its existing practice. The marginal cost of an electricity customer was set to £200, and of a gas customer to

£300.[8] Using the built-in solver in Microsoft Excel, each company in turn maximised its profits, holding the other companies' prices constant, until the prices converged on a Nash Equilibrium. The prices and market shares for the three types of region are shown in Table 7.

[8] In practice, the cost of supplying customers varies from region to region, for both electricity and gas, given regional differentials in transmission and distribution charges and taking such (estimated) variations into account is a possible extension to this model.

Table 7: Simulated prices and market shares, for standard credit customers

	Low-switching	Normal	High-switching
Cost from 2 incumbents	1037	934	903
Price of gas from BG	501	501	501
Dual-fuel price			
British Gas	697	709	697
Electricity incumbent	748	694	684
Electricity entrant	622	623	625
Electricity-only price			
British Gas	322	324	326
Electricity incumbent	536	433	402
Electricity entrant	322	324	326
Electricity market share			
British Gas	18.9	30.6	29.8
Electricity incumbent	58.7	42.8	38.4
Electricity entrant (each)	5.6	6.6	7.9
Gas market share			
British Gas	41.2	45.4	41.5
Electricity incumbent	36.2	28.5	26.9
Electricity entrant (each)	5.6	6.5	7.9
Size			
Dual-fuel	1	1	1
Electric-only	0.7	0.2	0.1
θ	115	115	115
Switching cost			
Elec Incumbent	170	120	100
British Gas	250	80	67
Other company	510	360	300

All of these prices are well above marginal cost, although it is worth noting that the companies also have some non-marginal costs that they will need to recover. It is clear that the incumbent companies can afford to keep their prices well above those of

their rivals Margins are greater for electricity-only customers than for dual fuel customers, in part because British Gas is (by assumption) less effective as a competitor. (Adding an extra parameter, for electricity-only customers' cost of switching to British Gas, is an obvious extension here.) Given that the calibration gave British Gas a switching cost advantage in attracting dual-fuel customers in most markets, British Gas has the highest price, while the electricity incumbents' prices are much closer to British Gas' than to the non-incumbents'. The exception is the low-switching market, based on the north of Scotland, in which British Gas is at a disadvantage to Hydro-Electric, and charges a lower price.

For the electricity incumbent, prices are highest in the markets with high switching costs, but these are also the markets in which they can sustain the highest market shares. The entrants' prices hardly vary across markets, although they rise slightly as switching costs fall, in line with the simpler model. British Gas has a higher market share, and dual fuel price, in the market with medium switching costs than in the market with low costs. The incumbents' market shares are much lower in the simulations than they are at present. Their prices are currently below the levels seen here, implying that it would be profit-maximising to raise prices and lose market share.

5. Empirical analysis

In this part of the paper, we compare the predictions from the models with market data. Price data for April 2003, May 2004, and May 2005 were taken from the energywatch web site. We have prices for the six large suppliers (British Gas, EdF Energy, npower, PowerGen, Scottish and Southern Energy, and Scottish Power) for three payment methods (standard credit, direct debit, and prepayment) and two products (electricity only and dual fuel) in each of the 14 regions. We also have the price of gas from British Gas, which is needed to calculate the cost of continuing to buy from both incumbent companies, rather than taking a dual fuel supply. As before, we take the unweighted average of each company's price for low, medium and high consumption levels. All prices are normalised for differences in cost between regions by dividing them by the average of the prices charged by the four non-incumbent electricity companies in that region. Those average prices will exceed marginal costs, from the discussion in the previous sections, but may not be too far from competitive

levels, given the relatively small market shares of non-incumbent electricity companies.

Table 8: Average prices by year

Incumbent in:		Dual Fuel			Electricity only	
		Both	BG	Elec.	BG	Elec.
Standard Credit	2003	1.144	1.086	1.048	1.008	1.074
	2004	1.132	1.076	1.041	1.013	1.083
	2005	1.117	1.067	1.027	1.006	1.070
Direct Debit	2003	1.113	1.055	1.030	1.021	1.082
	2004	1.110	1.049	1.039	1.021	1.097
	2005	1.091	1.036	1.027	1.010	1.083
Prepayment	2003	1.027	1.008	1.010	0.963	1.008
	2004	1.052	1.031	1.019	0.991	1.040
	2005	1.069	1.059	1.029	1.038	1.063

The patterns for credit and direct debit customers are similar, and rather different from prepayment customers. It is around ten per cent more expensive to buy from both incumbents than to take a dual fuel supply from a non-incumbent electricity company, although the difference has been falling over time. Both British Gas and the incumbent electricity company offer savings to consumers who take a dual fuel supply from them, but they are less competitive than the non-incumbents, and British Gas is less competitive, on average, than the incumbent electricity companies. Once again, these price differences seem to have been falling. For electricity-only customers, incumbents are around seven to nine per cent more expensive than non-incumbent electricity companies, with no clear trend over time. British Gas is slightly more expensive than the other entrants to this segment, but within one standard deviation.

