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ABSTRACT

Can competition Replace Regulation for Small Utility Customers?*

Many utility markets are now being opened to competition and some regulators have expressed the hope that this will make the regulation of consumer prices unnecessary. In this Paper, entrants offer (differentiated) ‘added value’, but consumers incur a switching cost if they buy from one of them. The incumbent’s profit-maximising price may be well above the level of its costs. This is likely to be the case in the UK’s energy industries, but competition may be able to replace regulation in telecommunications, where marginal costs are lower, demand elasticity higher and entrants can give more ‘added value’.

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Keywords: regulation, competition, utilities, switching costs

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NON-TECHNICAL SUMMARY

Many utility markets are now being opened to competition. Large customers have generally been the first to have the option of choosing their supplier, but this right has gradually been extended to smaller customers: households and small businesses. The traditional model of a utility was a monopoly, subject to regulation intended to protect consumers, but its shortcomings have become well known and moves towards liberalizing the utilities are a reaction to these.

Many regulators hope that they will be able to stop regulating prices in markets where competition is sufficiently well established and concentrate on the remaining areas of natural monopoly. In the UK telecommunications market, for example, only the (retail) prices paid by the bottom 80% of BT's customers are regulated, while the energy regulator is just about to remove price controls from one of the three main tariffs for gas and electricity (the cheapest of the three, involving payment by automatic bank transfers).

This Paper asks whether the hope that competition can succeed regulation is justified, in the light of the fact that most consumers have not switched supplier, even though savings of up to 20% were available for doing so. This inertia can be modelled as a type of 'switching cost', albeit mainly psychological, since the process of changing suppliers has been designed to be as easy as possible. The 'fear of the unknown' may diminish over time, as more customers hear of people who have successfully switched. Nevertheless, there are still reasons to expect many people to be insensitive to price differentials – in particular, 'new customers' are inherited by the previous supplier at their address and there is no 'annual renewal notice', as with insurance contracts, to spur people to shop around.

In this Paper, an endogenous number of entrants compete with an incumbent utility in a single-period model. Each consumer has a price-sensitive demand for the utility product: the elasticity of this demand is a key parameter affecting the results. Each entrant offers a different type of 'added value', such as giving Air Miles which can be exchanged (eventually) for free flights – consumers vary in the utility they would get from each entrant's feature. Consumers who switch from the incumbent must incur a switching cost, which is also customer-specific. Customers also take the price charged by each supplier into account when choosing the supplier that maximizes their utility. The firms' market shares depend on their prices and on the distribution of switching costs and added values.

Each supplier independently chooses a profit-maximizing price. In equilibrium, the entrants choose the same price, which undercuts the incumbent's price, at least for the parameter values studied here. (There seems to be little hope for

competition in a market in which entrants are unable to undercut incumbents.) This price can be above marginal cost, since the added value features and switching costs differentiate the firms, but entry will occur until the entrants' price approaches their average cost and further entry would be unprofitable.

The model is solved numerically, with parameter values chosen to represent the energy utilities in the UK. A regulator might require the utility to charge a 'safety net' price equal to its average costs, to protect customers who do not change suppliers, but an unregulated incumbent would choose a price well in excess of its marginal costs and above average cost. For a gas supplier, marginal costs may be around 90% of average costs, implying a low mark-up for the regulated incumbent. An unregulated incumbent would maximise profits by increasing this margin and sacrificing market share. If individual demands are very insensitive to price, the incumbent might be willing to give up half of the market to entrants. The high prices would reduce welfare by one-sixth of the regulated monopoly's turnover. The equilibrium mark-up, loss of market share and welfare cost all fall as individual demands become more sensitive to price. Most of the incumbents in the UK electricity industry combine supply with distribution networks and have a lower ratio of marginal costs to average costs. Their higher initial mark-ups make them less willing to sacrifice market share for higher prices and so the welfare costs of complete deregulation are lower, although probably still too high to be acceptable. In the telecommunications industry, however, marginal costs are very low, initial mark-ups high and some entrants (particularly those selling cable television and mobile phones) offer significantly enhanced services. Competition is likely to be far more effective in this industry and relaxing regulation a sensible policy.

While this model suggests that competition in the energy utilities may not be sufficiently powerful to replace regulation, the model is static and many of the benefits of competition are dynamic. If competition leads incumbents to reduce their costs, for example, there will be benefits ignored by this model. That is most likely to happen, however, if the incumbents' prices are kept down, which could be the result of safety-net regulation, or could be the profit-maximizing response to consumer mobility. The argument of this Paper is that consumers have not yet shown themselves sufficiently mobile for competition to be an adequate restraint on prices.

Can Competition replace Regulation for Small Utility Customers?

Richard Green

University of Hull and CEPR

I. Introduction

Many utility markets are now being opened to competition. Large customers have generally been the first to have the option of choosing their supplier, but this right has gradually been extended to smaller customers: households and small businesses. In the United Kingdom, Mercury was BT's only rival for fixed-link telephone services between 1983 and 1991, and concentrated on the business market, but cable television companies were allowed to offer telephone services in their own right from 1991 onwards, and now have a market share approaching 10% of households. Since the cable networks only pass a proportion of the country's homes, the companies' market share of the homes they pass is much higher. Large gas consumers were offered a choice of supplier from 1986 (although much regulatory action was needed to make this effective), while competition was extended to households in stages between 1996 and 1998. Domestic electricity consumers have been able to choose their supplier from late 1998 or early 1999. In the US, consumers have been able to choose their long distance telephone company since 1984, and this choice is gradually being extended to their local company. Several states are liberalising their electricity markets and allowing domestic customers a choice of supplier. Similar trends exist in other countries.

