Supermarket Choice and Supermarket Competition in Market Equilibrium*

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Abstract

Multi-store firms are common in the retailing industry. Theory suggests that cross-elasticities between stores of the same firm enhance market power. To evaluate the importance of this effect in the UK supermarket industry, we estimate a model of consumer choice and expenditure using three data sources: profit margins for each chain, a survey of consumer choices, and a data set of store characteristics. To permit plausible substitution patterns, the utility model interacts consumer and store characteristics. We measure market power by calculating the effect of merger and demerger on Nash equilibrium prices. Demerger reduces the prices of the largest firms by between 2% and 3.8% depending on local concentration; mergers betwen the largest firms lead to price increases up to 7.4%.

Keywords: spatial competition, discrete choice, retailing, oligopoly, merger, market concentration.

JEL Nos: L13, L81

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1 Introduction

RECENT INDUSTRY STUDIES typically have data on prices but lack data on costs, and use an equilibrium pricing condition to obtain costs and profit margins (see Porter (1984), Bresnahan (1987), Berry, Levinsohn and Pakes, hereafter BLP (1995), and Feenstra and Levinsohn (1995)). This paper does the reverse. We use data on profit margins and an equilibrium pricing condition to identify price parameters in consumer utility. The method is useful for industries for which gross profit margins are observable but price data are difficult to obtain—as in the supermarket industry with its multi-product, multi-location nature.

In many economies the supermarket industry has a concentrated market structure. The concentrated structure and high price-cost markups of the UK supermarket industry have attracted the scrutiny of competition authorities. One obvious cause of the concentration is multiple store operation by the largest firms. This may also cause the high markups: standard oligopoly theory tells us that positive cross–elasticities between stores of the same chain increase the Nash equilibrium price in each store.

The concentrated industry structure in the UK emerged in the 1980s and 1990s when the largest four firms opened most of the new stores, increasing their market share from under 20% to over 60% (see p19 of Seth and Randall (1999)). In the 1990s newspapers and consumer groups claimed that the largest firms were taking advantage of market power (e.g. *Sunday Times,* 23 August 1998). In 1999 the industry was referred to the Competition Commission, hereafter CC, for investigation. The CC investigation made international profit comparisons using a number of measures of profit. They found that the main UK firms enjoyed higher gross profits than five selected overseas companies, although the return on capital employed (ROCE) was lower for the UK firms.[1] Policy recommendations in the CC report (CC (2000)) stopped short of ordering break-up, but warned against mergers that would increase concentration.

The effect of break-up or merger depends on the extent to which firms enjoy market power from operating multiple stores. In this paper we evaluate the importance of this effect. We estimate a model of consumer choice and pricing equilibrium and use it to compute the change in price resulting from (i) a total demerger in which all stores set prices independently and (ii) a series of hypothetical mergers. To focus on multiple-store effects we assume that marginal costs and quality characteristics remain at initial levels. We

[1] The CC argued that these figures were reconciled by the higher capital costs of UK firms—e.g. higher land prices and store specification.

find that demerger reduces prices of the largest firms by between 2% and 3.8% depending on local concentration. Mergers among the four largest firms increase the prices of insider firms by 1.2% to 4.4% on average and up to 7.4% in some local areas. Taken together, the results caution against these mergers and suggest, in some local areas, a policy of break-up.

The modelling strategy is to specify the consumer's utility maximizing choice of store, and expenditure at the store, as a function of consumer and store characteristics. The demand model is combined with a Nash pricing assumption in which firms account for cross-effects between own stores. The result is a model of equilibrium pricing with four primitives: (i) the observed and unobserved characteristics of individual consumers and stores, including assumptions about the distribution of the unobservables; (ii) the utility and cost functions; (iii) utility maximizing consumers; and (iv) Nash profit maximizing firms. These primitives deliver an equilibrium vector for prices, choice probabilities, utility, and profits. This facilitates detailed policy analysis by perturbing the primitives, e.g. by merging two of the firms.

We combine information from three sources. The first is gross profit margins for each firm, which is a useful and readily available form of information on prices; this is used instead of direct price data, which are difficult to obtain because of the large number of prices at each store and the large number of stores. The second is a store characteristics database, giving firm (e.g., Sainsbury, Tesco, etc.), floorspace, location, and the availability of car parking at all 1207 stores in the area of study. The third is a survey of over 114,000 households, which asks each each to report the firm at which it shops, and to specify which of these firms is used for the main or 'primary' shopping trip (the others being designated 'secondary'). The survey asks for the level of weekly expenditure on primary and secondary shopping, and for consumer location and income. The model covers a large area in southern England including some areas of very high concentration.

We follow Lancaster's (1979) characteristics approach: utility is a function of store characteristics. Other applications of this approach are BLP (1995), Goldberg (1995), and Nevo (2001). In our application there is a close correspondence between attributes consumers value and observables: car parking, location, and floorspace are observed, while the firm is strongly associated with important characteristics including quality and freshness.

The consumer model combines a discrete store choice and a continuous expenditure choice. The latter is unusual in recent applications of the characteristics approach. We include expenditure in the model because we expect that high-volume retailers choose lower margins in equilibrium than low-volume specialist or convenience retailers. We allow expenditure to depend on consumer and store characteristics.

We use iid Type–1 Extreme Value disturbances in the discrete choice. To avoid the unnatural substitution patterns associated with this assumption, we interact consumer characteristics with all observable characteristics of the store, including operating firm; we do this by estimating different utility parameters for each of a number of consumer types. Expressions for Nash equilibrium prices and profit margins follow from the consumer model.

The model is estimated as follows. For each vector of parameter values the choice model implies a set of probabilities at a store level. At this stage prices are treated as an unobservable. Probabilities are aggregated to the firm level, giving for each household a probability for each expenditure category at each firm. This corresponds to the observable; parameters follow by likelihood maximization. Price parameters are estimated in a second stage using the derived expression for Nash profit margins which is in terms of the price parameter; the price parameter is chosen to minimize the sum of the squares of the differences between predicted and observed profit margins.

There are several related papers on competition in the supermarket industry. Armstrong and Vickers (2001) develop a theoretical model of competition in utility space that may be applied to retailing. Cotterill (1986) performs a reduced form analysis of market power using data on supermarket prices from a Vermont court case and finds that market concentration has a positive effect on prices after controlling for various cost effects. Cotterill and Haller (1992) analyze entry decisions of supermarkets and find support for theories of strategic entry deterrence. Chevalier (1995) and Chevalier and Sharfstein (1996) estimate the effect of capital structure on pricing and store opening decisions of supermarkets.

The paper is related to a growing empirical literature on spatial competition. Davis (1998) estimates a model of spatial competition for the movie theatre industry using a structural discrete choice model. This paper, unlike ours, does not use survey data but combines aggregate firm-level demand data with information on the geographic distribution of households. Pinske and Slade (forthcoming) estimate a spatial model of competition which allows the model to discriminate between local competition (where products only compete with near neighbours) and global competition (where cross-effects exist between all products). The approach is applied to the US wholesale gasoline industry where it is found that competition is highly localized.

In a broader sense the paper is also related to several studies of price setting in the supermarket industry. These have focussed on dynamic price setting behaviour. Pesendorfer (2002) estimates a model of intertemporal pricing decisions of supermarkets on ketchup products, in which sales are used to discriminate between consumers with high and low shopping costs. The paper finds that the timing of sales, and the level of demand during sales, are explained by the number of time periods since the last sale, which is consistent with the model. Slade (1998) uses a data set of weekly retail prices and sales of saltine crackers in four grocery chains in a small US town; the paper estimates a model of dynamic price setting and finds significant fixed costs of changing prices. Aguirregabiria (1999) investigates the role of inventory decisions in sales promotions using data on sales stocks and prices in a supermarket chain. The paper estimates a structural model in which the existence of stockout probabilities and fixed inventory ordering costs predicts periods of price reduction after an order is placed.

The rest of the paper is organized as follows. In section 2 we describe the industry. In section 3 we specify the utility function which determines store choice and expenditure, and aggregate predictions to the level of observation (i.e., the firm). In section 4 we derive the expression for equilibrium profit margins; this is used at a later stage to obtain the price parameter. Assumptions required to identify parameters are discussed in section 5. In section 6 we discuss the data, the estimated parameters, and the plausibility of the estimated model's predictions. Section 7 implements and discusses the demerger and merger experiments and section 8 concludes.