For prepayment customers, entrants set their prices much closer to the incumbents' prices, on average, at the start of the period. The less intense competition to serve prepayment customers was because they were often believed to be less profitable than those paying by other methods, despite their higher tariffs. During the period, however, four of the five electricity companies increased their

prepayment tariffs in areas where they were entrants by less than they increased their other tariffs (prepayment as incumbent, and other payment methods). This meant that the incumbents' prices became relatively higher, as shown at the bottom of table 8.

The next tables report the results of regressions on the five electricity companies' patterns of (relative) prices. In each region, the mean of the four non-incumbent electricity companies' prices is equal to one. There are dummy variables for being the local incumbent in each year, and dummy variables for 2004 and 2005. The year dummies apply to all observations in that year, so that the incumbency variables measure the additional impact of being the incumbent in an area. Table 9 gives the results for credit customers. Except for PowerGen, incumbency is significant at the one per cent level in every year, and involves raising dual fuel prices by between two and four per cent in 2005.

Table 9: Regressions on (relative) dual fuel prices, credit customers

	EdF	npower	PowerGen	Scottish and Southern	Scottish Power
Inc 2003	0.0458 ***	0.0370 ***	0.0824 ***	0.0426 ***	0.0294 ***
	(0.00897)	(0.00670)	(0.00985)	(0.00615)	(0.00894)
Inc 2004	0.0507 ***	0.0401 ***	0.0118	0.0338 ***	0.0646 ***
	(0.00897)	(0.00670)	(0.00985)	(0.00615)	(0.00894)
Inc 2005	0.0278 ***	0.0412 ***	0.0236 **	0.0268 ***	0.0290 ***
	(0.00897)	(0.00670)	(0.00985)	(0.00615)	(0.00894)
2004	0.0508 ***	-0.00096	0.0096	-0.0190 ***	-0.0370 ***
	(0.00587)	(0.00438)	(0.00645)	(0.00403)	(0.00477)
2005	0.0418 ***	-0.0257 ***	-0.0157 **	-0.0125 ***	0.0112 **
	(0.00587)	(0.00438)	(0.00645)	(0.00403)	(0.00477)
Constant	0.9713 ***	1.0171 ***	0.9807 ***	1.0136 ***	1.0136 ***
	(0.00415)	(0.00310)	(0.00456)	(0.00338)	(0.00338)
R^2	0.8284	0.8141	0.7439	0.7888	0.8301

Standard Errors in parentheses

* Significant at 10%; ** Significant at 5%; *** Significant at 1%

Table 10 gives the results for direct debit customers. Again, incumbency results in a statistically significant price increase in twelve of our fifteen company-year combinations. The impact, of between two and four percent in most cases, is similar to that for credit customers.

Table 10: Regressions on (relative) dual fuel prices, direct debit customers

	EdF	npower	PowerGen	Scottish and Southern	Scottish Power
Inc 2003	0.0406 ***	0.0331 ***	0.0027	0.0433 ***	0.0288 ***
	(0.00834)	(0.00749)	(0.00539)	(0.00648)	(0.01279)
Inc 2004	0.0503 ***	0.0437 ***	0.0038	0.0391 ***	0.0503 ***
	(0.00834)	(0.00749)	(0.00539)	(0.00648)	(0.01249)
Inc 2005	0.0268 ***	0.0443 ***	0.0263 ***	0.0302 ***	0.0113
	(0.00834)	(0.00749)	(0.00539)	(0.00648)	(0.01249)
2004	0.0158 ***	-0.00096	0.0179 ***	-0.0167 ***	-0.0222 ***
	(0.00546)	(0.00490)	(0.00353)	(0.00424)	(0.00668)
2005	0.0101 ***	-0.0257 ***	-0.0075 **	-0.0147 ***	0.0245 ***
	(0.00546)	(0.00490)	(0.00353)	(0.00424)	(0.00668)
Constant	0.9953 ***	0.9965 ***	0.9974 ***	1.0136 ***	1.0136 ***
	(0.00386)	(0.00347)	(0.00250)	(0.00300)	(0.00338)
R^2	0.7005	0.7598	0.6787	0.7856	0.6499

Standard Errors in parentheses

* Significant at 10%; ** Significant at 5%; *** Significant at 1%

Table 11 gives the results for prepayment customers, which are far more mixed. After the first year, all the coefficients on incumbents' prices are positive, but only three coefficients are significant at the 5% level (or better). In the most recent data, however, the best estimate of the impact of incumbency on prices is similar to that for the other payment types.