The traditional model for a utility was a franchised monopoly, which served all the customers in its area, at regulated prices. Regulation was intended to protect consumers from the monopoly, but its shortcomings have become well-known, and moves towards liberalisation are a reaction to these. In many industries, competition between firms provides good outcomes for consumers: products are supplied at prices close to their costs, which are kept low. Many regulators hope that they can stop regulating prices in markets where competition has become established, and concentrate on the remaining areas of natural monopoly. Once a market has been opened to competition, regulating part of it is likely to create distortions, and competition may be a more effective safeguard for consumers, in any case. The most recent price control for BT only covers the prices paid by the smallest 80% of the companies' domestic customers, and the regulator has expressed the hope that it will be the last control on retail prices. Final prices to large gas and electricity customers are no longer regulated, and the regulator has just proposed lifting the controls on customers who pay by direct debit. This automatic bank transfer is the cheapest payment method, and customers using it are statistically most likely to change supplier. Other tariffs will still be price-capped, but the caps have only been set for one year in gas, and two in electricity, raising the possibility that further caps will not be needed.

This paper asks whether such hopes are justified. In countries like the UK and the US, most utility markets are saturated, and entrants can only compete by winning customers from the incumbent utility. Furthermore, most customers incur switching costs (real or psychological) before they can move away from the incumbent. The need to find out about alternative suppliers, to go through the administrative procedures required to switch, and the fear that they will receive a lower quality service after switching are all likely to deter people from changing suppliers. The facts that alternative suppliers may bombard customers with information, that the customer needs to do very little to change supplier, and that there cannot be any change in the quality of service (for a homogeneous product like electricity, supplied through the same network) may be much less important than the perceptions. How else can we explain the fact that around 75% of British Gas consumers in the trial areas where a choice of supplier was allowed did *not* choose to save around 20% of their gas bill[1] by switching to one of several rival firms?

Klemperer (1987a, 1987b) models competition between firms when consumers must incur a cost before they switch to another firm's product. These costs can limit competition once a market is established, but strengthen it in the early stages of the market (or once entry

[1] The annual average gas bill when competition began was £335, so that this represented an average saving of £65 in the first year. Customers with higher bills (and therefore larger savings) were somewhat more likely to switch supplier (Waddams Price, 1997).

is allowed (Klemperer, 1989)) as firms fight to establish a high market share. Farrell and Shapiro (1988) show that an incumbent with a large number of "locked-in' consumers might be content to charge a high price and exploit these consumers, even though this means ceding all "new" consumers to a rival. Knittel (1997) shows that long distance telephone rates in the US were higher when consumers had to pay a switching cost to change their carrier.

This paper sets out a model of price competition between an incumbent utility and competing entrants, when consumers have switching costs, but also gain utility from some (company-specific) features of the entrants' services, which we will call their "added value". The best example of such a feature is the television service provided by cable companies, but gas suppliers have offered a variety of incentives, on top of price reductions, to attract customers. This means that we can treat the entrants as offering a differentiated product (if only slightly so) and need not condemn them to pricing at marginal cost. This follows the discrete choice approach to product differentiation (Perloff and Salop, 1985; Anderson *et al*, 1992). We can derive (symmetric) profit-maximising prices for the entrants, whose number is determined endogenously by the need to cover their fixed costs. The entrants will want to undercut the incumbent in order to overcome the switching costs (which are assumed to have a greater support than the entrants' added value). The main aim of the paper is to derive the profit-maximising price which an unregulated incumbent would set. If switching costs allow the incumbent to charge a high price, then continued regulation may well be desirable. We do not attempt to derive exact conditions which make this regulation desirable, but to raise the issue as one which regulators should consider.

The paper does derive (static) estimates for the change in welfare resulting in deregulation, but regulators are pinning their hopes on the dynamic impacts of competition. Companies' costs may fall faster in a competitive market, and customers' (subjective) switching costs may fall once they are aware of other people who have changed supplier without any problems. At the same time, the market for utility services may never become as competitive as (say) the market for car insurance. There are switching costs in changing insurance company, but the receipt of an annual renewal notice will prompt some consumers to shop around – unless the receipt of a utility bill is viewed as an equivalent reminder, there will be no "annual churn" of customers. Furthermore, someone moving house will almost automatically take over the existing utility services, which removes the competition for "new buyers" which is a powerful feature of other models with switching costs (e.g. Farrell and Shapiro 1988). If competition is unlikely to strengthen over time, then a static approach may not be inappropriate.

Section II describes the model and derives (algebraic) conditions for profit maximisation. These are somewhat involved, and so Section III turns to numerical solutions, deriving the incumbent's and the entrants' profit-maximising prices for high and low marginal costs, and for different values of the elasticity of demand. In Section IV, these parameter values and solutions are related to the circumstances of the utilities in the United Kingdom, which are now being opened up to competition.