2 The UK Supermarket Industry

In 1998 the UK supermarket industry had sales of £51.3bn, of which the largest four firms (the "big four") had a share of 71.2%, indicating a very concentrated market.[2] There are 11 supermarket firms in southern England. Their characteristics for the UK market as a whole are summarized in Table 1. The big four are ASDA, Safeway, Sainsbury, and Tesco. Compared to the others, they have larger stores (column 4), more product lines per store (column 2), and, typically, a higher proportion of own-label products—i.e. products which carry the supermarket's name (column 3). The other firms are Budgen, Co-op, Iceland, Kwik Save, Marks & Spencer, hereafter M&S, Somerfield, and Waitrose. They typically use smaller stores located on high streets (rather than out-of town). M&S sells only own-label products.

The average price of a basket of products varies both by firm and by store within firm. Variation by firm is illustrated in column 5, which gives the average price of a basket of 20 branded products at a sample of each firm's stores in 1995. The data are from the Consumer Association's *Which?* magazine (January 1995) and suggest that Waitrose has the highest prices

[2] See CC (2000) Table 2.2 for market share figures. The definition used is grocery chain stores over 6458sq feet. In our paper we define the supermarket industry as sales from *all* grocery chain stores, which is slightly broader than the CC definition.

Table 1: The Supermarkets

	Market Share[c] (%)	Store Characteristics[a] Avg Lines[d]	Own Label (%)	Avg Size[d] sq ft	Price[b] Branded Basket £	Storewise Range[c] All Prices (%)	Varying Prices (%)
Big Four:							
ASDA	13.4	38	34	45.2	25.89	0	0
Safeway	12.5	22	41	22.1	27.23	1.1	4.3
Sainsbury	20.7	21	54	29.4	27.16	NA[e]	NA[e]
Tesco	24.6	31	45	27.0	27.21	1.7	19.2
Others:							
Budgen	0.4	9	27	8.4	NA	3.1	9.8
Co-op	4.2	10	27	13.3	28.7	0.5	6.7
Iceland	0.1	3	50	5.8	25.80	0	0
Kwik Save	NA[f]	6	13	9.0	25.39	0.8	9.8
M&S	5	8	100	6.4	–	0	0
Somerfield	8.5	12	33	8.5	27.52	0.2	6.3
Waitrose	3.3	13	39	13.8	28.47	0	0

Source: a: Institute of Grocery Distribution; b: Consumer Assoc; c: CC(2000); d units in 1000s

e: Sainsbury varies prices but provided no data; f: Kwik Save was acquired by Somerfield 1997

and ASDA, Kwik Save, and Iceland have the lowest prices.

Seven firms vary prices by store, the others set uniform prices. Variation is not on an individual store basis. Instead firms have several price categories and stores are allocated depending on local conditions, e.g. Tesco has five such categories. Stores in the same local area typically belong to the same category; usually this is the city and surrounding hinterland so that price variation may be described as varying by city-based regions rather than storewise (see Chapter 7 of CC (2000)). The firms vary prices storewise for only a subset of products. In a survey of 200 products, the CC found storewise variation of up to 3.1% for an index of 200 prices including prices which do not vary (column 6). When the index is limited to varying prices, storewise variation is as high as 19.2% (column 7). The four firms with uniform prices are identified by a zero in columns 6 and 7.

To motivate the consumer model, we make two observations about shopping behaviour. First, survey evidence finds that most consumers divide their regular shopping into a main shopping trip and further secondary trips for top-up shopping (see Chapter 3 of CC (2000)). Second, shoppers of different income levels and on different types of shopping trips are attracted to different firms. This is shown in Table 2 using data from the *National Shoppers*

Table 2: Primary and Secondary: Shoppers and Market Shares

	Primary Shoppers				Secondary Shoppers			
	Household Income[a]				Household Income[a]			
	Low	Medium	High	All	Low	Medium	High	All
Market Shares (%):								
ASDA	10.4	11.5	9.5	10.1	6.3	7.4	7.4	7.0
Safeway	9.2	10.1	9.8	9.6	7.9	7.8	5.7	8.3
Sainsbury	17.5	20.9	27.2	21.4	11.4	13.3	15.2	13.5
Tesco	22.3	29.5	33.6	27.8	13.8	16.0	17.5	15.6
Budgen	1.1	0.8	0.6	0.9	0.5	0.7	1.1	0.7
Co-op	9.3	6.2	3.5	6.7	9	7.8	5.8	7.6
Iceland	1.3	0.6	0.3	0.8	9.1	7.8	5.7	7.7
Kwik Save	5.8	3.4	1.1	3.8	6.2	3.4	2.7	4.5
M&S	0.6	0.5	0.6	0.5	7.9	7.8	10.5	8.7
Somerfield	14.4	10.4	6.3	10.9	13.7	12.1	8.8	11.7
Waitrose	2.3	2.3	5.1	3.1	2.3	2.8	5.7	3.5
Corner/Other	5.7	3.7	2.3	4.1	11.9	11.1	11.9	11.1

Source: National Shoppers Survey. a: low <£10k; medium £10k-20k; high >£20k.

Survey—which we use to estimate the model. The first four columns give market shares of primary shopping by number of shoppers in each income category; the next four columns are for secondary shopping. The figures suggest that some firms (Sainsbury, Tesco, and Waitrose) attract high income consumers, some (Co-op, Somerfield, Kwik Save and Iceland) attract low income consumers, and some (Iceland and M&S) attract secondary shoppers.

The costs of supermarket operation are simple in structure. There are four operating costs incurred up to the point of sale: buying the goods, distribution to stores, store labour, and other store operating costs (such as store overheads and utilities). We classify the first three of these as marginal costs—this classification is obvious for the cost of buying goods, and evidence from CC (2000) suggests that labour and distribution costs are overwhelmingly marginal while store overheads overwhelmingly fixed.[3] These cost components are available publicly for most of the firms from company accounts, Chapter 10 of CC (2000), and, for Somerfield, HSBC (1996). (De-

[3]In Appendix 10.1 of CC (2000), plots of store labour costs against store sales are a sharp ray from the origin for all major firms suggesting that store labour costs are marginal. Figure 10.4 in Chapter 10 of CC (2000) plots ratios of distribution costs to sales against firm sales; values remain constant to firm sales suggesting a marginal cost at 3%-4% of firm sales. Plots of other store operating costs to sales converge to low levels at high sales levels suggesting they are mainly fixed.

Table 3: Costs and Profits as Percentage of Sales

	Store and Distribution Costs					Profit Margin		
	Variable Costs							
	Cost of Goods	Dist'n & Labour	Total V'ble	Other	Total Store	(i)	(ii)	(iii)
	(1)	(2)	(3)	(4)	(5)	100-(1)	100-(3)	100-(5)
ASDA	77.5	10.6	88.1	3.5	91.6	22.5	11.9	9.4
Safeway	–	11.5	88.6	4.8	93.4	–	11.4	6.6
Sainsbury	–	11.7	86.0	4.2	90.2	–	14.0	9.8
Tesco	–	11.8	87.1	4.9	92.0	–	12.9	8.0
Budgen	90.5^a	5.5	96.0	–	–	–	4.0	–
Iceland	–	–	–	–	91.7	–	–	8.3
Kwik Save	85.3	9.9	95.2	–	–	14.7	4.8	–
M&S	72.0	14.4	86.4	–	–	28.0	13.6	–
Somerfield	77.9	10.3	88.4	5.3	93.7	22.1	11.6	6.3
Waitrose	77.1	12.5	89.6	–	–	22.9	10.4	–

Source: CC(2000), Company Accounts, HSBC(1996). a: incl. labour; (3)=(1)+(2); (5)=(4)+(3)

tailed Iceland and Co-op data are not available however). Table 3 presents a summary of the cost and profit data. Costs (1)-(5) in the table are incurred at a store or up-to-store level; firm-level level overheads such as advertising and headquarter costs are not included in the table and are assumed fixed.

Three profit measures are reported in the right hand panel of the table; we label these measures (i)–(iii) respectively. (i) is revenues minus the cost of buying the goods as a proportion of revenues; (ii) is the gross profit margin, i.e. revenue minus marginal costs as a proportion of revenue; and (iii) is revenue minus all store costs including store operating costs. We use (ii) in the study. The cost components in the left hand panel are used to define the three profit measures. Accounting conventions in company accounts differ: some firms (e.g. ASDA) report definition (i) of profits while others (e.g. Sainsbury and Tesco) report definition (iii). As the reader may see from the table, we obtain (ii) using the data on store labour costs, distribution costs, and store operating costs, as appropriate.

3 Consumer Choice

We consider a typical consumer shopping decision in a single shopping period. In any period the consumer makes one primary and one secondary shopping decision, where primary shopping is that on which the greatest weekly amount is spent. We refer to the distinction between primary and secondary as the "mode" of shopping.

