



Nonlinear Pricing and Tariff Differentiation

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Research Group in Cambridge, IOS at Atlanta, the Competition Law and Economics European Network workshop in Bonn, Norges Handelshøyskole in Bergen, DICE in Dusseldorf, and the Centre for Competition Policy, Norwich. An earlier, substantially different, version of the paper was circulated under the title "How Far Does Economic Theory Explain Competitive Nonlinear Pricing in Practice?"

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Nonlinear Pricing and Tariff Differentiation

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ABSTRACT. Liberalisation of the British household electricity market, in which previously monopolised regional markets were exposed to large-scale entry, is used as a natural experiment on oligopolistic nonlinear pricing. Consistent with some previous theory, each oligopolist offered a single two-part electricity tariff, but inconsistent with the theory, the two-part tariffs are heterogeneous in ways that cannot be attributed to asymmetric costs or variations in brand loyalty or market frictions. Instead, the evidence suggests that firms deliberately differentiated their tariff structures resulting in market segmentation according to consumers' usage.

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1. INTRODUCTION

Nonlinear pricing is frequently observed in oligopolistic markets, often as quantity discounts which are not totally explicable in terms of costs. Yet the theory of oligopolistic nonlinear pricing (or second degree price discrimination more generally) remains incomplete and largely untested. However two papers (Armstrong and Vickers, 2001 and Rochet and Stole, 2002) derive the striking result that, in any symmetric equilibrium, firms will offer single two-part tariffs which are cost-based in the sense that marginal prices are equal to marginal costs.

This paper compares these and other theoretical predictions with outcomes immediately after liberalisation of the British household retail electricity industry. Consistent with the theory, each oligopolist offered a single two-part electricity tariff, but inconsistent with the theory, the two-part tariffs were heterogeneous across firms. Throughout the time period and across all geographical regions, entrants typically selected tariffs with a higher fixed fee and a lower marginal price than the incumbent. There were also systematic variations amongst the entrants' tariffs which increased over time. These tariff asymmetries cannot be attributed to asymmetric costs, the existence of brand loyalty or market frictions. Instead, we present evidence that firms differentiated their tariff structures to segment the market according to consumers' usage patterns, with some firms offering tariffs that are more attractive to lower volume consumers and other firms offering tariffs targeting consumers with higher usage. By the end of the period studied, the six major firms collectively offered a range of two part tariffs which qualitatively resembled a monopolist's optimal menu of two-part tariffs, a finding for which there is no current theoretical explanation.

Empirical literature on nonlinear pricing has expanded considerably in recent years. Leslie (2004) estimates the welfare effects of price discrimination at a Broadway theatre; Cohen (2008) demonstrates that 35-45% of the unit price variation in paper towels is consistent with price discrimination; and several papers show how increases in competition can i) increase the number of pricing options offered by

firms (Borzekowski et al., 2009 and Seim and Viard, 2011); and ii) reduce the level of firms' tariffs, with a greater reduction for higher usage consumers (Miravete and Röller, 2004; Busse and Rysman, 2005; and Seim and Viard 2011). McManus (2007) examines the empirical implications of Armstrong and Vickers (2001) and Rochet and Stole (2002) in the context of product size in the specialty coffee market. Consistent with their predictions of marginal cost pricing, he finds that product sizes in the most competitive product category are close to the efficient level.

However, by concentrating on empirical regularities at the market level, this literature has paid little attention to any asymmetries between firms' pricing strategies, which form the main focus of our paper. Miravete (2011) considers tariff asymmetries in the early US cellular industry, finding that the incumbent's tariffs were more often dominated by the entrant than vice versa. In our oligopoly context, we also find that entrants' tariffs dominated the incumbent's in approximately 25% of cases. However, our paper differs from Miravete in focusing on asymmetries in tariff structures. We employ a simple summary statistic for any two-part tariff, the ratio of the fixed fee to variable fees for the median consumer, which we term the Fixed to Marginal (FM) Ratio. We find an increasing tendency for each entrant's FM ratio to differ systematically relative to both the incumbent and the other entrants, with the effect of segmenting the market according to consumption volume.

The next section introduces the market and section 3 summarises recent theoretical literature. The data and initial findings are presented in section 4. The remaining sections further explore the heterogeneity amongst firms' tariffs: section 5 establishes that they cannot be explained by cost asymmetries, brand loyalty or market frictions, and section 6 shows that they imply a robust and systematic strategic segmentation of the market, according to consumers' usage patterns. Section 7 discusses.

2. THE MARKET

The electricity industry in Great Britain comprises four vertical stages: generation, transmission, distribution and retail. We focus on the retail sector, which was traditionally separated into 14 geographical regions, each with an incumbent monopolist; consumers were only able to buy from their local incumbent, and arbitrage was not possible. The industry was privatised in 1990/1, and the household retail sector opened to competition in 1998/9. Thereafter consumers were free to switch away from their incumbent (or any subsequent supplier) to any provider within their region without financial penalty, resulting in significant entry. The average prices of incumbents (although not entrants) continued to be regulated until April 2002, but with no effective regulatory constraint imposed on tariff structures for any of the suppliers (Harker and Waddams Price, 2007). Indeed, permission for alternative tariff structures was confirmed in the Electricity Act 1989 which explicitly permits (without mandating) two part tariffs (Section 18(3)).

The product is essentially homogenous but households vary significantly in their levels of consumption. Public sources report data for low, medium and high consumption households, typically defined respectively as 1650, 3300 and 4950 kWh/year (e.g. Ofgem 2003, p.49). These levels will be employed later in this paper, and approximately identify the four quartiles.

Firms are required to offer three alternative payment methods to consumers (standard credit, direct debit and prepayment) and typically offer different tariffs for each.¹ Nearly all electricity suppliers were also active in the gas market, which had been liberalised over the previous two years. Suppliers have increasingly participated in mixed bundling by offering a ‘dual-fuel’ discount to consumers who buy both fuels from them.

Following liberalisation, there was almost 100% cross-entry by the original re-

¹These are effectively three separate markets, catering for self-selecting consumers who opt for different billing arrangements, rather than a single market with multiple tariff options.

gional incumbents into each others' markets. The incumbent gas supplier, British Gas, also entered all regions, as did a few small Independents. However, the Independents gradually exited, and there was steady consolidation amongst incumbents. By autumn 2002, the surviving electricity retailers had consolidated into 5 large companies, referred to here as the 'Majors'. By early 2006, these firms (each owning ex-incumbents in two or three regions) and British Gas were the only suppliers.²

Electricity transmission is provided by the National Grid (a regulated privatized monopolist) and there is a monopoly distributor in each region (sometimes one of the Majors) which is required to serve all retailers on identical and regulated terms.