II. The model.

The agents in our model are an incumbent utility, N entrants (where N is determined endogenously), and a continuum of consumers. The market lasts for a single period. In a multi-period framework, fully rational consumers would need to forecast prices and to take account of the consequences of becoming "locked in" to one supplier when deciding whether to switch in the first period. Our model sidesteps these issues, although our price and quantity variables might be seen as the present values of sequences of prices and quantities.[2]

Each consumer (indexed by *j*) buys from a single supplier, and chooses their supplier and the quantity they consume (x_j) to maximise their utility, given by:

$$\begin{aligned} U_j &= \frac{A}{b}x_j - \frac{1}{2b}x_j^2 + Y - p_i x_j && \text{if buying from the incumbent} \\ &= \frac{A}{b}x_j - \frac{1}{2b}x_j^2 + Y - p_e x_j + v_{ej} - s_j && \text{if buying from entrant } e, \quad e = 1 \dots N \end{aligned} \tag{1}$$

[2] If all the entrants adopt the same price path, no consumer would switch between entrants, and if the entrants' prices never exceed the incumbent's, then any consumer who is going to switch to an entrant should do so as soon as possible. There could well be multi-period equilibria without these characteristics, however.

where p_i is the incumbent's price, p_e the price charged by entrant *e*, and *Y* is the consumer's income, so that $Y - p_e x_j$ is their consumption of all other goods: their utility is assumed separable in these. The switching cost incurred by consumer *j* if they stop buying from the incumbent is s_j, while the added value of buying from entrant *e* is v_{ej}. These are treated as random variables. The first-order condition for utility maximisation gives us the amount which a consumer will buy if they choose a supplier with a price of *p*:

$$x_j = A - bp \tag{2}$$

It is straightforward to show that the consumer's utility is given by:

$$\begin{aligned} U_j &= \frac{1}{2b}\left(A - bp_i\right)^2 + Y && \text{if buying from the incumbent} \\ &= \frac{1}{2b}\left(A - bp_e\right)^2 + Y + v_{ej} - s_j && \text{if buying from entrant } e \end{aligned} \tag{3}$$

The consumer thus chooses their supplier to maximise their utility as given by (3). They will prefer entrant *e* to the incumbent if:

$$v_{ej} > s_j - A\left(p_i - p_e\right) + \frac{b}{2}\left(p_i^2 - p_e^2\right) \tag{4}$$

and will prefer entrant *e* to entrant *f* if:

$$v_{ej} > v_{fj} - A\left(p_f - p_e\right) + \frac{b}{2}\left(p_f^2 - p_e^2\right) \tag{5}$$

We will assume that s_j is uniformly distributed on [0,S], while the v_{ej} are independently uniformly distributed on [0,V]. Many discrete-choice models use an extreme value distribution, but this would imply that some consumers would lose utility from an entrant's "added value", which seems intuitively unlikely. We assume that V<S, so that there are some consumers who will only switch to an entrant if it offers a lower price than the incumbent: the highest switching costs are larger than the entrants' greatest "added value." If the entrants undercut the incumbent, (which they will in equilibrium)[3] then consumers with low switching

[3] This is probably due to the assumption that V<S. Schlesinger and von der Schulenburg (1991) model the insurance market with switching costs and differentiated products and find equilibria in which the entrants' brands are so strongly preferred by some consumers that they maximise profits by charging higher prices than the incumbent firms.

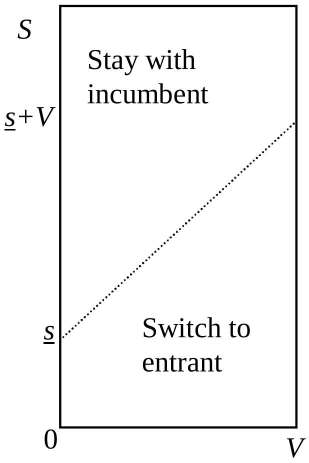


Figure 1: Switching with one entrant

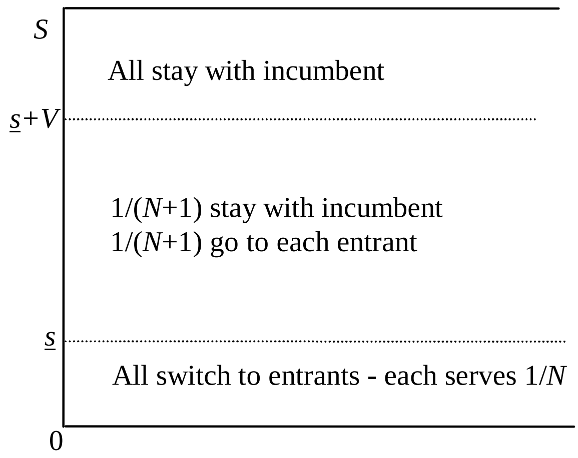


Figure 2: Switching with N entrants

costs will all buy from an entrant, whatever their values of v_{ej}. The highest switching cost at which all consumers will switch will be defined as $\underline{s}$, given by:

$$\underline{s} = \left(p_i - \underline{p}\right)\left(A - \frac{b}{2}\left(p_i + \underline{p}\right)\right) \tag{6}$$

where $\underline{p}$ is the (symmetric) price charged by the entrants.

With a single entrant, it is simple to plot values of s_j and v_{ej} and determine whether each consumer will buy from the entrant or the incumbent. Figure 1 does so, showing that consumers with high values of s_j and low values of v_{ej} will stay with the incumbent. Figure 2 shows what will happen if we have N entrants, each setting the same price (as they will in our symmetric equilibrium). Each entrant will serve $1/N$ of the customers with switching costs below $\underline{s}$, since none of them will stay with the incumbent. All of the customers with switching costs of more than $\underline{s}+V$ will find it optimal to stay with the incumbent, because their switching costs outweigh even the best entrants' added value. The remaining customers are shared evenly between the N+1 firms. The customer chooses the firm with the highest value of v_{ej} , unless (s_j - $\underline{s}$) is greater, and each of these N+1 variables has the same, independent, distribution within this group of customers. The incumbent serves almost all of the customers with switching costs which are close to $\underline{s}+V$, and very few of those with costs close to $\underline{s}$, of course, but across this group as a whole, each firm serves the same proportion.