We analyze the two decisions separately and treat the decisions as independent, although we allow utility parameters to differ between the two modes. The independence assumption greatly simplifies the analysis and is reasonable for secondary shopping motivated by top-ups of perishables or mistakes made in primary shopping. It is less plausible where the motivation is a desire for differentiation. However, given that secondary shopping is 20% of total expenditure, and that top-ups and mistakes are likely to account for a sizeable fraction of this, differentiation based secondary spending is only a small proportion of overall shopping. Even for secondary spending motivated by differentiation, independence may be a reasonable approximation, as there are no obvious complementarities or substitutabilities between any of the firms.[4]

The observable characteristics of consumer I on any trip are income, location, and shopping mode. We use discrete measures for these: three income categories, two shopping modes, and 1027 locations. Using these characteristics we classify each consumer I into observationally equivalent types i. There are 3 x 2 x 1027 = 6162 such i-types.

The 1027 consumer locations are distributed across nine regions to be described in section 6. We allow consumer taste parameters to differ by region, income, and mode. Consumer types i are assembled by region, income, and mode into taste groups $g = g(i)$ within which consumer (taste) parameters $\theta^{g(i)}$ are identical. Each g corresponds to a unique region, income, and mode combination. There are 9 x 3 x 2 = 54 such groups.

Consumer I of type i values store j according to the indirect utility function:

$$V_j^I = v\left(z_j^i, p_j, \zeta^I; \theta^{g(i)}\right) + \epsilon_j^I = v_j^I + \epsilon_j^I \tag{1}$$

where $z_j^i = (dist_j^i, size_j, park_j, F_j)$ denotes the observed characteristics of store j, i.e. distance, floorspace, availability of parking, and firm. p_j is the price of a unit of groceries at store j and, to aid exposition, is treated as an observable until section 5.

The terms ζ^I and ϵ_j^I are independent random variables. ζ^I represents unobserved household characteristics which influence weekly spending on groceries. A natural interpretation is household size. The idiosyncratic ϵ_j^I is unobserved disturbances to consumer I's valuation of store j. This could include, for example, the effect of consumer I's (unobserved) place of work.

[4]Secondary shopping at small specialized shops such as butchers (which might depend on primary store characteristics) plays a negligible role here—as Table 2 shows, the "corner/other" category represents only 11% of secondary shopping, and much of this is likely to be in convenience rather than specialist shops.

Parameters $\theta^{g(i)} = (\alpha^g, \beta^g, \phi^g, \lambda^g, \mu^g)$ are as follows: α^g is on store characteristics other than F_j; β^g is on price p_j; ϕ^g is on firm dummy variables; and λ^g and μ^g are scaling terms on random deviates ζ^I and ϵ_j^I respectively. The variation in ϕ^g by g allows consumers in different groups to value the characteristics of each firm F differently.

A consumer of type i chooses from choice set J^i, defined as the nearest 30 stores by distance plus a convenience store $j = 0$. The convenience store is similar to the "outside good" used in other models. We discuss its treatment in section 5. The consumer chooses the store which offers the maximum realized value of V_j^I. Conditioning on a given value of ζ^I we define s_j^I as the (conditional) market share of store j among consumers of type i:

$$s_j^I \equiv \Pr\left(V_j^I = \max V_k^I \middle| z^i, p, \zeta^I; \theta^{g(i)} \right) = s_j^i(z^i, p, \zeta^I; \theta^{g(i)})$$

where z^i and p are J^i–vectors of store characteristics and prices respectively. We assume that ϵ_j^I is an iid Type–1 Extreme Value deviate of standard form with unit scale parameter so that s_j^I is given by the standard multinomial logit choice probability:

$$s_j^I = \exp v_j^I \Big/ \sum_{k \in J^i} \exp v_k^I \qquad \text{for all } j \in J^i.$$

Integrating out over the (univariate) distribution of ζ^I gives r_j^i, the market share of store j among of consumers of type i:

$$r_j^i \equiv r_j^i(z^i, p; \theta^{g(i)}) = \int_{\zeta^I} s_j^i(z^i, p, \zeta^I; \theta^{g(i)}) dH(\zeta^I) \tag{2}$$

where $H(.)$ is the distribution function for ζ^I, which is assumed to be lognormal such that $\ln \zeta^I \sim N(0, \lambda^g)$.

Note that, conditional on ζ^I, consumers make a multinomial logit choice. A familiar property of the multinomial logit framework is the Independence of Irrelevant Alternatives. This has been criticized for imposing unnatural substitution patterns in which cross-elasticities between stores for any consumer type i depend exclusively on type i's vector $\mathbf{s}^I$ of (conditional on ζ^I) market shares: this is unrealistic if i–types are not narrowly defined. For example, a discount store (e.g. Kwik Save) in a broadly defined market may have the same share of overall market demand as a high quality store (e.g. Waitrose); but, because the discount store appeals to different (lower income) customers, the pattern of cross elasticities with other stores should not be identical for the two stores. The problem may also arise if stores differ by location (and appeal to differently located customers) or differ by suitability for secondary shopping. Our study avoids these problems by separating consumers into i–type markets which are defined narrowly—by income, location, and mode—so that there is a minimal level of variation within any i–type. Each i–type has a different (conditional on ζ^I) valuation v_j^I for any store, and therefore a different s_j^I.

Given the large number of stores in the data set, the absence of store–specific unobservables, other than the idiosyncratic term, greatly simplifies estimation. The suppression of store unobservables is justified by the importance of the firm in determining the character of its stores. The most important decisions about stores are taken at company headquarters—e.g. the lay-out, the speed and quality of assistance, freshness, decor, and the quality of the product lines. The company name rather than the store is emphasized in advertising and features prominently in the stores.

Consumer I optimizes with respect to the quantity of groceries bought at the chosen store. A unit of groceries is a bundle of product lines in fixed proportions with price p_j. The demand x_j^I for groceries conditional on choice of store j is obtained from the utility function using Roy's identity:

$$x_j^I = x_j^i \left(size_j, F_j, p_j, \zeta^I; \theta^{g(i)} \right). \tag{3}$$

We construct the utility function to exclude from conditional demand those variables which we believe do not influence grocery demand ($park_j$ and $dist_j^i$) while retaining the others ($size_j$, F_j and p_j). Multiplying by price gives conditional expenditure:

$$e_j^I = e_j^i \left(size_j, F_j, p_j, \zeta^I; \theta^{g(i)} \right).$$

The functional form for utility V_j^I is chosen to deliver expressions for conditional expenditure and store choice which are realistic and convenient for estimation. We use the following function:

$$\begin{aligned} V_j^I \;\; = \;\; & \mu^g \left[\beta_2^g y^i + \beta_1^g \ln p_j + \phi_{1F}^g + \alpha_1^g \ln size_j \right] \exp((\phi_{2F}^g - \beta_2^g \ln p_j)\zeta^I) \\ & + \alpha_2^g park_j - \alpha_3^g \ln dist_j^i + \epsilon_j^I \end{aligned} \tag{4}$$

where y^i is household income and μ^g is a scaling term.

The utility function allows combined discrete and continuous demand analysis. The form used here is discussed further in Haneman (1984) and is related to the well known form used by Dubin and McFadden (1984). Application of Roy's identity implies the following form for conditional demand

$$x_j^I = \frac{1}{p_j} \left[\left(\beta_2^g y^i + \beta_1^g \ln p_j + \phi_{1F}^g + \alpha_1^g \ln size_j \right) \zeta^I - \frac{\beta_1^g}{\beta_2^g} \right] \tag{5}$$

and conditional expenditure:

$$e_j^I = \left(\beta_2^g y^i + \beta_1^g \ln p_j + \phi_{1F}^g + \alpha_1^g \ln size_j\right)\zeta^I - \frac{\beta_1^g}{\beta_2^g}. \qquad (6)$$

There are two firm-specific taste parameters $(\phi_{1F}^g, \phi_{2F}^g)$ for each firm. The first parameter ϕ_{1F}^g appears in both conditional demand and the utility function; the second ϕ_{2F}^g does not appear in the expression for conditional demand—it is eliminated by Roy's identity. This separation allows some firm characteristics to determine store choice without affecting conditional demand—e.g. checkout waiting times or friendliness of staff.

Note that the firm-specific taste parameters appear additively next to price in the utility and expenditure. This arrangement is convenient because it allows the effect of the (unobserved) price variable to be combined with the ϕ^g parameters at estimation. This is done in section 5.

We model conditional demand explicitly to allow a more realistic treatment of price setting. An increase in any store characteristic which increases conditional demand in equation (5) also increases the derivative of (4) with respect to price—i.e. a consumer who buys more units is more sensitive to a change in unit price. This effect, other things equal, reduces the equilibrium price of high volume retailers (as we see in section 4).