Thus each regional market included up to five different types of firm:

- The **Incumbent** within their home regions
- **British Gas** - entrant into electricity, but incumbent and previous monopoly gas supplier in each region³
- **Majorsaway** - the four major incumbents from other regions
- **Mini-Majorsaway** - (10) other original incumbents, acquired by the Majorsaway during the first half of the period
- **Independents** - (up to 5) suppliers with no region of previous incumbency.

There were two potential sources of asymmetry between these types. First, the Incumbents, Majorsaway and British Gas were all integrated upstream into generation, unlike the others (with one exception). Second, consumers may have favoured incumbents because of brand loyalty or search and switching costs. British Gas would have been less disadvantaged, both because of consumer familiarity within the gas market and the possibility of bundling gas and electricity; so British Gas was as much an incumbent as the customer's existing electricity supplier (Hviid and Waddams Price 2012). These sources of asymmetry are discussed in Section 5.

²Other small independent companies have entered since, but few have survived long.

³8% of households, mainly in rural areas, are not connected to the gas network. Of the remainder, 95% consume gas (Office of Fair Trading (2011) Annex A Table A3).

Data on market shares by firm and region over time are unavailable. However, it is known that during the seven years after liberalisation, nearly half of consumers switched away from their regional electricity incumbents. By 2005, the average market share of original incumbents in their home region was just over 50%, with British Gas accounting for about 23%, and the Majorsaway (together) for another 23%; Independents had around 1% of the market (Ofgem 2006, p. 18). British Gas derived much of its success from widespread switching to dual-fuel tariffs. By 2004, 80% of switching in the energy market was to dual fuel deals (Ofgem 2004, p. 78).

3. THEORETICAL LITERATURE

The standard results of nonlinear pricing for monopoly are well established (e.g. Mussa and Rosen 1978, Maskin and Riley 1984). If consumers possess private information about their tastes, with higher types having a higher marginal utility over all units, the monopolist's optimal price-quantity schedule is concave such that higher types are offered a lower average price per unit. This can be approximated by offering a menu (continuum) of two-part tariffs, with decreasing marginal prices, p , and increasing fixed fees, F , such that higher types optimally select a tariff with a lower marginal price and a higher fixed fee. Intuitively, marginal prices are above marginal cost for all but the highest type, in order to extract larger rents from higher types by discouraging them from selecting a tariff intended for a lower type.

The literature on oligopolistic nonlinear pricing is less well established (see reviews by Armstrong 2006 and Stole 2007). In a one-stop setting, where consumers can buy from at most one supplier, the related papers by Armstrong and Vickers (AV, 2001) and Rochet and Stole (RS, 2002) are of particular interest.⁴ In their simplest form, the results can be presented as follows. Two firms, $j = L, R$, located at each end of a unit line, sell a single good. They have symmetric per-consumer costs,

⁴Although RS present their model in the context of quality discrimination, we refer to their results in the context of quantity discrimination.

$C(q)$. In a one-shot game, each firm simultaneously sets a price-quantity schedule, $T_j(q)$, to a unit mass of consumers. Consumers exhibit two forms of unobserved, independent heterogeneity in their tastes: as in the monopoly literature, they display vertical heterogeneity in their marginal utility over all units of consumption; but also they display horizontal heterogeneity, captured by a travel cost independent of consumption volume as in a Hotelling framework. This generates the following proposition, which can be generalised to a multi-product setting (AV) and to an n -firm oligopoly (RS, Proposition 7).⁵

Proposition 1. *Assuming that i) the market is covered in equilibrium for all types; horizontal preferences are ii) independent of vertical preferences and iii) symmetrically distributed, and iv) production costs are symmetric, then in the unique symmetric equilibrium both firms offer a single, identical two-part tariff, $T(q) = F + pq$, with the marginal price equal to marginal cost, $p = C'(q)$.*

Thus, in contrast to the variety of largely non cost-related tariffs offered by a monopolist, the introduction of competition may prompt firms to adopt a single, identical two-part tariff. Further, the equilibrium tariff will be ‘cost-based’ in the (AV) sense that marginal price equals marginal cost.

The intuition is as follows. If consumers’ vertical preferences were known to firms, in response to a rival’s choice of the cost-based tariff, it can be shown that a firm would optimally offer each consumer its efficient quantity for a total charge of $(F + C'(q)q)$. However, even when vertical preferences are unknown, this strategy can still be implemented by using the proposed two-part tariff. No other symmetric equilibrium can exist because any supplier would always be able to increase its profits

⁵Specifically this follows from i) AV Proposition 5 for the case of a single good, where uniqueness is further demonstrated in Armstrong and Vickers (2006, Proposition 1) and ii) RS Proposition 6 under the assumption of a symmetric distribution.. Related results are in Thanassoulis (2007) if consumers can only buy one or two units.

and consumer surplus by offering the more efficient cost-based two-part tariff. Due to associated technical difficulties, the possible existence of asymmetric equilibria remains an open question.⁶

We consider the applicability of this Proposition to the present case by assessing the applicability of the four assumptions to the UK electricity market. We draw on other theoretical work to examine the effect of relaxing each assumption.

3.1. Market coverage. The market is covered since electricity is universally available in the UK. Indeed, Armstrong and Vickers (2010) cite the UK electricity market as a motivating example for their model. However, if this is not true, then, in a symmetric equilibrium, firms are likely to offer a menu of non-cost-based tariffs, more akin to the monopoly prediction (Yang and Ye, 2008).

3.2. Independent heterogeneity. There is no evidence of interdependence between vertical and horizontal preferences. However, if buyers with stronger brand preferences also have stronger vertical preferences, Bonatti (2011) shows that firms will offer a menu of tariffs in a symmetric equilibrium.⁷

3.3. Symmetric horizontal (brand) preferences. As discussed in Section 5.2, brand preferences may not be symmetric because some consumers may favour the incumbent. RS (Proposition 6) show that firms still employ cost-based two-part tariffs when facing asymmetric brand preferences, but tariffs are no longer identical, with the favoured firm setting a higher fixed fee.