Figure 3: Two entrants with equal prices

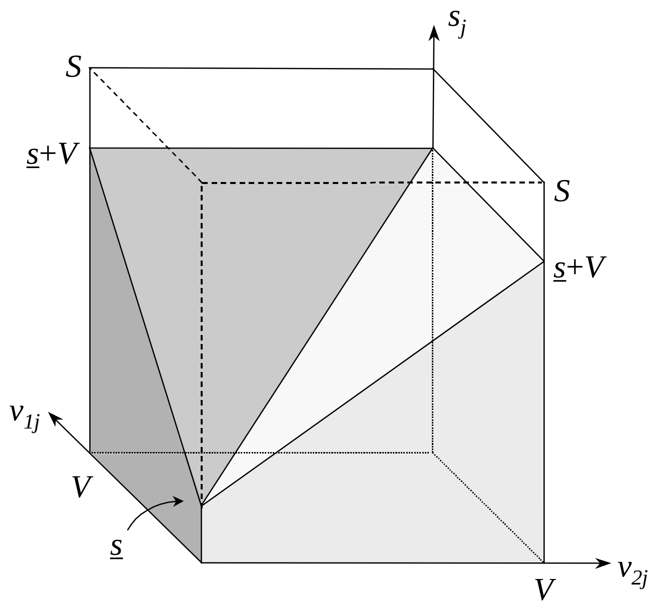


Figure 3 shows what will happen when there are two entrants, in three dimensions. Consumers with low values of s_j change to one of the entrants: those for whom v_{1j} is higher will switch to entrant 1 (the darker shaded solid in the "north-west" half of the box), while those for whom v_{2j} is higher will switch to entrant 2 (the lighter shaded solid). Consumers with high values of s_j , towards the top of the cube (the transparent part of the figure), will remain with the incumbent.

If we normalise the size of the population to one, the number of customers served by the incumbent (h_i) is equal to:

$$h_i = 1 - \frac{\underline{s}}{S} - \frac{N}{N+1}\frac{V}{S} \tag{7}$$

and the incumbent's total sales are given by:

$$q_i = \left(1 - \frac{\underline{s}}{S} - \frac{N}{N+1}\frac{V}{S}\right)\left(A - bp_i\right) \tag{8}$$

We can differentiate equation (8) with respect to the incumbent's price:

$$\frac{\partial q_i}{\partial p_i} = -b\left(1 - \frac{\underline{s}}{S} - \frac{N}{N+1}\frac{V}{S}\right) - \frac{1}{S}\left(A - bp_i\right)\frac{\partial \underline{s}}{\partial p_i}$$

$$= -b\left(1-\frac{\underline{s}}{S}-\frac{N}{N+1}\frac{V}{S}\right) - \frac{1}{S}\left(A-bp_i\right)^2 \qquad (9)$$

It is harder to derive an entrant's demand, since we need to consider deviations from the symmetric equilibrium. Assume that N-1 firms charge the price $\underline{p}$, but that one entrant (number 1) decides to undercut this price by δ. Customers who switch to this entrant will now derive slightly more utility, since they respond to the lower price by consuming slightly more. We can calculate this gain, ε, from the consumers' utility function:

$$\varepsilon = \delta\left(A - \frac{b}{2}\left(2\underline{p} - \delta\right)\right) \qquad (10)$$

All consumers with a switching cost of less than ($\underline{s}+\varepsilon$) will now leave the incumbent for one of the entrants. Any of the entrants may be able to offer enough "added value" to attract a consumer with switching costs between ($\underline{s}+\varepsilon$) and ($\underline{s}+V$). Only the low-price entrant will be able to attract any consumers with a switching cost of between ($\underline{s}+V$) and ($\underline{s}+\varepsilon+V$). All customers with switching costs of more than ($\underline{s}+\varepsilon+V$) will stay with the incumbent. Figure 4 shows this in two dimensions, and figure 5 in three: note that the dark solid, representing the customers served by entrant 1, is larger than in figure 3.

We derive the number of customers (h_1) served by entrant 1, by integrating over their switching costs. We denote the density function of these costs by g(s):

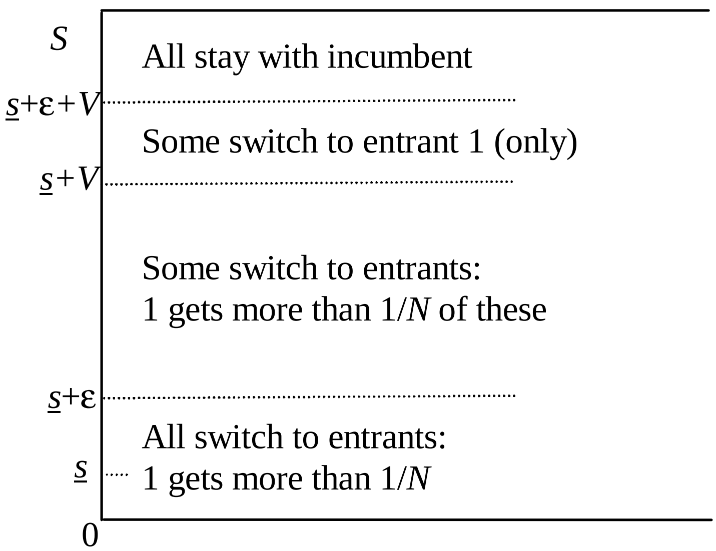
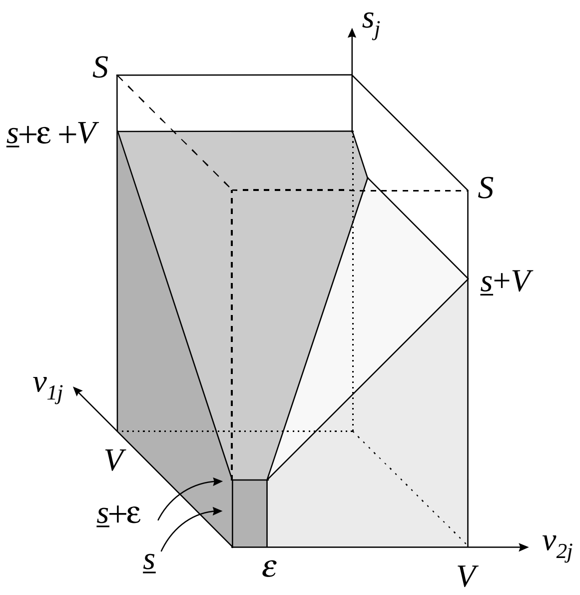