The price elasticity of conditional grocery demand η^I for consumer I of group g follows from (5):

$$\eta^I = -1 + \zeta^I \beta_1^g \Big/ x_j^I p_j. \qquad (7)$$

If $\beta_1^g = 0$ the conditional elasticity of demand is unity.

The expenditure model implies an ordered log-probit model for the probability that conditional expenditure falls within a given range. The expenditure categories in the survey $l = 1, ..., \bar{l}$ are partitioned at expenditure levels $e_l = e_1, ..., e_{\bar{l}}$. The lowest expenditure category is e_1 to e_2 and so on up to $e_{\bar{l}-1}$ to $e_{\bar{l}}$. The probability of a consumer I of type i spending an amount in range $[e_l, e_{l+1}]$, conditioning on store j, is given by the probability of ζ_l falling between the limits $\zeta_l = \{\zeta_l^I\colon\ e_j^I = e_l\}$ and $\zeta_{l+1} = \{\zeta_{l+1}^I\colon\ e_j^I = e_{l+1}\}$, i.e.

$$\Pr\left(e_l < e_j^I \leq e_{l+1} | z_j^i, p_j; \theta^{g(i)}; V_j^I = \max V_k\right) = \int_{\zeta_l}^{\zeta_{l+1}} dH\left(\zeta^I\right) \qquad (8)$$

where $H(.)$ is as defined previously. The *joint* probability q_{jl}^i of observing a consumer of type i visiting store j and spending an amount in range $[e_l, e_{l+1}]$ is obtained by integrating conditional (on ζ^I) market share $s_j(z_j, \theta^{g(i)}, \zeta^I)$ over the relevant range for ζ^I:

$$q_{jl}^i \equiv \Pr(e_l < e_j^I \leq e_{l+1}, V_j^I = \max V_k^I) = \int_{\zeta_l}^{\zeta_{l+1}} s_j^i(z^i, p, \zeta^I; \theta^{g(i)}) dH(\zeta^I). \quad (9)$$

As s_j^i is a closed form and the integral univariate, computation is simple.

We now aggregate to the level of the firm. Aggregating over q_{jl}^i for the stores of firm F gives the probability of type i spending in the lth category at firm F:

$$\Pr\left(e^i = l; F^i = F | z^i, p; \theta^{g(i)}\right) = \sum_{\{j:F_j=F\}} \int_{\zeta_l}^{\zeta_{l+1}} s_j^i(z^i, p, \zeta^I; \theta^{g(i)}) dH(\zeta^I) \quad (10)$$

where we use $e^i = l$ to denote the event that consumer I of type i spends an amount in the lth category and $F^i = F$ to denote that he chooses firm F.

Let D_{lF}^i be the observed number of consumers of type i selecting firm F and expenditure category l. The likelihood for group g is:

$$\ln L^g = \sum_{i \in g} \sum_l \sum_F D_{lF}^i \ln \Pr\left(e^i = l; F^i = F | z^i, p; \theta^{g(i)}\right) \quad (11)$$

There is a separate set of parameters θ^g for each g so the likelihoods are defined at the level of the group and maximized separately.

4 Equilibrium Prices and Profit Margins

We take as given that prices are determined in a multi-store Nash pricing equilibrium, in a single stage at which store characteristics z_j are predetermined. We also take as given that each firm sets uniform prices within each of nine geographic areas called "pricing regions". These regions are described in section 6. Additionally, the four national-pricing firms identified in section 2 are assumed to set uniform prices across pricing regions. We do not model the firms' decisions to adopt these constraints on pricing but we note that they may be rationalized by marketing considerations and fixed costs of price setting.

Consider the problem facing a firm F setting a *uniform* price p_F in a set J_F of its stores. For regional-pricing firms J_F is the set of F's stores in the pricing region; for national-pricing firms J_F is the set of all F's stores. The marginal cost of a unit of groceries c_F is assumed uniform for the J_F stores. Let the price-cost markup be denoted $\delta_F = (p_F - c_F)$; then profit margins m_F are defined $m_F = \delta_F / p_F$.

To simplify exposition we proceed in two conceptual stages. We first condition on ζ^I to obtain an analytical closed form expression for optimal profit margins for any ζ^I. We then integrate out over the distribution of ζ^I. For expositional convenience, in the rest of this section, we suppress the I

and write (s^i, x^i, e^i) instead of (s^I, x^I, e^I) etc., the dependence on ζ^I being understood.

First condition on ζ^I. Imagine initially that the firm faces only type i consumers of whom there is a population M^i. Then the gross profit of firm F, from its chain of J_F stores, is given by:

$$\Pi_F^i = M^i \sum\nolimits_{j \in J_F} \delta_F s_j^i x_j^i. \tag{12}$$

The first order condition for p_F is:[5]

$$\frac{\partial \Pi_F^i}{\partial p_F} = M^i \sum_{j \in J_F} s_j^i \left[\delta_F x_j^i (1 - s_j^i) \frac{\partial v_j^i}{\partial p_F} + x_j^i - \sum_{k \in J_F} \delta_F x_k^i s_k^i \frac{\partial v_j^i}{\partial p_F} + \delta_F \frac{\partial x_j^i}{\partial p_F} \right] = 0. \tag{13}$$

The market power effects which operate in the model can be seen here. The first and second terms are as obtained in standard zero-elastic, single-firm, logit oligopoly (see Berry (1994)); in this framework prices are increasing in market share and diminishing in the price sensitivity of consumers. The third term is the effect of generalizing to multiple-store operation; the merger and demerger counterfactuals performed in section 7 alter the number of components in this summation. The fourth term is the effect of generalizing to non-zero price elasticity of conditional demand. Generalizing now to many i–types the first order condition becomes:

$$\frac{\partial \Pi_F}{\partial p_F} = \sum_i \frac{\partial \Pi_F^i}{\partial p_F} = 0. \tag{14}$$

Substituting (13) into (14) we can derive an analytical equation for equilibrium profit margins in terms of the variables and parameters of the model. This is done in Appendix A (equation (36)). Here we summarize it as follows:

$$m_F = m_F\left(M, z, p, \zeta^I; \theta\right) \tag{15}$$

where the vectors M, z, and θ are comprised of M^i, z^i and $\theta^{g(i)}$ for all i in the pricing region.

We now integrate (14) over the distribution of ζ^I to give:

$$\frac{\partial \Pi_F}{\partial p_F} = \int_{\zeta^I} \left\{ \sum_i \frac{\partial \Pi_F^i}{\partial p_F} \right\} dH\left(\zeta^I\right) = 0. \tag{16}$$

[5] Some useful expressions (where type scripting has been suppressed):

$$\frac{\partial s_j}{\partial v_j} = s_j(1 - s_j); \qquad \frac{\partial s_j}{\partial v_k} = -s_j s_k \quad j \neq k; \qquad \frac{\partial s_j}{\partial p_j} = s_j(1 - s_j)\frac{\partial v_j}{\partial p_j}.$$

This can be solved numerically to give m_F for any $(M, z, p; \theta)$, i.e. we have:

$$m_F = m_F(M, z, p; \theta). \tag{17}$$

So far the analysis has been at the level of the relevant pricing region for each F. To match the model to the *observed* profit margin data, however, which are at a firm level, we require a single profit margin prediction for each F. For a national-pricing firm we get this directly from (17); for a regional-pricing firm we take a revenue-weighted average of the nine regional m_F's. Hereafter (17) is used to represent profit margin predictions at a firm level.

We assume existence of equilibrium. Conditions for existence of equilibrium prices in multi–product logit oligopoly are studied in Spady (1984).

5 Identification

We now discuss identification of parameters, i.e.: $\theta^{g(i)} = (\alpha^g, \beta^g, \phi^g, \lambda^g, \mu^g)$.

There are two parameters $(\phi^g_{1F}, \phi^g_{2F})$ on firm dummies in the utility function (4). The identification of two parameters for each F is possible by the observation of two household decisions for each firm: expenditure and choice. ϕ^g_{1F} is the only one which appears in the expenditure function. It determines the effect of unobservable characteristics of firm F on expenditure, and is identified by variation in observed expenditures by firm for each g. ϕ^g_{2F} has no effect on expenditure but affects market share. In the utility function (4) the ϕ^g_{2F} parameter multiplies the parameters and variables which enter the expenditure function. Thus ϕ^g_{2F} is identified by variation in firm market shares relative to firm expenditure. A firm with high market shares but average expenditure levels for group g, other things equal, will have a high ϕ^g_{2F} and an average level of ϕ^g_{1F}.