3.4. Cost symmetry. As explained in Section 5.1, there may be some very small cost asymmetries between firms. While little is known about the effects of asymmetric

⁶Similar results occur in a multi stop setting where consumers can buy from none, one or more suppliers. Armstrong and Vickers (2010, proposition 3) demonstrate the existence of a symmetric equilibrium where each firm sets three cost-based two-part tariffs, the two-product tariff consisting of the sum of the single product tariffs minus a lump sum discount.

⁷Related results are found in Stole (1995) and Yin (2004).

costs, Yin (2004) establishes a result for the special case with firms constrained to use only two-part tariffs with vertical homogeneity. He shows that in equilibrium, tariffs may be asymmetric but remain cost-based in the sense that each firm sets its marginal price equal to its marginal cost.

In summary, theory predicts that firms will offer a single, identical two-part tariff under assumptions i)-iv). If assumptions i)-iv) fail to hold, the existing literatures suggests firms may offer either a symmetric menu of non-cost-based tariffs or offer asymmetric cost-based tariffs. There is no relevant theoretical explanation for firms to select asymmetric non-cost based tariffs.⁸

4. THE DATA AND STYLISTED FACTS

This section describes the data and identifies three stylised facts which are directly relevant to the above propositions.

Each firm's tariffs are observed within each of the 14 regions at 14 six-monthly intervals over the period 1999-2005.⁹ This period is selected to include two sub-periods: (i) 1999-2002, the opening years of liberalisation in which there was rapid entry, followed almost immediately by consolidation and exit; and (ii) 2003-5, years following consolidation with stable market structure. After 2006 there was considerable volatility in the wholesale market to which firms responded by introducing a

⁸In the context of quality discrimination, Champsaur and Rochet (1989 and 1990) show how duopolists can optimally select asymmetric quality and prices. In a two-stage game, the firms each pre-commit to producing a single, asymmetric quality level, before selecting asymmetric prices. However this logic is not transferable to a setting of quantity discrimination, because suppliers cannot commit to marginal prices as they can to product quality.

⁹The source was price sheets from the Consumers Association and Energywatch. Data were collected in June and December because tariffs rarely changed more than twice a year, and typically occurred in April (and October), so would have been fully recorded by June and December. Exceptionally, for 1999, observations relate to February and October to capture the effects of market opening.

variety of additional tariffs (Ofgem 2008), taking the market beyond the pure setting of non-linear tariffs addressed by the theoretical literature reviewed here. We focus on standard credit electricity, the default payment method prior to liberalisation and the predominant payment method for this period (Ofgem, 2004, p.137).¹⁰

Before liberalisation, each regional incumbent offered standard credit consumers only a single two-part tariff, with a fixed fee, F (in pounds per year), and a single marginal price, p (in pence per kWh), rather than a menu of multiple two-part tariffs, as theory would predict for a profit maximising monopolist (Giulietti and Waddams Price, 2005). This might reflect potential costs of providing multiple tariffs or the firms' reluctance to risk an adverse regulatory response.

Following liberalisation, each firm continued to offer only a single tariff (per payment method). Moreover, only three types of tariff structure were provided: i) a standard two-part tariff, $\{p, F\}$, ii) a zero fixed fee, but two marginal prices, $\{p^H, p^L\}$, where the higher price, p^H , was charged on the first q^T units consumed, and the lower price, p^L , applied to all subsequent units, and iii) a three-part tariff, $\{p^H, p^L, F\}$, with a positive fixed fee and two marginal prices that followed the structure of (ii).

The standard two-part tariff accounted for 70% of all tariffs. Structure (ii) constituted most of the remainder, but for our analysis we interpret this as a variation of (i), since the threshold q^T was typically set at levels well below the consumption of most consumers¹¹. Rational consumers buying more than q^T units should treat such tariffs as 'equivalent' to a standard two-part tariff, with marginal price, p^L , and fixed

¹⁰As noted above, alternative methods of payment were direct debit and prepayment. The former typically offer a lump sum discount on standard credit, which differs only slightly across firms and time within the narrow range £8-15 per annum during this period. Given the lump sum, broadly constant, nature of the discount, our findings remain qualitatively robust across these two payment methods. Prepayment entails surcharges on standard credit (Ofgem 2008). Consumers exhibit clear preferences for a particular payment method, which they rarely change, justifying classification into different markets. We focus on discrimination in the form of nonlinear pricing. (Ofgem 2008).

¹¹In 97% of cases the threshold was no more than 900kWh, a level exceeded by 94% of households (DECC 2009).

fee, $F = (p^H - p^L)q^T$. The three-part tariff, (iii), accounted for a small proportion of the tariffs, was offered by only three firms, and had virtually disappeared by 2002. Moreover, the curvature of these tariffs was minimal, with a small difference between p^H and p^L . This leads to:

Stylised Fact 1: Firms predominantly offered single tariffs, and these were pervasively two-part.

This is consistent with the first part of the Proposition, and we next turn to the second part of the Proposition - were these tariffs symmetric across firms?

Figure 1 plots each firm's F against p for the pooled database.¹² This reveals considerable heterogeneity, although, in itself, this is inconclusive because this reflects variability over time and regions as well as between firms. Nevertheless, simple descriptive statistics reveal that a considerable part of this is due to variability between firms in a given region at each point in time: in the average year, the within-region standard deviations of p and F are approximately 10% and 30% of their respective means, and rising through the period. The dominant source of dispersion is *within-region* rather than *between-region*: at a given point in time, the within-region variance accounts for 63-97% of the total variance in p and for 82-97% of that in F .

In order to focus more clearly on within-region asymmetries, Figure 2 re-presents the data using a simple normalisation. This plots the difference in the fixed fee between each entrant and the incumbent in its region at a given point in time. ($F_E - F_I$), against the difference in their marginal prices, ($p_E - p_I$). This controls for much of the inter-regional and inter-temporal variability. As can be seen, considerable variability remains, leading us to conclude:

¹²Hereafter, each firm's tariff is expressed in terms of just F and p . For the 'equivalent' two-part tariffs, the 'equivalent F ' is computed as described above. For the three-part tariffs, p is measured by whichever of p^H or p^L applies for the 'typical' consumer, with $q = 3300\text{kWh}$, which is invariably p^L .