Figure 4: Switching when one entrant undercuts the others

Figure 5: Two entrants with different prices



$$h_1 \quad = \quad \int_0^{\underline{s}+\varepsilon} g(s)\,prob(v_{1j} > (v_{2j}-\varepsilon)...(v_{Nj}-\varepsilon))ds \qquad (11)$$

$$+\int_{\underline{s}+\varepsilon}^{\underline{s}+V} g(s)\,prob(v_{1j} > (s-\underline{s}-\varepsilon),(v_{2j}-\varepsilon)...(v_{Nj}-\varepsilon))ds \;+\; \int_{\underline{s}+V}^{\underline{s}+\varepsilon+V} g(s)\,prob(v_{1j} > s-\underline{s}-\varepsilon)ds$$

The first integral represents the bottom "slice" of figure 4, when all customers switch, and choose entrant 1 if it offers the highest value to them (given that its lower price increases their utility by *ε*). The second integral represents the second slice, when customers will only switch if their cost of doing so is less than the gain from buying from an entrant, and will again only choose entrant 1 if it offers the highest value among the entrants. The third integral represents the third slice of figure 4, in which only entrant 1 is an effective competitor to the incumbent. Using *f(v)* and *F(v)* for the density and distribution functions of the entrants' added value, we can rewrite this as:

$$\begin{aligned} h_1 \quad = \quad & \int_0^{\underline{s}+\varepsilon} g(s)\left[\int_0^{V-\varepsilon} f(v)F(v+\varepsilon)^{N-1}dv + \int_{V-\varepsilon}^{V} f(v)dv\right] ds \\ & + \int_{\underline{s}+\varepsilon}^{\underline{s}+V} g(s)\left[\int_{s-\underline{s}-\varepsilon}^{V-\varepsilon} f(v)F(v+\varepsilon)^{N-1}dv + \int_{V-\varepsilon}^{V} f(v)dv\right] ds \qquad (12) \\ & + \int_{\underline{s}+V}^{\underline{s}+\varepsilon+V} g(s) \int_{s-\underline{s}-\varepsilon}^{V} f(v)dv \;\; ds \end{aligned}$$

Once we substitute our chosen (uniform) distributions, and solve, we get:

$$h_1 = \frac{\underline{s}+\varepsilon}{S}\left(\frac{1}{N}\left(1-\frac{\varepsilon^N}{V^N}\right)+\frac{\varepsilon}{V}\right)+\frac{1}{S}\left(\frac{V}{N+1}+\frac{N-1}{N}\varepsilon+\frac{\varepsilon^{N+1}}{N(N+1)V^N}-\frac{\varepsilon^2}{V}\right)+\frac{\varepsilon^2}{2SV} \quad (13)$$

Note that if $\delta = 0$, then $\varepsilon = 0$, and we get:

$$h_1 = \frac{\underline{s}}{S}\frac{1}{N}+\frac{V}{S}\frac{1}{N+1} \quad (14)$$

which is the market share predicted in figure 2. The entrant's sales are given by:

$$q_1 = h_1\left(A-b\left(\underline{p}-\delta\right)\right) \quad (15)$$

We can find the derivative of q_1 with respect to δ:

$$\frac{\partial q_1}{\partial \delta} = b\,h_1 + \left(A-b(\underline{p}-\delta)\right)\frac{\partial \varepsilon}{\partial \delta}\left(\frac{1}{S}+\frac{\underline{s}+\varepsilon}{VS}-\frac{(\underline{s}+\varepsilon)}{S}\frac{\varepsilon^{N-1}}{V^N}\right) \quad (16)$$

This is positive, because δ is the amount by which the price is *reduced*. It is easier to work with the derivative of quantity with respect to the entrant's price,[4] and in the symmetric equilibrium, we have:

$$\left.\frac{\partial q_1}{\partial p_1}\right|_{p_1=\underline{p}} = -\frac{b}{S}\left(\frac{\underline{s}}{N}+\frac{V}{N+1}\right)-\left(A-b\underline{p}\right)^2\left(\frac{1}{S}+\frac{\underline{s}}{SV}\right) \qquad N \geq 2$$

$$= -\frac{b}{S}\left(\underline{s}+\frac{V}{2}\right)-\frac{\left(A-b\underline{p}\right)^2}{S} \qquad N = 1 \quad (17)$$

We assume that each firm will set its price independently, to maximise its profits, given the prices set by the other firms. Any firm may enter the industry, on paying a fixed cost of *e*, and entry will continue until an additional entrant would just make losses.[5] The entrant's profits are given by:

$$\pi_e = q_e(p_e - c_e) - e \quad (18)$$

where c_e gives the level of the entrants' marginal costs (assumed symmetric). The entrant's first order condition[6] can be obtained by differentiation:

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[4] The derivative with respect to a unilateral price *increase* is the same at $p_1 = \underline{p}$, although a different formula is needed for larger deviations.