In many models of demand for differentiated products the inclusion of even a single dummy for unobserved product characteristics creates difficulties in identifying parameters α^g on observed characteristics z_j, as the characteristics are perfectly predicted by the dummy variable (see Nevo (2001)). In our study this problem does not arise as the dummies vary by firm while the observed characteristics z_j vary by store. The α^g parameters are identified by correlation (across i–types) between firm F market shares and the observed characteristics z^i_j of F's stores (in the choice sets of the i–types).

We use a two–stage strategy to estimate parameters. In stage one we estimate the choice model, by maximum likelihood (separately for each g), incorporating the price variables p_F into the unobserved firm characteristics parameters. In stage two we use the estimated parameters from stage one in the expression for profit margins (17) and estimate price parameters by nonlinear least–squares, minimizing the difference between predicted and observed profit margins. We do not employ the the conventional approach of estimating price parameters using price data in the consumer demand model as we do not observe prices at the level of the pricing region—e.g. the prices reported in Table 1 are national averages.

The roles of the two price parameters are as follows: β_1^g determines price elasticity of conditional demand, and β_2^g determines price sensitivity of utility (and market share). This is confirmed by differentiating (4) and (5) with respect to price—see (34) and (35) in Appendix A.

As the number of profit margin observations is limited to the number of firms, it is not possible to estimate separate price parameters for each of the 54 groups g. Instead, we define two "base" parameters (β_1, β_2) to which the group parameters (β_1^g, β_2^g) are related. In the case of the β_2^g's we set these uniform across groups, i.e.

$$\beta_2^g = \beta_2 \quad \text{for all } g$$

giving a common price sensitivity of utility and market share across g, other things equal. In the case of the β_1^g's we assume uniform conditional demand *elasticity* (7) across groups for households with median unobservable characteristics ζ_g^I (i.e. $\zeta_g^I = 1$) with expenditure $x_j^I p_j$ that is equal to the average amount for its group. Inspection of (7) shows that this assumption implies a proportional relationship between the β_1^g's and group average expenditures, so we set

$$\beta_1^g = w^g \beta_1$$

where weighting term w^g is the mean household expenditure in group g as a proportion of mean household expenditure across all groups.

To eliminate price parameters in stage one we define new firm parameters (d_{1F}^g, d_{2F}^g) that include the effect of price:

$$\begin{aligned} d_{1F}^g &\equiv \beta_2^g y^i + w^g \beta_1 \ln p_F + \phi_{1F}^g &\quad (18)\\ d_{2F}^g &\equiv \exp(\phi_{2F}^g - \beta_2 \ln p_F). &\quad (19) \end{aligned}$$

The term d_{1F}^g incorporates $\beta_2^g y^i$ which is observationally equivalent for all households in group g. As the ϕ_F^g are replaced by d_F^g in the rest of the paper, we define θ^g hereafter as follows: $\theta^{g(i)} = (\alpha^g, \beta, d^g, \lambda^g, \mu^g)$ for all g where d^g is a vector comprising (d_{1F}^g, d_{2F}^g) for each firm. Note that d^g is not a structural parameter as it changes if prices change; thus we will not hold it constant in the experiments.

Variation in price by region implies a different value for d_F^g for each region; this is accommodated by separate estimation of parameters for each group

g. Substituting (18) and (19) into (4), the utility function to be estimated is:

$$V_j^I = \mu^g \left[d_{1F}^g + \alpha_1^g size_j\right] \left(d_{2F}^g\right)^{\zeta^I} + \alpha_2^g park_j - \alpha_3^g dist_j^i + \epsilon_j^I. \tag{20}$$

Substituting (18) into (6), the expenditure function to be estimated is:

$$e_j^I = \left(d_{1F}^g + \alpha_1^g \ln size_j\right) \zeta^I - \frac{w^g \beta_1}{\beta_2}. \tag{21}$$

where $\ln \zeta^I \sim N(0, \lambda^g)$ for each g. The λ^g term is identified by matching the predicted spread of expenditures for each g to the observed distribution by category.

Independent retailers which are not part of a chain have a separate box in the survey (the "corner/other" option). We do not have data on the characteristics of these stores although they are typically small, local, and without car parking. We assume that all consumers have one such store in their choice set, denoted $j = 0$ with firm characteristics $z_0^i = (size_0,\ dist_0^i,\ park_0, F_0)$. We assume that size does not vary significantly for these stores, allowing us to include the (unobserved) size variable into $d_{1F_0}^g$, giving the following expression for corner/other expenditure:

$$e_0^I = \left(d_{1F_0}^g\right) \zeta^I - \frac{w^g \beta_1}{\beta_2}. \tag{22}$$

Since corner/other stores are typically local and without parking we set $park_0 = \ln dist_0^i = 0$ giving corner/other utility as follows:

$$V_0^I = \mu^g \left[d_{1F_0}^g\right] \left(d_{2F_0}^g\right)^{\zeta^I} + \epsilon_0^I \tag{23}$$

where $d_{2F_0}^g$ is the second firm parameter for the corner/other option. Finally we set $d_{2F_0}^g = 1$ to fix the utility of the corner/other option at the same value for all consumers of given g.

Note that the price variable has been eradicated from the utility and expenditure expressions to be estimated. However price parameters have not been totally eradicated: the ratio β_1/β_2 appears in the expenditure functions (21) and (22). To deal with this, we maximize likelihoods for an assumed fixed value of β_1/β_2. In stage two the estimation of equation (17) is then reduced to estimating β_2 which implies a value for β_1 and hence the conditional (on choice of store) demand elasticity. The plausibility of the assumed ratio β_1/β_2 should therefore be judged by the implied conditional elasticity; we do this by comparison with figures from Blundell, Pashardes and Weber, hereafter BPW (1993), who estimate the uncompensated demand elasticity of food and alcohol demand using UK household demand data. A weighted average of these elasticities gives a figure of approximately -0.7, where weights are based on the relative shares of food and alcohol in supermarket revenues.[6]

As a convenient starting point we estimate the model assuming $\beta_1 = \beta_1/\beta_2 = 0$. As shown by equation (7), this assumption implies a conditional demand elasticity of -1. After obtaining the β_2 (in stage two) we re–run the choice likelihoods using alternative assumed values for $\beta_1/\beta_2 > 0$ to obtain an implied conditional elasticity close to BPW's figure of -0.7. In setting alternative values for β_1/β_2 we are guided by the estimate of β_2 at $\beta_1 = 0$.

With the choice parameters from stage one in hand we now turn to stage two and the estimation of the price parameter using the equation for profit margins (17). As written, (unobserved) prices p appear in (17). It is possible, however, to manipulate the first order condition for m_F so that prices appear only via the estimated d^g parameters (see equation (37) in Appendix A). Thus we rewrite (17) without prices as an argument:

$$m_F = m_F\left(M, z; \theta\right). \tag{24}$$

The observed $\bar{m}_F$ for each F are related to the predictions of the model as follows:

$$\bar{m}_F = m_F\left(M, z; \hat{\theta}, \beta_2\right) + \varepsilon_F \tag{25}$$

where we split parameters into those estimated in stage one $\hat{\theta}$ and the remaining price parameter β_2, and where ε_F is an iid mean-zero measurement error in profit margins, part of which arises because the profit margins are observed nationally and the model is estimated sub-nationally. Taking as given that the store characteristics z are predetermined, and noting that prices do not appear as an argument in $m_F()$, there should arise no simultaneity bias in estimation of β_2. For a given $(M, z; \hat{\theta})$ the price parameter β_2 is obtained by minimizing the objective function:

$$\sum_F \left(\bar{m}_F - m_F\left(M, z; \hat{\theta}, \beta_2\right)\right)^2 \tag{26}$$

with respect to β_2 (i.e. nonlinear least squares). With β_2 in hand, the value of β_1 follows by the assumed value of β_1/β_2.

The overall estimation strategy allows structural parameters to be obtained using the model of consumer choice and consistency of the pricing model with observed gross profit margins.

[6] BPW (1993) estimate uncompensated own price elasticity of demand for the median household at -0.564 for food and -1.735 for alcohol. Expenditure shares at supermarkets from Table 8.33 of CC(2001) are 69.7 for food (groceries and perishables) and 9.0 for alcoholic drinks. Using these as weights gives an elasticity of -0.698.

Table 4: Descriptive Statistics

Store Data:				
Variable	Mean	St. Dev.	Min	Max
size (sq ft)	16,250.7	14,233.8	616.0	105,600.0
park	0.6	0.5	0.0	1.0
dist (km)[a]	14.7	12.0	0.0	138.0
# stores	1207			

Source: IGD, Goad, a: consumer/store pairs in choice sets

Consumer Data:		
#Respondents[a]	Low Income	47,167
	Medium Income	33,246
	High Income	33,645
	Total:	114,058
Sample as % of all households		4.8%
#Postal Sectors in area		1027
Mean # households (hh) per Postal Sector		2309
Standard deviation # hh per Postal Sector		(1190)

Source: National Shoppers Survey; a: low <£10k; medium £10k-20k; high >£20k.