Stylised Fact 2: Firms did not set identical two-part tariffs in the typical market (region).

Table 1 reports the frequencies of observations within each quadrant of the Figure. Comparing quadrants II (top left) and IV (bottom right), at this stage for the ‘All entrants’ column, leads to:

Stylised Fact 3: In two-thirds of all cases, the entrant set a higher F and a lower p than the incumbent (quadrant II). The reverse was true (quadrant IV) in only 5% of cases. Typically, the entrant’s tariff was more attractive than the incumbent’s for higher volume consumers.

Combining quadrants I and II and comparing with quadrants III and IV, we see that entrants set a higher fixed fee than incumbents in 68% of cases and a lower marginal price in 92% of cases respectively - typically 20% higher for the fixed fee and 10% lower for the marginal price, and these differentials were maintained throughout the period.

Finally, 25% of the observations lie in quadrant III - where the entrant charged both a lower F and a lower p - in one quarter of cases, the entrant’s tariff dominated the incumbent’s. The reverse was true (quadrant I) in only 1% of cases, similar to Miravete’s (2011) finding in the US cellular industry, mentioned earlier.

5. SOME POSSIBLE EXPLANATIONS

This section considers whether this heterogeneity across firms might be explained by asymmetric costs, brand loyalty or market frictions.

5.1. Asymmetric costs. While there are few published data on the costs of individual firms at the retail level, we can easily establish from simple deduction that the above heterogeneity cannot be explained by cost asymmetries between firms.

At the retail level, firms face four types of cost: generation, transmission, distribution and retail. Of these, distribution and transmission are both charges levied by upstream firms. Transmission charges may vary between retailers, depending on location of generation sources and consumers, but constitute less than 5% of total costs. Regulated distribution charges are identical for all retailers in any region. Therefore any significant cost variations between retailers within a region could only emanate from differences in generation and retailing costs.

The wholesale generation market is accessible to all retailers, but those who are integrated upstream into generation may enjoy cost advantages (e.g. Giulietti et al 2010). Since British Gas, the Incumbents, and therefore the Majorsaway are all vertically integrated, the only group of disadvantaged firms would be the Independents. Therefore, at this stage we omit these firms from all further analysis. This is at little loss of generality, given that they only ever had a transitory presence in the market and never achieved more than 1% aggregate penetration. This leaves a set of six firms, all vertically integrated, and therefore with similar generation costs.

Little is publicly documented on the ‘purely’ retail costs. A priori most are likely to depend on the number of consumers rather than the volume of electricity supplied (Waddams Price and Hancock, 1998), and any asymmetry is likely to occur in per consumer, rather than energy, costs. This is likely to favour Incumbents, who should benefit from having an established brand name and marketing network in the region, although they may be handicapped by legacy retailing operations. Either way, because pure retail accounts for only 15% of all costs, even a 10% advantage would imply an overall cost differential of at most 1.5%. Ofgem (2008, p.83) estimated that the differential costs between incumbents and others in serving each consumer were trivial at £3 per year (1% of a typical electricity bill.)

In summary, any cost differentials between Incumbents, British Gas and the Majorsaway are likely to be extremely small, and confined to the fixed cost of serving each consumer.

Against this backcloth, we use Figures 3 and 4 to reject the cost explanation of asymmetric tariffs: Figure 3 disaggregates Figure 2, by showing the scatters separately for British Gas and for the Majorsaway as a group. Figure 4 shows the typical magnitudes of the differentials in F and p , averaged across regions over time, for Incumbents, British Gas and Majorsaway (as a group and also for the individual Majorsaway).

Figure 3(i) shows that British Gas invariably charged a higher fixed fee but lower marginal price than the incumbent (in 97% of cases – see Table 1), and Figure 4(i) and (iii) show that these differences were sustained throughout the time period. Typically, British Gas’s fixed fee was 44% higher, and its marginal price 14% lower than the Incumbents’. This cannot be explained by cost differences. British Gas and the Incumbents are all vertically integrated, and the only possible asymmetry lies in pure retail costs, which we have shown are likely to be negligible. Moreover, British Gas’s retail costs would likely be very similar to the Incumbents’ because of its own regional incumbency status. If the tariffs were to be cost based, all observations in this scatter should lie close to the origin, but clearly they do not.

Figure 3(ii) compares the Majorsaway (as a group) with the Incumbents. Using similar reasoning, any cost differentials are likely to be very small and confined to fixed costs per consumer and so most observations should lie on the vertical axis slightly above the origin. However most lie in quadrant II: Majorsaway set a higher (typically 11%) fixed fee and lower (typically 5%) marginal price than Incumbents. Figure 4(i) and 4(iii) confirm that these differentials persisted throughout the period. Moreover, there are considerable persistent differences in both p and F between individual Majorsaway (Figures (ii) and (iv)), and there is no cost explanation for this.

5.2. Brand loyalty or market frictions. By 2005, six years after the market opened, only half of consumers had switched from their electricity incumbent, despite

potential savings of around 10% (Ofgem, 2008). Such inertia indicates either brand loyalty or market frictions such as search costs and switching costs (e.g. Giuliatti et al., 2005, Hartman and Ibanez, 2007, Giuliatti et al., 2011, Hviid and Waddams Price, 2012).

While the literature has examined the implications of switching costs for differential tariff *levels*, it has not considered the *structure* of tariffs. Here, RS (Proposition 6) provide a theoretical insight: they show that, with asymmetric consumer brand preferences, firms should continue to select two-part tariffs with the same, cost-based, marginal price but that the favoured (incumbent) firm will charge a higher fixed fee. This seems intuitively plausible if the cost to a consumer of switching is largely a lump sum invariant to their consumption level.

In the present context, this would suggest that the Incumbent Electricity supplier would charge the highest fixed fee. British Gas, by virtue of its incumbency in the adjacent Gas market, should also set a relatively higher fixed fee because, for consumers wishing to switch to a dual fuel bundle, British Gas is as much an incumbent as the incumbent electricity supplier. The Majorsaway should set the lowest fixed fee, and there is no reason for expecting this to differ between individual Majorsaway.