[5] This is the zero-profit condition, adapted for the need to have an integer number of firms.

[6] Caplin and Nalebuff (1991) study discrete choice models and prove that if the density of consumers' utility parameters (s_j and v_{ej})is logconcave (which it is for our distributions), then the first order conditions will give a profit-maximising equilibrium.

$$\frac{\partial \pi_e}{\partial p_e} = \frac{\partial q_e}{\partial p_e}(p_e - c_e) + q_e \quad \Rightarrow \quad p_e = c_e - \frac{q_e}{\frac{\partial q_e}{\partial p_e}} \tag{19}$$

The incumbent has a similar profit function and first order condition:

$$\pi_i = q_i(p_i - c_i) - f_i \tag{20}$$

$$\frac{\partial \pi_i}{\partial p_i} = \frac{\partial q_i}{\partial p_i}(p_i - c_i) + q_i \quad \Rightarrow \quad p_i = c_i - \frac{q_i}{\frac{\partial q_i}{\partial p_i}} \tag{21}$$

where c_i gives the level of the incumbent's marginal costs and f_i the level of their fixed costs. The first order conditions contain terms in p_e cubed, and while analytical solutions exist, we are likely to gain more insight from a numerical approach.

Before calculating numerical solutions, however, we can derive algebraic expressions for welfare, equal to the sum of consumer surplus and profit. Consumers who still buy from the incumbent obtain consumer surplus of:

$$\sigma = \frac{1}{2b}\left(A - b\, p_i\right)^2 \tag{22}$$

while if consumer j buys from entrant e they will get:

$$\sigma_{ej} = \sigma + \underline{s} + v_{ej} - s_j \tag{23}$$

Note that the consumer will only buy from an entrant if (23) is greater than (22), and will chose their seller to maximise the value of (23). The surplus gained by consumer j is therefore equal to:

$$\sigma_j = \max\left\{\sigma, \sigma_{ij} ... \sigma_{nj}\right\} \tag{24}$$

The appendix shows how to derive the expected surplus across all consumers, which turns out to equal:

$$\Sigma = \sigma + \frac{N}{N+1} \frac{\left(\underline{s} + V\right)V}{S} + \frac{\underline{s}^2 - V^2}{2S} + \frac{1}{N+1} \frac{1}{N+2} \frac{V^2}{S} \tag{25}$$

Overall welfare can then be calculated.

III. Parameters and Model Solutions

The size of the population has been normalised to equal one. The parameters of the utility function, A and b, are chosen together so that each consumer buys one unit of the product at a price of one. Our parameters give elasticities (ignoring changes in demand due to switching between firms) of -0.1, -0.5, -1, and -2 at this price. The highest switching cost, S, was set to

1.8, and the highest "added value", V, to 0.3. Given these parameters, if five entrants each offered a price of 0.8, 5% of customers would switch to each entrant. This fits the "stylised fact" from the UK gas industry, that British Gas lost 25% of its customers when its rivals undercut it by 20%.[7]

We will assume that the incumbent and the entrants have the same marginal costs, but that their fixed costs may differ. The incumbent's fixed costs are assumed to equal ($1-c_i$), so that the regulator would wish to set an incumbent monopoly's price to equal one. We will not ask how the regulator sets this price: although a cost-plus rule would be the most straightforward, the fixed costs might be defined to include an information rent, if a more complex regulatory process takes account of asymmetric information. Our "regulated price" will equal the incumbent's average costs, given its equilibrium output, in each scenario.

The values for the entrants' fixed costs will be low enough to allow these smaller firms to break even while undercutting the incumbent by a substantial margin, but high enough to keep the equilibrium number of entrants low. The entrants' average costs will be less than the incumbent's, which could reflect the entrants' use of more modern technology, or "stranded costs" incurred by the incumbent, such as purchase contracts at prices which are now "above market". In the US, mechanisms have been designed to ensure that these costs are recovered from the customers of all suppliers, but in the UK, regulators have expected incumbents to cover their costs from their own revenues alone.

The tables present the change in welfare which would come about if the incumbent's prices were deregulated. Note that an incumbent monopoly, regulated as described above, would have revenues equal to 1, and so the figures given for welfare changes can be interpreted as a proportion of the industry's "base case" revenues.

With high marginal costs, an unregulated incumbent will maximise its profits with a price which is well above the regulated price. The incumbent is willing to lose a lot of market share in order to increase its profits from the customers which it continues to supply: in the case with the lowest elasticity, it serves less than half of the market. When the elasticity is higher, a higher price means that the incumbent will lose a significant amount of sales from the customers which it continues to supply, as well as from the customers who

[7] In this model, the amount of market share lost depends upon the number of entrants, since the incumbent retains $1/(N+1)$ of the customers with switching costs between $\underline{s}$ and $\underline{s}+V$. A single entrant would capture 19% of the market, while a very large number would take 28%. Using five equally-sized entrants produces "round numbers". More than five firms have entered the British gas industry, but their market shares are very uneven, implying a smaller "n-firm equivalent".