6 Data and Estimation

6.1 Data

We use three data sources. The first is the gross profit margin data, marked (ii) in Table 3, which correspond to m_F in the model. This is an indirect form of information on prices. For further discussion see Section 2.

The second is store characteristics for all stores of the supermarket chains, obtained from the Institute of Grocery Distribution (UK), hereafter IGD, and Charles Goad (UK) Ltd. The two data sets give the same information—firm, location, floorspace, and availability of parking spaces—allowing cross-checking. Each store's Postcode identifies its exact location. The data are for January 1995, the date of the consumer survey. Table 4 gives descriptive statistics, where distance statistics treat each consumer/store pair in the choice sets as an observation.

Third is the *National Shoppers Survey*—a mass survey distributed to households in a variety of ways including inserts in magazines and posting through doors. The survey is made attractive using guaranteed money-off vouchers, prize draws etc. The survey is run by Claritas (UK) Ltd. In January 1995. 114,058 households in our area participated in the survey;

representing 4.8% of all households. The household is asked for: [i] the firms visited; [ii] the firm in which main (primary) shopping is done; [iii] the weekly amount spent on primary shopping; [iv] the weekly amount spent on secondary shopping; and [v] Postcode and annual household income. Expenditure and income information is recorded by ticking an expenditure and income range.

We are not given the full Postcode. Instead we have each household's Postal Sector—i.e., the area covered by the first four characters of the Postcode. There are 1027 Postal Sectors in the area studied. The average number of households per Postal Sector is 2309 (standard deviation 1190). This corresponds to a village-size community; they are small enough that consumers in each face a similar distance to any given supermarket. To calculate the distance between consumers and stores we use National Grid referencing. The grid reference for the Postal Sector is the arithmetic mean of household addresses in the sector.

Table 4 gives descriptive statistics from the survey. There are six primary shopping weekly expenditure categories (£0 to £ 15; £15 to £30; £30 to £45; £45 to £ 60; £60 to £75; and £75 and above), three secondary categories (£0 to £10; £10 to £ 20; and £ 20 and above) and three annual household income bands (up to £ 9,999; £10,000 to £19,999; and £20,000 and above). Claritas provide us with the total number of households in the population in each income band in each Postal Sector; we use this in the counterfactual experiments to scale up the estimated model to represent the entire population.[7]

The survey asks households to record the firm where primary shopping is done and weekly expenditure on primary shopping. In the case of secondary shopping the survey is slightly different: it asks households to record the firm *or firms* visited, usually two or three firms, and the typical weekly *total* spent on secondary shopping. We assume that households make one secondary trip per period, alternating between the ticked firms. For the likelihood maximization, we allocate people in each i type to secondary firms in proportion to the number of ticks the firm receives.

The model covers a large contiguous area in southern England comprising 5.9 million people. We disaggregate the area into 9 regions which are shown in Table 5. The table gives demographic information for each region and the regional distribution of stores by firm. The areas vary widely by income

[7] The number of households in teach Postal Sector is available from Census data. The proportions in each income group are estimated from market research surveys including the sample of Anonymized Records from the 1991 census; Target Group Index data collected by the British Market Research Bureau (London, UK) and published market research surveys such as the MORI financial survey.

Table 5: Pricing Regions: Demographics and Distribution of Stores

	BATA	BHDT	BS	EXTQ	OX	PLTR	RG	SNSP	SO	All
Households and Population (units in 100,000s):										
Households	2.9	3.0	2.8	3.2	2.0	3.6	2.1	2.0	2.3	23.7
Population	6.9	7.5	6.8	8.0	5.1	9.3	5.1	5.1	5.6	59.4
% in household income group:[a]										
Low	43	46	43	48	31	49	27	37	41	41
Medium	31	30	29	32	27	32	23	30	26	29
High	26	24	27	20	42	19	49	33	34	29
Number of Stores by Firm:										
ASDA	2	3	4	0	1	2	2	2	4	20
Safeway	7	10	3	5	0	7	3	4	6	45
Sainsbury	5	6	5	5	6	3	7	5	6	48
Tesco	4	11	8	7	7	10	6	6	6	65
Budgen	1	0	1	0	4	0	3	3	1	13
Co-op	6	11	11	14	13	17	4	5	5	86
Iceland	2	3	6	2	2	3	4	6	3	31
Kwik Save	9	4	9	2	3	2	1	5	3	38
M&S	4	5	3	5	2	3	3	3	3	31
Somerfield	18	15	21	34	9	15	10	15	2	139
Waitrose	1	4	1	0	5	0	6	3	3	23
Floorspace concentration:										
C2	31	39	38	43	45	40	52	35	41	37

Source: National Shoppers Survey, IGD, Goad; a: low <£10k; medium £10k-20k; high >£20k.

level. The regions are based on postal geography and comprise one or a pair of neighbouring large towns and their immediate hinterlands.[8] These are thus natural areas to approximate the regional pricing noted in section 2; we assume that firms set uniform prices within these regions. The bottom row gives the two-firm floorspace concentration ratio for region; some have very high concentration. Tesco and Sainsbury have a substantial presence in all regions; in some they face little competition from other big four firms.

6.2 Estimated Parameters and Model Predictions

Tables 6 and 7 give parameters for primary and secondary shopping respectively, estimated assuming $\beta_1 = 0$. We call this specification I. To save space, we present summary statistics from the full set of parameters rather than results for each individual pricing region. The results are presented in threes for each consumer income level. The three columns for each income level give (i) the average of the nine regional parameter values; (ii) the average of the nine regional standard errors; and (iii) the standard deviation of the nine regional parameter values. The first twelve rows report the d^g_{1F} (expenditure) parameters. The next eleven rows report the d^g_{2F} (choice) parameters. The final five parameters are those on floorspace, parking, distance, and the expenditure and choice scaling parameters.

The plausibility of the parameters is best assessed by looking at the predictions of the choice and expenditure model. We do this later in the section. First we note some patterns in the parameters.

The d^g_{1F} (expenditure) parameters are much smaller for secondary shopping than primary, reflecting the lower level of expenditure on a secondary shopping trip; variation in d^g_{1F} by firm is the effect of the firm on expenditure. The d^g_{2F} parameters indicate the effect of price and firm quality on store choice *given* any level of expenditure. Total utility depends on the interaction of the two parameters. For example, in the case of M&S, which is a high–price firm with a low market share, the d^g_{1F} parameter is higher than average (for primary shopping), but the d^g_{2F} parameter is lower than average, resulting in a low market share.

The remaining parameters in the final five rows of the table are all of the expected sign (positive): floorspace has a positive effect on expenditure, parking has a positive effect on store choice, and distance has a negative effect on store choice. This is true for all (unreported) regional parameters.

[8] The main towns in each region are: BATA (Bath and Taunton); BHDT (Bournemouth and Dorchester); BS (Bristol); EXTQ (Exeter and Torquay); OX (Oxford); PLTR (Plymouth and Truro); RG (Reading); SNSP (Swindon and Salisbury); Southampton (SO).

Table 6: Primary Shopping Parameters (Specification I)

Estimate: Average value of regional parameters

S.E: Average value of regional standard errors

SD: Standard Deviation of regional parameters

LLF: Sum of regional likelihood values — OBS: Sum of regional number of observations