These expectations are not borne out by the evidence of the above Figures and Table 1: facts. First, we observe that both British Gas (nearly always) and the Majorsaway (more often than not) set higher fixed fee than Incumbents. Second, there are also major differences amongst the Majorsaway (Figure 4(iv)). Third, there is no tendency for the differentials to diminish over time (Figures 4(ii) and (iv)), as might be expected if brand loyalty tends to decay over time.¹³

¹³The only tendency in the data which might be consistent with a differential switching cost explanation is that British Gas typically sets a higher fixed fee than Majorsaway. At most, this would suggest a relatively minor contributory effect of asymmetric switching costs.

6. SYSTEMATIC ASYMMETRY: EVIDENCE OF MARKET SEGMENTATION?

Given that tariff asymmetries cannot be explained by asymmetric costs, brand loyalty or market frictions, we now identify whether they exhibit any systematic and robust features suggesting that individual firms are pursuing deliberate and systematic strategies by which to differentiate their tariffs from each other, in order to segment the market.

To fix ideas, consider first a duopoly with incumbent I and entrant E , each offering a single two part tariff, but where E sets a higher fixed fee and lower marginal price. E thereby sells to high volume ($q > q^*$ in Figure 5(i)) consumers, and I to low volume consumers. This appears consistent with the British Gas-Incumbent differentials observed above.

More generally, with $(N - 1)$ entrants, each offering a different non-dominated tariff, consumers are segmented into N groups by usage, each firm being cheapest for one group, as illustrated in Figure 5(ii). As discussed earlier, there is no known theoretical explanation of how such an outcome might constitute a competitive equilibrium. However, it can be noted that, qualitatively, this would approximate to an optimising monopolist's menu of N two-part tariffs and so might constitute a *cooperative* equilibrium.

We now explore whether the observed tariff asymmetries exhibit robust features – both over time and across regions – which might be consistent with different firms pursuing systematic and different tariff structures strategies; and, if so, how far these can be described by the market segmentations portrayed in Figure 5.

We introduce a simple statistic which summarises any two-part tariff, the ratio of the fixed fee, F , to the variable element of the bill for a representative consumer (as mentioned earlier, typically, the median consumer has an annual consumption of about, 3300kWh.)

$$FM = (F/3300p) \tag{1}$$

The mean value of FM for the pooled dataset is 0.22. It remained stable during the

first part of the period, before declining steadily in the second part, as marginal prices rose to reflect higher wholesale costs from 2003 (Giulietti et al., 2011). Asymmetry, measured by the standard deviation, is 0.075 over the pooled sample, rising sharply in the second part of the period after initial stability in the first part. Within-region variance dominated throughout, accounting for about 90% of the total variance, and rising further in the later years. This confirms that asymmetry between firms within regions (i.e. individual markets) is the main cause of dispersion, as already found for the component parts, F and p .¹⁴

Figure 6 depicts the inter-firm differences in FM over the period in the form of averages across regions ('incumbent' refers to the average across the different incumbents in the 14 regions.) This confirms that the major entrant, British Gas, consistently set a higher FM ratio than Incumbents, corresponding to the asymmetric duopoly of Figure 5(i). Amongst the five Majors away there was a broad dichotomy in the early years, with three firms (Powergen, SSE and EDF) choosing FM close to the incumbents', and two (SPower and NPower) positioning themselves close to British Gas. Thereafter however, this dichotomy is replaced by a spreading out, more consistent with Figure 5(ii).

Although this Figure is suggestive of strong systematic inter-temporal and inter-firm tendencies in the data, it is based only across-region averages. A more rigorous disaggregated test of robustness can be effected by fitting the following equation.

$$FM_{Ejt} - FM_{Ijt} = \beta_0 BGAS + \beta_1 SP + \beta_2 NP + \beta_3 EDF + \beta_4 SSE + \beta_5 POW + \alpha_j + \varepsilon_{ijt} \quad (2)$$

This examines how far the differential in FM between each entrant (E) and the corresponding incumbent (I) in region j at time t can be explained purely in terms of

¹⁴Decomposing alternatively by firm, between-firm dominates, but less heavily, showing that firms vary tariffs across regions, even allowing for regional cost differences.

fixed effects for each of the entrants (*BGAS*, *SP*, *NP*, *EDF*, *SSE* and *POW*), and α_j for $j = 1, \dots, 14$, the region fixed effects. Since this includes only dummy variables, it is equivalent to analysis of variance, and is estimated using pooled OLS. It is estimated separately for the two sub-periods: the first two years post-liberalisation; and the remaining four years, 2002-2005. Results are shown in Estimations I and II in Table 2.

In the earlier period, the magnitudes of the firm fixed effects confirm the conclusion from Figure 6: British Gas and two of the Majorsaway (*SP* and *NP*) set FM ratios about 0.1 higher than Incumbents, and three (*EDF*, *SSE* and *POW*) opted for an FM very close to (within 0.01 of) Incumbents. Conducting t-tests and Wald tests on the estimated coefficients establishes two distinct groups, within each of which the firms are insignificantly different from each other, but where the groups are significantly different from each other. The outcomes of these tests are shown in the lower part of Table 2. Three of the Majorsaway, along with the Incumbents, offer ‘low’ FM, while two, along with British Gas, offer ‘high’ ratios. This confirms the initial dichotomy. Moreover, the overall fit of the equation is high: 88% of the overall variance is explained by these firm fixed effects alone, confirming that these asymmetries are largely robust across regions and stable in the early years after liberalisation.

For the later period, 2002-2005, recall that this was a period when market structure had stabilised, following consolidation and exit of Independents. Estimation II shows that the simple high-low dichotomy largely disappears. Relative to the Incumbent, one ‘high’ firm moved to a much lower FM ratio; while two ‘low’ firms reduced their FM ratios so as to be now significantly lower than the Incumbents. Wald tests for significant differences between coefficients (at the 5% level, one tailed test) establish the following descending ranking: $\{SP\}$; $\{BGAS\}$; $\{NP, EDF\}$; $\{\text{Incumbent}\}$; $\{SSE \text{ and } POW\}$. The simple dichotomy has been replaced by ‘fanning out’. Again, the overall fit of the equation is quite high, although now just under 70%.

Since this second period appears, from Figure 6, to entail greater inter-temporal change, Estimation III introduces a dynamic element by also including the lagged endogenous variable as an explanatory variable. This provides a simple a method for testing whether the firms' FM ratios are converging towards potentially different long-run levels.