Table 11: Regressions on (relative) dual fuel prices, prepayment customers

	EdF	npower	PowerGen	Scottish and Southern	Scottish Power
Inc 2003	0.0105	-0.0043	0.0169 *	0.0122	-0.0056
	(0.00843)	(0.00663)	(0.00911)	(0.00902)	(0.01664)
Inc 2004	0.0208 **	0.0133 *	0.0175 *	0.0041	0.0320 *
	(0.00843)	(0.00663)	(0.00911)	(0.00902)	(0.01664)
Inc 2005	0.0497 ***	0.0319 ***	0.0193 *	0.0138	0.0276
	(0.00843)	(0.00663)	(0.00911)	(0.00902)	(0.01664)
2004	-0.0060	0.0282 ***	0.0097	-0.0309 ***	-0.0009
	(0.00552)	(0.00434)	(0.00596)	(0.00591)	(0.00890)
2005	-0.0091	0.0084 *	0.0284 **	-0.0557 ***	0.0257 ***
	(0.00552)	(0.00434)	(0.00596)	(0.00591)	(0.00890)
Constant	0.9882 ***	1.0611 ***	0.9783 ***	1.0054 ***	0.9697 ***
	(0.00390)	(0.00307)	(0.00422)	(0.00418)	(0.00629)
R^2	0.5453	0.7287	0.5416	0.7655	0.3844

Standard Errors in parentheses

* Significant at 10%; ** Significant at 5%; *** Significant at 1%

It is not possible to run the same regressions for British Gas, since it is an incumbent in every regional market. In table 12, however, we regress British Gas' dual fuel prices against the proportion of electricity customers who also take gas in each region, yearly dummies, and the (relative) price paid by customers who have not switched from the two incumbents in each region. British Gas charges the same price for gas in each region (as is generally the case with other gas suppliers), and so the variation in customers' payments is due to the different prices charged by incumbent electricity companies. This means that we can treat the variable as exogenous to British Gas' conduct in the dual fuel market.

We find that British Gas' prices for credit and direct debit customers have been in (relative) decline, while their prepayment prices have been rising relative to those charged by entrant electricity companies. British Gas charges relatively more for credit customers and direct debit customers in regions where there are a high proportion of gas customers, which could reflect a stronger brand in these regions.

The company charges more, relative to entrant suppliers, in regions where staying with both incumbents is particularly expensive. This effect is strongest in the prepayment market, but also statistically significant in the direct debit market, and not contradicted in the credit market). This is consistent with the reaction functions derived in equation (4) and with the numerical estimates in the second two columns of table 7.

Table 12: Regressions on (relative) dual fuel prices, British Gas

	Credit	Direct Debit	Prepayment
Relative charge of 2 incumbent suppliers	0.1935 (0.12337)	0.2917 ** (0.13016)	0.5345 *** (0.06104)
Proportion of gas customers	0.0404 ** (0.01546)	0.0346 * (0.01765)	0.0053 (0.01459)
2004	-0.0078 * (0.00406)	-0.0051 (0.00434)	0.0103 ** (0.00384)
2005	-0.0143 *** (0.00507)	-0.0133 ** (0.00514)	0.0289 *** (0.00437)
Constant	0.8305 *** (0.14040)	0.7010 *** (0.14378)	0.4540 *** (0.06177)
R^2	0.4976	0.4596	0.8870

Standard Errors in parentheses

* Significant at 10%; ** Significant at 5%; *** Significant at 1%

Table 13 shows the correlation matrices for the incumbents' regional market shares in electricity and gas for each payment method, at three points in the development of competition. By September 2004, the proportions still buying from the incumbent are very similar in gas and in electricity for direct debit customers (52%) and credit customers (63%), but more prepayment customers have stayed with the incumbent in gas (73%) than in electricity (63%). The standard deviation of incumbent shares is greater in electricity than in gas, however.[9]

[9] While the standard deviation of incumbent market shares in electricity is increased by the low switching rates in the north of Scotland (which is not separately identified in the gas data), the difference persists when looking at England and Wales alone.