High Marginal Costs (c = 0.9, e = 0.003)

Elasticity	Incumbent	Incumbent's Price	Entrants' Price	N	Incumbent's share of customers	Change in Welfare
-0.1	Regulated	1.02	0.977	3	0.85	
	Unregulated	1.69	0.941	7	0.45	-0.168
-0.5	Regulated	1.02	0.974	3	0.85	
	Unregulated	1.60	0.945	6	0.54	-0.157
-1.0	Regulated	1.02	0.971	3	0.85	
	Unregulated	1.37	0.950	5	0.66	-0.105
-2.0	Regulated	1.03	0.965	3	0.84	
	Unregulated	1.18	0.954	4	0.76	-0.057

switch, and so the profit-maximising price is lower. The entrants' price does not vary much in response to the incumbent's price, but entry ensures that this price is kept close to the entrants' average cost, and an increase in the incumbent's price leads to a greater number of entrants. Welfare could fall by up to one-sixth of the industry's "base case" revenues as a result of deregulating the incumbent's prices – a dramatic reduction.[8]

With lower marginal costs, the incumbent's fixed costs are higher, and its average cost increases more significantly as it loses sales to the entrants. It has to raise its price to compensate for this effect, but if the elasticity is too great, this will reduce the incumbent's sales so much that it cannot find a break-even point. With marginal costs of 0.7, fixed costs of 0.3, and an elasticity of -2, the incumbent cannot break even. For less elastic demands, the regulated and unregulated prices are closer together than in the previous table: the regulated price already includes a much larger mark-up over marginal cost, and the profit-maximising incumbent does not need to increase the price by as much. Even so, the reductions in welfare from deregulating the incumbent's prices remain high.

We chose a fairly high value of the entrant's fixed costs, ensuring that there is only one entrant in most of the equilibria. With more than one entrant, it would be even harder for the incumbent to recover its fixed costs, while the entrants, who cannot sustain large mark-

[8] With high marginal costs, allowing entry but regulating the incumbent's prices increases welfare compared to the monopoly outcome – consumers' gains from the entrants' added value and price reductions exceed the entrants' fixed costs. In the second set of cases, however, fixed costs are relatively higher, and allowing entry produces a (static) welfare loss, even when the incumbent remains regulated.

Low Marginal Costs (c = 0.7, e = 0.025)

Elasticity	Incumbent	Incumbent's Price	Entrants' Price	N	Incumbent's share of customers	Change in Welfare
-0.1	Regulated	1.05	0.947	1	0.86	
	Unregulated	1.56	0.831	2	0.49	-0.171
-0.5	Regulated	1.07	0.939	1	0.85	
	Unregulated	1.41	0.815	2	0.57	-0.150
-1.0	Regulated	1.11	0.935	1	0.82	
	Unregulated	1.24	0.975	1	0.79	-0.056

ups, would only survive if they had very low fixed costs, which might seem implausible relative to the incumbent's.

To represent the telecommunications industry, we would need to increase the ratio of fixed to variable costs, and hence the mark-up needed by the incumbent. The elasticity of demand could also be quite high. If so, the incumbent would find it difficult to sustain a mark-up which was high enough to break even, unless switching costs were higher than we have assumed, or competition was less intense. We would not have to worry about excessive profits.

IV. Conclusions

The numerical examples of section 3 show that many incumbent companies could wish to raise prices substantially if competition is used to replace regulation. Real or perceived switching costs mean that many of their customers will remain loyal, even when entrants offer much lower prices.

The incentive to raise prices is particularly pronounced when the incumbent's marginal costs are close to its regulated price. In the UK, electricity and gas suppliers pay regulated charges for the use of the delivery network, and can trade supplies in a wholesale spot market. Even if they have made prior commitments to buy more energy than they are able to resell to consumers, their marginal cost is given by the spot price at which they "sell back" the surplus.[9] Centrica, the incumbent supplier in the gas industry (which trades in the UK as British Gas) has a legacy of high-priced contracts which means that its average cost is greater than this marginal cost. The company's prices are set to recover as much as possible

[9] Without such a spot market, the marginal cost under a contract which was for a truly fixed volume, with storage impossible (for electricity) or not allowed (for gas), would be zero.

of the excess cost of these contracts (which can be seen as a (largely) fixed cost), which has allowed entrants to undercut it by 20%. The (relatively low) cost of dealing with customers is also largely fixed, but most of the company's remaining costs are the variable charges it pays for the use of pipelines. Overall, the gas industry fits our "high marginal cost" case quite closely.

The electricity industry in the UK is more complicated, because the incumbent suppliers also own the distribution networks. Payments for the use of the distribution system make up about one-quarter of the supply businesses' costs, and while these represent variable costs for the supply business, much of the cost of distribution is fixed, from the point of view of the group as a whole. This would seem to imply that the group has a lower marginal cost than the supply business alone. If the supply business loses a customer to a rival supplier, however, the distribution business will still be paid for delivering that customer's electricity, but by the new supplier. If each customer had a fixed demand, the distribution business would be completely indifferent to its choice of supplier, and we should continue to look at the supply business alone when setting the profit-maximising price. Once we recognise that each customer's demand is price-sensitive, the problem becomes more complicated, since customers who switch to a rival supplier with a lower price will consume more. Insofar as a price increase by the incumbent's supply business pushes more customers out to its rivals, this actually helps the distribution business. In our examples, however, this effect is outweighed by the impact on consumers who stay with the incumbent and consume less after a price increase. With marginal costs of 0.9 and an elasticity of -1, the profit-maximising price falls from 1.37 to 1.29 when the incumbent takes the distribution business into account. This is probably still too high for regulation to be abandoned.