As usual in such an adjustment model, the long-run equilibrium is identified by the ratio of the intercept to the complement of the adjustment parameter. The estimated coefficient on the lagged endogenous variable is significantly lower than unity, indicating convergence to equilibria. The magnitudes of the firm-specific equilibrium FM ratios, shown in the lower panel of the Table, confirm the rank ordering of firms from Estimation II, although the significance of Wald tests is lowered somewhat in for *EDF* and *SSE* relative to the incumbents. To check for bias in the estimates, the model was re-estimated normalising the dependent variable by the region-mean differential at time t , so obviating the need to include region effects. The coefficient on the lagged endogenous variable becomes 0.809, still strongly significantly less than unity, with ranking and relative magnitudes of the firm level coefficients unchanged from Estimation III. Including this variable raises the explanatory power to 85%, which is now line with that achieved for the first part of the period.

These results establish two stylised facts:

Stylised Fact 4: Individual entrants set tariffs (FM ratios), relative to incumbents which are largely robust across different markets (regions).

Stylised Fact 5: Over time, there is a significant evolution from a dichotomous grouping, in which the Majorsaway clustered around British Gas, the major entrant, or the Incumbent, towards dispersion over a wider range of tariff structures, both below and above that of the Incumbent.

These findings suggest that entrants appear to have pursued systematic strategies across regions and over time, and are consistent with a growing awareness by entrants

that segmentation of the market by consumer volume is preferable to a simple strategy of matching the tariff structure of either the incumbent or the main entrant.

7. DISCUSSION AND CONCLUSIONS

This paper has confronted results from the theory of oligopolistic nonlinear pricing with evidence from the first six years of the liberalised British electricity market. As theory suggests, firms offered single two-part electricity tariffs. However, contrary to predictions of current theory, suppliers varied considerably and systematically in their chosen tariffs. Relative to the incumbent, the main entrant, British Gas, selected a tariff with a consistently higher fixed fee and lower marginal price, making it more attractive to households with higher usage, across all regions and time periods. There is also systematic variation in the fixed fees and marginal prices offered by the other major entrants. Immediately after liberalisation, they opted for tariffs with fixed to marginal (FM) ratios which were very similar to those of either the incumbent or British Gas. However, during the second part of the period, this pattern gave way to ‘fanning out’, as firms increasingly offered tariff structures that differed from each other, in a way that would be consistent with market segmentation, according to consumers’ usage.

We have shown that these asymmetries cannot be accounted for by asymmetric costs or variations in brand loyalty or market frictions. While part of the explanation might lie in the institutional details of the pre-liberalised, regulated market (Giulietti and Waddams Price 2005), this fails to explain the systematic and increasing heterogeneity between *different* entrants.

We know of no current theoretical explanation of how the observed asymmetries might form a non-cooperative oligopolistic equilibrium. Existing theory offers few insights into possible tariff asymmetries such as those documented here, and future theoretical work to understand these issues would be valuable. Whether the differentiation of tariffs should be interpreted as the result of unilateral behaviour by firms

designed to soften competition; or of tacitly collusive behaviour approximating a monopolist's optimal menu of two-part tariffs within a setting of repeated (multi-market) interaction, remains an open question.

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8. TABLES AND FIGURES

Figure 1: F and p for all firms, across all regions, across all periods (pooled data)

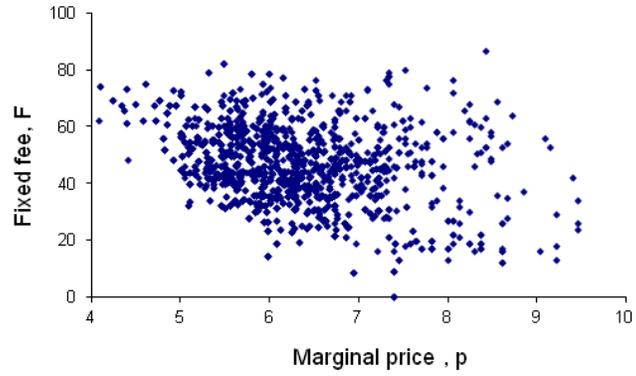


Figure 2: Difference between Entrant and Incumbent charges: all entrants

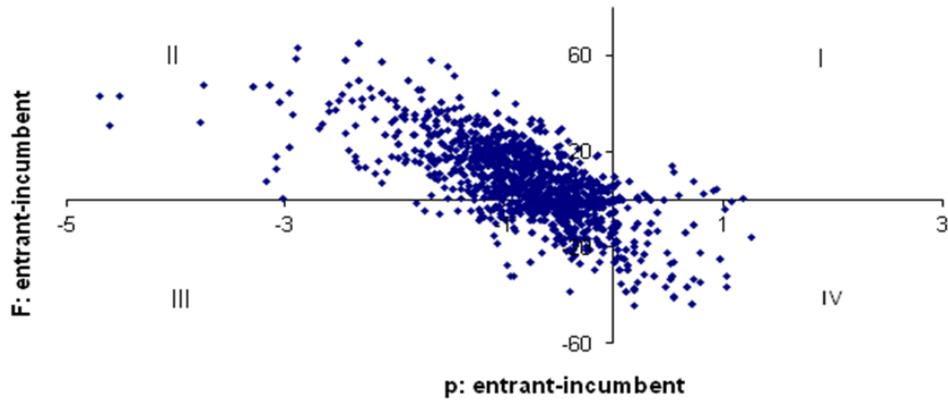


Table 1: Relative frequencies (%) of entrant-incumbent differentials (as shown in Figure 2)

Quad	$F_E - F_I$	$p_E - p_I$		Entrant type		
				All	Brit Gas	Majorsaway
I	>0	>0	Incumbent dominates	1	0	0.2
II	>0	≤ 0	Entrant cheaper for high volume	67.4	97	54.3
	0	0	Symmetry	1.3	0	2.4
III	≤ 0	≤ 0	Entrant dominates	24.7	3	37
IV	≤ 0	>0	Entrant cheaper for low volume	5.6	0	6.1
Total				100	100	100