		Low Income			Medium Income			High Income		
Parameter	Variable	Estimate	S.E.	S.D.	Estimate	S.E.	S.D.	Estimate	S.E.	S.D.
d_1	ASDA	25.144	2.542	0.205	31.785	4.180	10.690	24.202	6.871	8.133
	Safeway	22.073	2.263	0.133	29.093	3.320	11.381	25.281	5.245	10.261
	Sainsbury	22.193	2.299	0.273	27.365	3.656	12.345	27.266	6.036	7.366
	Tesco	24.095	2.075	0.231	28.976	3.656	12.321	24.644	5.663	10.903
	Budgen	24.044	2.837	0.099	35.837	4.761	5.165	35.454	5.533	7.180
	Co–op	21.742	1.715	0.054	29.275	3.326	9.606	26.849	4.893	9.513
	Iceland	26.568	2.660	0.071	32.295	4.651	9.294	30.321	6.806	7.829
	Kwik Save	21.880	1.597	0.211	27.940	2.967	8.744	21.879	4.709	7.455
	M&S	22.530	3.374	0.195	31.581	5.465	8.893	40.768	7.136	8.103
	Somerfield	22.185	1.550	0.136	29.424	3.029	8.002	28.929	4.087	8.250
	Waitrose	22.097	2.188	0.218	33.737	3.864	7.469	33.781	4.967	6.886
	Corn/Oth	24.089	0.847	1.365	36.872	1.610	2.099	45.582	2.333	2.968
d_2	ASDA	1.001	0.148	0.205	1.317	1.610	0.054	1.729	0.476	0.768
	Safeway	1.047	0.102	0.133	1.285	0.161	0.407	1.647	0.392	0.625
	Sainsbury	1.123	0.140	0.273	1.434	0.225	0.512	1.851	0.448	0.712
	Tesco	1.052	0.129	0.231	1.409	0.230	0.518	1.867	0.491	0.727
	Budgen	0.930	0.094	0.099	0.951	0.109	0.061	1.016	0.126	0.113
	Co–op	1.051	0.086	0.054	1.144	0.125	0.229	1.226	0.152	0.279
	Iceland	0.810	0.079	0.071	0.955	0.135	0.152	0.942	0.279	0.340
	Kwik Save	1.145	0.123	0.211	1.332	0.167	0.343	1.503	0.235	0.296
	M&S	0.823	0.124	0.195	0.875	0.160	0.244	0.882	0.194	0.195
	Somerfield	1.069	0.088	0.136	1.231	0.146	0.263	1.357	0.193	0.379
	Waitrose	1.059	0.104	0.218	1.137	0.158	0.277	1.450	0.312	0.564
α_1	Size	1.654	0.614	1.697	3.504	1.011	1.011	7.849	1.603	3.038
α_2	Park	0.249	0.094	0.437	0.416	0.142	0.142	0.604	0.155	0.522
α_3	Dist	1.075	0.021	0.139	1.069	0.027	0.027	1.140	0.029	0.100
λ	Scale	1.967	0.024	0.042	2.221	0.031	0.031	2.292	0.035	0.089
μ	Scale	0.260	0.146	0.164	0.112	0.054	0.054	0.106	0.050	0.081
	LLF	-147449.27			-105509.23			-103529.25		
	OBS	47167			33246			33645		

Table 7: Secondary Shopping Parameters (Specification I)

Estimate: Average value of regional parameters

S.E: Average value of regional standard errors

SD: Standard Deviation of regional parameters

LLF: Sum of regional likelihood values — OBS: Sum of regional number of observations

		Low Income			Medium Income			High Income		
Parameter	Variable	Estimate	S.E.	S.D.	Estimate	S.E.	S.D.	Estimate	S.E.	S.D.
d_1	ASDA	6.040	0.364	2.635	6.820	0.034	2.695	7.631	0.403	3.204
	Safeway	6.374	0.300	2.608	7.067	0.036	2.752	8.144	0.299	3.376
	Sainsbury	6.809	0.279	1.124	7.574	0.034	0.866	8.589	0.269	1.686
	Tesco	6.863	0.270	1.143	7.599	0.029	0.770	8.485	0.251	1.620
	Budgen	3.930	0.376	3.765	4.694	0.079	4.491	5.461	0.451	5.326
	Co–op	7.456	0.306	0.850	8.470	0.059	0.590	9.849	0.727	1.068
	Iceland	7.846	0.349	0.769	9.199	0.062	0.456	10.523	0.732	1.008
	Kwik Save	7.518	0.353	0.892	8.934	0.057	0.508	9.690	1.377	1.104
	M&S	7.663	0.392	0.891	9.085	0.069	0.577	10.611	0.559	1.259
	Somerfield	7.528	0.225	0.840	8.925	0.043	0.581	10.223	1.042	0.712
	Waitrose	5.477	0.318	3.185	6.715	0.046	3.856	7.613	0.397	4.488
	Corn/Oth	7.971	0.241	0.402	9.233	0.274	0.337	10.821	0.293	0.593
d_2	ASDA	0.979	0.044	0.420	0.950	0.306	0.362	0.981	0.046	0.371
	Safeway	0.914	0.042	0.372	0.885	0.308	0.339	0.926	0.030	0.350
	Sainsbury	1.102	0.032	0.181	1.098	0.281	0.072	1.159	0.026	0.076
	Tesco	1.086	0.032	0.140	1.089	0.254	0.053	1.161	0.025	0.087
	Budgen	0.695	0.070	0.409	0.742	0.480	0.377	0.725	0.066	0.364
	Co–op	0.924	0.041	0.087	0.893	0.385	0.104	0.866	0.086	0.154
	Iceland	1.044	0.066	0.136	0.977	0.432	0.066	0.973	0.069	0.051
	Kwik Save	0.980	0.060	0.071	0.902	0.442	0.045	0.911	0.140	0.163
	M&S	1.074	0.071	0.121	1.002	0.441	0.031	1.060	0.070	0.092
	Somerfield	0.944	0.038	0.136	0.877	0.319	0.078	0.886	0.126	0.101
	Waitrose	0.754	0.047	0.440	0.728	0.360	0.416	0.769	0.038	0.441
α_1	Size	0.340	0.076	0.299	0.433	0.074	0.264	0.542	0.063	0.378
α_2	Park	0.129	0.053	0.323	0.304	0.082	0.328	0.322	0.083	0.389
α_3	Dist	0.733	0.017	0.098	0.707	0.018	0.095	0.705	0.019	0.102
λ	Scale	1.746	0.029	0.068	1.882	0.030	0.065	1.702	0.024	0.056
μ	Scale	2.436	0.069	3.830	0.655	0.222	0.638	0.893	0.061	0.850
	LLF	-140011.49			-101502.64			-106468.38		
	OBS	47167			33246			33645		

Table 8: Primary and Secondary Parameters (Specification III)

Estimate: Average value of regional parameters — S.E: Average value of regional standard errors

SD: Standard Deviation of regional parameters — LLF: Sum of regional likelihood values

		Low Income			Medium Income			High Income		
Parameter	Variable	Estimate	S.E.	S.D.	Estimate	S.E.	S.D.	Estimate	S.E.	S.D.
Primary										
α_1	size	1.666	0.544	1.649	3.123	1.035	2.816	6.982	1.684	2.978
α_2	park	0.249	0.103	0.435	0.416	0.142	0.434	0.604	0.155	0.526
α_3	dist	1.075	0.022	0.139	1.069	0.027	0.111	1.139	0.029	0.100
λ	scale	2.665	0.032	0.067	3.095	0.043	0.142	3.227	0.048	0.114
μ	scale	0.506	0.139	0.602	0.617	0.179	1.122	0.134	0.050	0.089
	LLF	-147126.06			-104892.21			-103053.87		
Secondary										
α_1	size	0.363	0.080	0.330	0.426	0.250	0.074	0.455	0.055	0.400
α_2	park	0.130	0.057	0.323	0.305	0.330	0.092	0.322	0.075	0.391
α_3	dist	0.733	0.017	0.098	0.707	0.095	0.019	0.705	0.018	0.102
λ	scale	2.114	0.035	0.082	2.329	0.080	0.037	2.174	0.030	0.072
μ	scale	0.703	0.056	0.469	0.794	0.532	0.235	1.614	0.282	1.909
	LLF	-140011.47			-101503.62			-106470.45		

Note: Parameters on firm dummies not reported.

Table 9: Price Parameters

	Specification			
	I	II	III	IV
$\frac{\beta_1}{\beta_2}$	0	5	10	15
Estimated β_2	0.930	0.947	0.970	0.983
Standard error	(0.071)	(0.076)	(0.076)	(0.077)
Implied β_1	0.000	4.735	9.700	14.745
η^I (for $\zeta = 1$)	-1.000	-0.848	-0.689	-0.526

observations = 9

As discussed in the previous section, the model is estimated under three alternative specifications (II to IV); we set β_1/β_2 equal to 5, 10, and 15 for specifications II to IV respectively. As we see later in the section, these imply a conditional elasticity in the range -1 to -0.526. To save space the consumer parameters are not reproduced for each specification; Table 8 summarizes parameters for model III where $\beta_1/\beta_2 = 10$. As we see in the next paragraph, this is our preferred model, as it predicts a conditional elasticity close to -0.7 for median consumers.

Table 9 presents results for the price parameter β_2 which is estimated in the second stage. The estimation minimizes the sum of the squares of the differences between predicted and actual profit margins. The results are reported in the second row of the table; the third row gives the standard errors.

The estimated value of β_2 increases for specifications I through IV. To understand why this happens, recall that a firm's profit margins in differentiated products markets are the inverse of overall demand elasticity for the firm, and that in this application the latter is the sum of conditional price elasticity (determined by β_1) and market share elasticity (determined by β_2). Going from specification I through IV, β_1/β_2 increases from zero, and the magnitude of the conditional demand elasticity (7) falls, reducing overall demand elasticity for each firm. To restore overall demand elasticity for each firm (and predicted profit margins) the sensitivity of market share with respect to price must increase, which requires an increase in β_2.