Nevertheless, the energy regulator in the UK has now decided to remove some tariff categories from price controls, in the belief that competition is now sufficiently well established to protect consumers (Ofgem, 1999).[10] The regulator has also raised the level of the remaining price controls, compared to preliminary proposals made two months earlier, in order to ensure that entrants have enough "headroom" with which to compete with the incumbents. The regulator is probably relying on the dynamic effects of competition, including a gradual reduction of perceived switching costs as more people change supplier successfully, that have not been modelled in this paper. Nevertheless, it is possible to apply the model to estimate the short-run impact of these prices, which are about 3% above the level of the preliminary proposals.

With the initial proposals, the incumbent would have retained 85% of the market, and entrants, undercutting it by about 5%, would have taken 15%. If the incumbent were allowed to raise its price to 3% above the level of its average costs, the entrants would keep their prices almost unchanged, making more profits from greater sales than higher margins. However, the 15% of customers who had been buying from the entrants would pay slightly more, with a welfare loss of £0.4 a year (the annual bill with the incumbent is about £250). Customers who stay with the incumbent are much worse off, by nearly £8 a year each, and 83% would continue to pay the incumbent's higher prices. Given the parameters in this model, only 2% of customers would switch because of the higher price differential, and they would also be worse off than if the regulator had kept the incumbent's prices down, by an average of £4 a year. Their switching cost (net of the added value from the entrant they chose) exceeded the initial price differential, and it is only the fact that staying with the incumbent has become less attractive that has persuaded them to change. The exact figures naturally depend on the functions and parameters chosen in this model, but the qualitative conclusion should be more general. Only the possibility of competition becoming more effective over time could justify a policy which raised prices to most consumers in order to increase the "headroom" for entrants in a low-margin business.

In the telecommunications industry, however, it may prove sensible to remove price regulation for small consumers. Marginal costs are much lower, relative to prices, and so a significant mark-up to recover fixed costs will be acceptable. The price elasticity of demand is generally much higher for telecommunications than for energy. There is also more scope for offering a differentiated product, and hence raising the entrants' added value, V. The main sources of competition in the UK have been mobile phones and the joint packages of entertainment and telephone services offered by cable television companies. Regulators have also acted to reduce switching costs (after a long delay) by ensuring that consumers can keep their former phone number when they change their phone company. In these circumstances, it is quite possible that competition will keep mark-ups down to an acceptable level, even though switching costs will still give the incumbent a significant advantage. The progress of competition so far has led the UK's telecommunications regulator to suggest that the price

[10] The regulator also retains powers to deal with abuse of a dominant position under general competition legislation, but it would be extremely embarrassing to have to invoke these soon after lifting sector-specific

control on BT's retail prices will not be renewed when it expires in 2001. Our model seems to suggest that competition will indeed give telecommunications consumers enough protection, but that in the energy industries, continued oversight, either through price controls or competition policy, may be needed to prevent excessive price increases.

Appendix

We need to find the expected welfare of a consumer who buys from an entrant, given that they will only do so if their gain from lower prices and their chosen entrant's added value exceeds their switching cost. They will buy from the entrant with the greatest added value, and so we start with the density of the highest of *N* variables, uniformly distributed on the interval [0,*V*], which is:

$$f(x) = N\, x^{N-1} V^{-N} \tag{A1}$$

Consumers with a switching cost of less than $\underline{s}$ will always choose one of the entrants. The expected value of their utility is given by:

$$\begin{aligned} \sigma_j\left(s_j \middle| \underline{s} \geq s_j\right) &= \sigma + \int_0^V (x + \underline{s} - s_j)\ f(x)\ dx \\ &= \sigma + \frac{N}{N+1} V + \underline{s} - s_j \end{aligned} \tag{A2}$$

that is, the expectation of the highest added value, plus the price differential, less the switching cost. Consumers with a higher switching cost will only change to an entrant if they can find one offering enough added value, and their expected utility is:

$$\begin{aligned} \sigma_j\left(s_j \middle| \underline{s} \leq s_j \leq \underline{s} + V\right) &= \sigma + \int_{s-\underline{s}}^V \left(x - \left(s_j - \underline{s}\right)\right) f(x)\ dx \\ &= \sigma + \frac{N}{N+1} V - \left(s_j - \underline{s}\right) + \frac{1}{N+1} \frac{\left(s_j - \underline{s}\right)^{N+1}}{V^N} \end{aligned} \tag{A3}$$

Consumers with a switching cost of more than ($\underline{s}$+*V*) will all stay with the incumbent, with utility of . To find the total utility, , we must integrate equations (A2) and (A3) across the appropriate ranges of switching costs:

$$\Sigma = \sigma + \int_0^{\underline{s}} \frac{1}{S}\left(\frac{N}{N+1} V - \left(s - \underline{s}\right)\right) ds + \int_{\underline{s}}^{\underline{s}+V} \frac{1}{S}\left(\frac{N}{N+1} V - \left(s - \underline{s}\right) + \frac{1}{N+1} \frac{\left(s-\underline{s}\right)^{N+1}}{V^N}\right) ds \tag{A4}$$

which gives us equation (25):

$$\Sigma = \sigma + \frac{N}{N+1} \frac{\left(\underline{s} + V\right)V}{S} + \frac{\underline{s}^2 - V^2}{2S} + \frac{1}{N+1} \frac{1}{N+2} \frac{V^2}{S} \tag{25}$$

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price controls.

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