Figure 3(i): Difference between British Gas and Incumbent charges

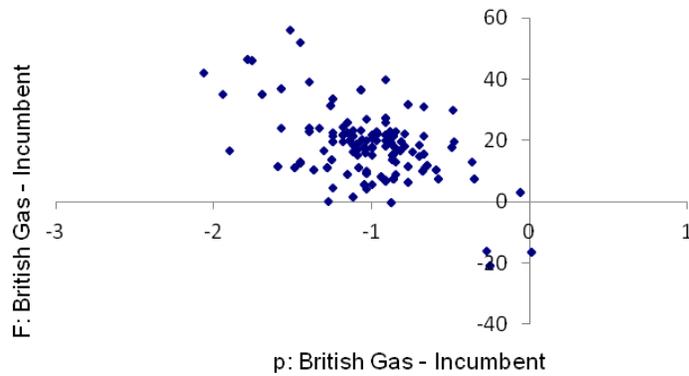


Figure 3(ii): Difference between Majorsaway and Incumbent charges

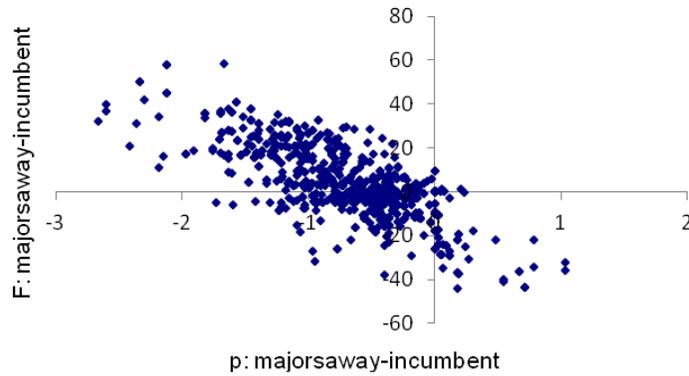


Figure 4(i): Mean p : Incumbents, British Gas and Majorsaway

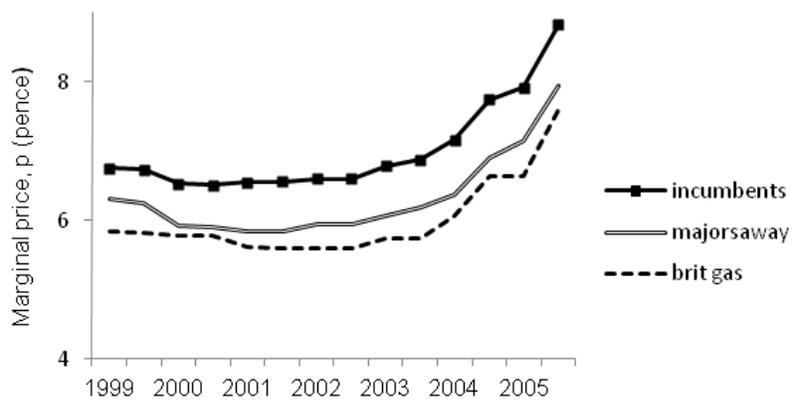


Figure 4(ii): Mean p : Individual Majorsaway

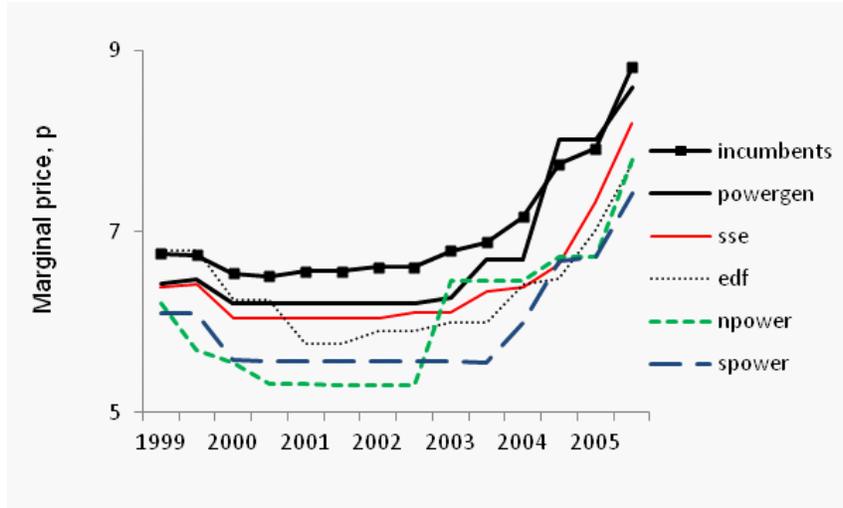


Figure 4(iii): Mean F : Incumbents, British Gas and Majorsaway

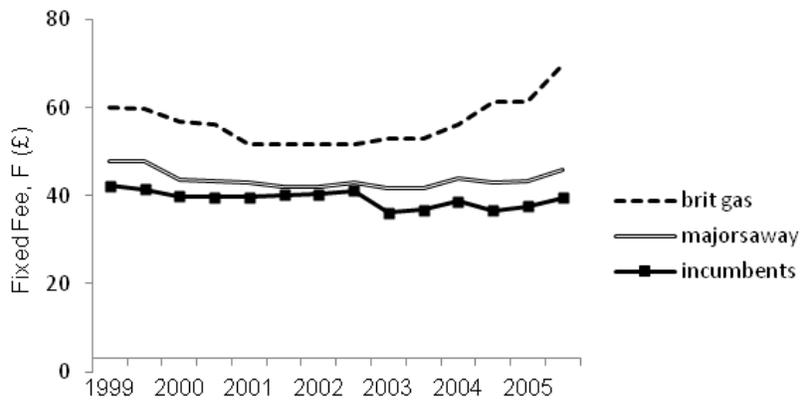


Figure 4(iv): Mean F : Individual Majorsaway

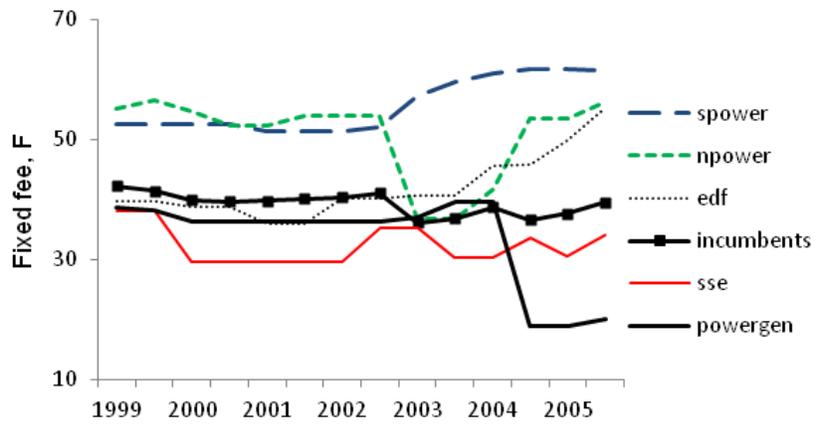
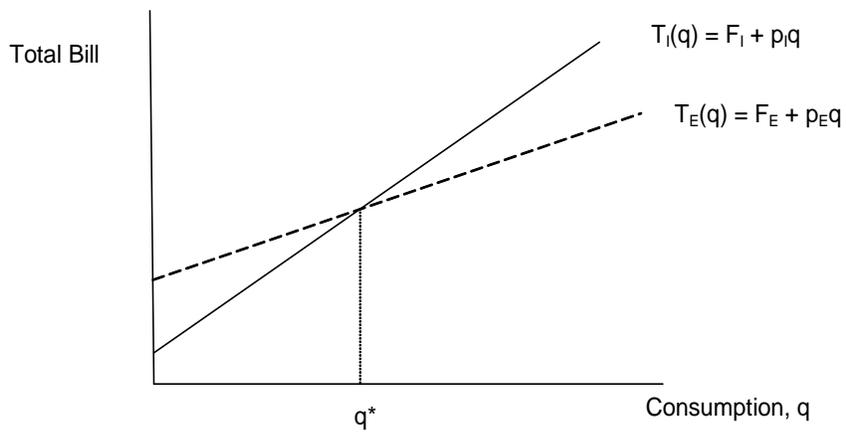


Figure 5(i): Asymmetric duopoly tariffs for entrant, E , and incumbent, I



Figures 5(ii): Asymmetric N -firm oligopoly tariffs ($N = 4$)

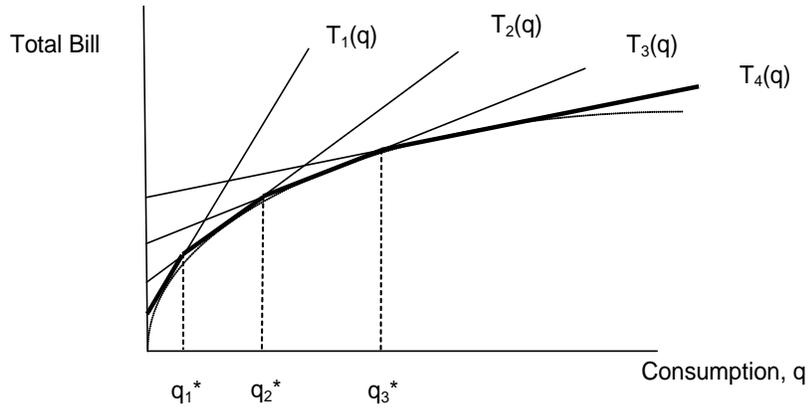


Figure 6: Mean FM ratio: Incumbents and individual entrants

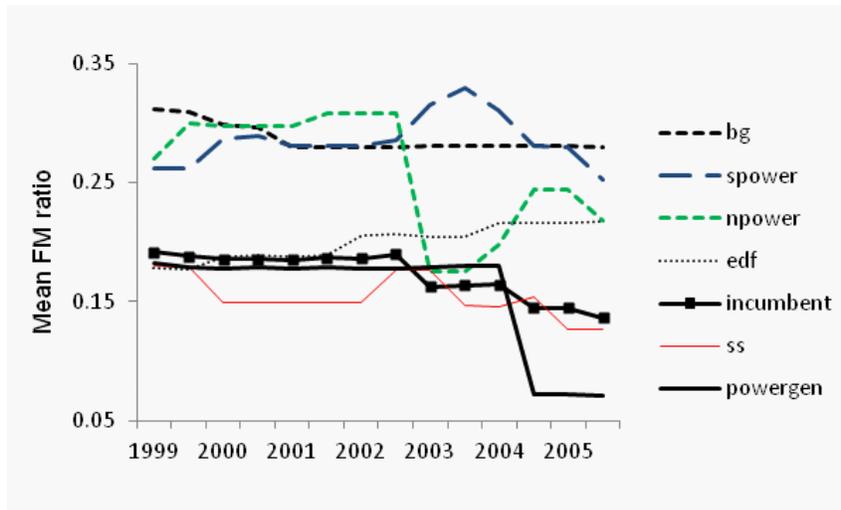


Table 2: Results for difference between Entrant's and Incumbent's FM ratios¹⁵

Estimation	I	II	III
Period	1999.1-2000.2	2001.1-2005.2	2001.1-2005.2
	Pooled OLS	Pooled OLS	Pooled OLS
BGAS	0.1316** (0.0081)	0.0912** (0.0081)	0.0270** (0.0071)