Table 13: Incumbent market shares, by payment type

September 2002		Electricity			Gas		
		Credit	DD	Prepay	Credit	DD	Prepay
Mean incumbent share		68.8	61.7	65.5	67.2	56.9	78.1
Standard deviation		7.0	7.4	8.4	3.7	4.4	7.3
Electricity	Credit	1					
	DD	0.586	1				
	Prepayment	0.786	0.670	1			
Gas	Credit	0.342	-0.026	0.223	1		
	DD	-0.128	0.080	-0.153	0.447	1	
	Prepayment	0.239	0.071	0.212	0.628	0.356	1
September 2003		Electricity			Gas		
		Credit	DD	Prepay	Credit	DD	Prepay
Mean incumbent share		64.4	56.4	64.1	64.6	55.4	73.6
Standard deviation		8.7	7.3	11.2	3.2	4.6	7.6
Electricity	Credit	1					
	DD	0.694	1				
	Prepayment	0.686	0.807	1			
Gas	Credit	0.053	-0.160	-0.203	1		
	DD	0.033	-0.030	-0.006	0.667	1	
	Prepayment	0.069	-0.073	-0.341	0.393	0.481	1
September 2004		Electricity			Gas		
		Credit	DD	Prepay	Credit	DD	Prepay
Mean incumbent share		63.1	51.9	61.1	63.0	52.4	72.8
Standard deviation		9.5	9.1	12.7	4.2	3.9	8.9
Electricity	Credit	1					
	DD	0.681	1				
	Prepayment	0.667	0.864	1			
Gas	Credit	-0.172	-0.396	-0.379	1		
	DD	-0.257	-0.345	-0.332	0.531	1	
	Prepayment	0.086	-0.199	-0.411	0.480	0.490	1

Within a fuel, incumbent market shares are positively correlated across regions – where the incumbent has been good at retaining direct debit customers, it tends to have been good at retaining credit and prepayment customers. The relationship is stronger for electricity than gas. At first, there was a weak positive correlation between market shares in gas and in electricity for each payment type, implying that in an area where customers were switching for one fuel, they were more likely to be switching for the other one. By September 2004, however, this had switched to a weak negative correlation. This is consistent with dual fuel competition becoming increasingly important, so that where an incumbent electricity company has been able

to defend its market share, it has done so, in part, by selling gas to an increasing number of customers, reducing British Gas' market share in the region.

6. Conclusions

The first part of this paper outlined some stylised facts about the British energy retail markets. Roughly speaking, about two-fifths of customers are still buying their gas from British Gas and their electricity from the regional electricity incumbent. Slightly over one fifth are buying both fuels from British Gas. About one fifth are buying both fuels from the regional electricity incumbent. Most of the remaining customers are buying both fuels from one of the other large electricity companies, although there are still some small independent suppliers, and some customers have switched one fuel, or switched both but to different suppliers. Table 8 showed that buying from any incumbent was slightly more expensive than buying gas and electricity from a non-incumbent electricity company, and buying from both incumbents could cost around 10% more. Since the average energy bill is around £700 a year, it is difficult to explain the incumbents' high market shares without assuming that customers face high (real or imagined) switching costs.

The following sections of the paper used an analytical model to show how the prices of gas and electricity might depend upon the level of switching costs and the relative sizes of the two markets, and a calibrated numerical model to calculate profit-maximising prices for entrants and incumbents. The simulations implied that the incumbents could find it profitable to raise prices well above current levels, even though their market shares would fall further.

Returning to the data, we found that the five main electricity companies charged more for a dual fuel supply in areas where they were the electricity incumbent, and that British Gas charged more in areas where the electricity company's price for electricity was high. We did not present any econometric analysis of market shares,[10] but note that the incumbents' regional market shares in gas and in electricity are becoming negatively correlated. This can be interpreted as a

[10] The main problem is identifying the relationship between market shares and patterns of prices, even if past prices are used as instruments. In the short term, a company's market share will fall if its prices are relatively high, but in the equilibria of the models in this paper, companies that are protected by higher switching costs will charge higher prices and still have higher market shares.

sign of the importance of dual fuel competition – the best way for an electricity company to defend its own market is to attack that of British Gas.

Dual-fuel competition is still evolving in the British retail energy markets – two years ago, incumbent market shares in gas and electricity were positively correlated – but it is clearly an important feature of those markets. Analysing the markets for gas and electricity on their own is likely to miss some important interactions. At the policy level, since both Ofgem and energywatch are responsible for both gas and electricity, we can hope that these interactions will be taken into account. The key policy question is whether competition is protecting consumers better than continued regulation (or a return to regulation) would have done. Any paper that does not present a reasoned case for what would have happened under regulation is only a partial answer to that question. However, it is clear that about half of the consumer switching that prompted the end of regulation came about because consumers were switching from the incumbent in one fuel in order to stay with the incumbent in the other. While this did give them savings, compared to staying with both incumbents, these customers were still paying more (on average) than if they had switched to a non-incumbent supplier. It is clear that there is competition in these markets, but it is far from clear that it is working as effectively to protect consumers as we might hope.

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Figure 1: The Electricity Regions of Great Britain