SP	0.1057** (0.0081)	0.1032** (0.0099)	0.0291** (0.0084)
NP	0.1182** (0.0072)	0.0578** (0.0108)	0.0121 (0.0084)
EDF	0.0111 (0.0064)	0.0155(*) (0.0085)	0.009 (0.0182)
SSE	-0.0061 (0.0071)	-0.0353** (0.0084)	-0.0094 (0.0072)
POW	0.0058 (0.0058)	-0.0436** (0.0088)	-0.0182** (0.0069)
Lagged Dep Variable			0.7150** (0.0411)
N	302	714	714
R ²	0.8826	0.6936	0.8455

Identifiable groups by magnitude of differential (% points)¹⁶

	I	II	III
High	BGAS 13.2 NP 11.8 SP 10.6	SP 10.3 BGAS 9.1	SP 10.2 BGAS 9.4
Intermediate		NP 5.8 EDF 1.6	(NP 4.2)
Low: Equal to Incumbent	EDF 1.1 POW 0.6 Incumbent 0.0 SSE -0.6	Incumbent 0.0	EDF 3.2 Incumbent 0.0 SSE -3.2
Low: Below Incumbent		SSE -3.5 POW -4.4	POW -6.4

¹⁵Notes: 1. Region individual effects not shown (Manweb is default region). 2. Standard errors shown in parentheses; ** denotes coefficient estimate significantly different from zero at the 1% level, * at the 5% level, (*) at the 10% level. 3. Equations are estimated in STATA employing the robust correction.

¹⁶Groups are identified using Wald tests of restrictions on coefficient estimates in each equation. All firms in each group are insignificantly different from each other but significantly different from those in other groups.