In each specification the β_2 parameter is positive (as expected) and significantly different from zero. The implied value of β_1 is also shown in the table, along with the implied elasticity (η^I) for a median household ($\zeta^I = 1$). Comparing the four alternative specifications, we see that the assumed value $\beta_1/\beta_2 = 10$ gives an elasticity (-0.689) nearest to the desired level (-0.7). We base our discussion in the rest of the paper on specification III, referring to the other specifications to check for robustness.

With the structural parameters of the model in hand, we check the realism of the model's predictions. We begin with predictions for consumer choice at a store level; this is important because the model is estimated at a firm level, and store probabilities are only indirectly estimated. The effect of distance on store choice probabilities r^i_j is given in Table 10, which shows the probability of choosing a store within various distances. The figures are plausible as they match the results of other surveys:[9] 41% of primary shoppers visit a store less than 5km distant, 61% less than 10km distant, and nearly all visit

[9] The survey results reported in CC(2000) show that 28% of respondents took 5 minutes or less to their supermarket; 65% took 10 minutes or less, and 91% 20 minutes or less.

Table 10: Customers by Distance to Store
(Specification III)

Mode	Income	Proportion of Customers by Distance <5km	<10km	<15km	<20km	<25km
Primary	Low	0.415	0.599	0.756	0.903	0.973
	Medium	0.413	0.606	0.762	0.910	0.976
	High	0.424	0.620	0.772	0.916	0.977
Secondary	Low	0.404	0.579	0.735	0.891	0.969
	Medium	0.398	0.576	0.735	0.892	0.970
	High	0.401	0.579	0.737	0.895	0.972

stores less than 25kms away. We note that variation by income and mode of shopping is minor.

The motivation for allowing firm parameters to vary by g is to allow realistic substitution patterns by consumer group. To assess substitution patterns, Table 11 gives the percentage of customers substituting to other firms from Tesco for a given price increase at all Tesco stores. Different income groups and mode types substitute differently. In particular, high income groups are more likely to substitute into "high quality" firms such as Sainsbury and Waitrose. Secondary shoppers (of any income level) are more likely (than primary shoppers) to substitute into firms offering smaller product range such as Iceland, and M&S, and the corner/other stores.

We now compare predicted and actual profit margins. Given the importance of the price parameters in determining equilibrium profit margins, this provides a check on the method used in estimating the price parameters. The assumptions relating to the variation in the price parameters β by group g (discussed in section 5) determine the variation in predicted markups by firm as different firms draw on different mixes of consumer groups.

Table 12 presents observed and predicted firm profit margins. The predicted figures match the observed figures quite closely for the firms, for both the big four and the others. Note in particular that there is no obvious systematic misprediction of the margins for firms which specialize in secondary shopping (Iceland and M&S) or high income customers (Sainsbury, Waitrose), although there is a slight tendency for the model to over-predict margins for firms which specialize in low income stores (Kwik Save, Somerfield). These findings are robust across specifications I–IV.

Profit margins by pricing region are shown in Table 13 for specification III. These provide a check on the pricing model at the level of the pricing region. The regional variations in profit margins reflect regional dominance indicated in Table 5; for example Somerfield has higher margins in BATA and EXTQ,

Table 11: Substitution by Consumer Type (Specification III)

For a given price increase at Tesco
% who substitute to each firm
(as a % of total substituting from Tesco).

	Primary			Secondary		
	Low	Medium	High	Low	Medium	High
ASDA	15.05%	18.05%	15.55%	8.70%	10.35%	9.82%
Safeway	12.86%	15.38%	15.92%	9.82%	11.09%	11.54%
Sainsbury	23.70%	30.60%	40.81%	14.83%	18.08%	22.83%
Budgen	1.44%	1.36%	1.44%	1.02%	1.30%	2.04%
Coop	12.07%	8.86%	5.32%	10.71%	9.20%	6.83%
Iceland	1.75%	0.98%	0.62%	9.03%	7.94%	5.81%
Kwik Save	8.10%	5.18%	1.92%	7.16%	5.16%	3.07%
M&S	0.79%	0.67%	1.01%	8.97%	9.02%	12.12%
Somerfield	16.83%	13.79%	9.09%	15.78%	14.15%	10.48%
Waitrose	4.35%	5.09%	11.23%	3.57%	4.53%	9.14%
Corner/Other	7.76%	5.47%	3.73%	13.72%	13.15%	11.63%

Table 12: Observed and Predicted Profit Margins

	Observed	Predicted			
		Specification			
		I	II	III	IV
ASDA	0.119	0.110	0.115	0.115	0.116
Safeway	0.114	0.112	0.115	0.115	0.116
Sainsbury	0.140	0.114	0.119	0.121	0.123
Tesco	0.129	0.120	0.126	0.127	0.130
Budgen	0.040	0.133	0.127	0.123	0.121
Co–op	NA	0.137	0.135	0.134	0.133
Iceland	NA	0.142	0.135	0.135	0.132
Kwik Save	0.048	0.130	0.130	0.129	0.130
M&S	0.136	0.133	0.126	0.127	0.124
Somerfield	0.116	0.137	0.136	0.135	0.135
Waitrose	0.104	0.109	0.109	0.108	0.107

Observed figures as Table 3 column (ii).

Table 13: Predicted Profit Margins by Pricing Region (Specification III)

	Pricing Region									price
	BATA	BHDT	BS	EXTQ	OX	PLTR	RG	SNSP	SO	range
ASDA	0.115	0.115	0.115	—	0.115	0.115	0.115	0.115	0.115	0.000
Safeway	0.120	0.121	0.121	0.120	—	0.114	0.096	0.110	0.119	2.912
Sainsbury	0.129	0.120	0.121	0.126	0.117	0.111	0.120	0.115	0.131	2.263
Tesco	0.123	0.130	0.134	0.124	0.134	0.140	0.117	0.126	0.118	2.663
Budgen	0.115	—	—	—	0.127	—	0.118	0.126	0.130	1.759
Co-op	0.132	0.141	0.134	0.130	0.136	0.131	0.127	0.127	0.144	2.082
Iceland	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.000
Kwik Save	0.131	0.133	0.131	0.134	0.118	0.124	0.129	0.122	0.141	2.649
M&S	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.000
Somerfied	0.140	0.143	0.135	0.158	0.138	0.138	0.109	0.129	0.126	5.845
Waitrose	0.108	0.108	0.108	—	0.108	—	0.108	0.108	0.108	0.000

Note: Blank cells indicate absent firms.

Tesco in OX and PLTR. The final column presents the maximum price range across regions for each firm, as implied by the regional profit margins; these price ranges are slightly higher than those found by the CC (see Table 1) but in both cases the predicted ranges are a few percent. The CC data should be seen only as an approximate guide as it is sensitive to the choice of items in the price index.

In Appendix B we report further results, namely: cross elasticities between stores by floorspace and distance, cross elasticities between firms, and expenditure per square foot by firm.

7 Demerger and Merger

A core issue in UK supermarket competition is whether cross-effects between stores result in market power and economic inefficiency. If so, a structural remedy exists: reorganization of store ownership configurations. In this section we explore this issue by computing the equilibrium response of the industry to a demerger and a series of hypothetical mergers.

We use the index t to indicate a given ownership structure so that m^t and p^t denote vectors of Nash margins and prices associated with t. We also write firm parameters d^t which depend on t through p^t. Let $t = 0$ represent the initial observed structure, so that initial Nash margins are m^0. A merger (or demerger) leads to new ownership structure t and new margins m^t. We assume that stores in the merging (or demerging) firms retain their original marginal costs and non-price attributes (product quality etc.). This allows us to concentrate on cross-effects between stores—i.e. the only effect of merger (demerger) on pricing behaviour is that merged (demerged) firms account for (cease to account for) these cross-effects.

To show how we compute the new profit margins m^t using original margins m^0 and estimated parameters $\hat{\theta}$, consider a demerger of all J stores. This results in J firms, one running each store; the store characteristics are denoted z^t to reflect the new ownership structure. New Nash margins are defined using (24)—i.e. the following system of J equations:

$$m^t = m(M, z^t; \theta^0, d^t) \tag{27}$$

where θ^0 denotes the vector of parameters estimated for the original market structure and d^t is now included because firm parameters change with prices. As d^t is unknown we cannot yet solve for m^t. To overcome this we derive the elements of d^t by updating original firm parameters d^0 as follows:

$$d^t_{1j} = d^0_{1j} + w^g \beta^0_1 \left(\ln p^t_j - \ln p^0_j\right) \tag{28}$$

$$d^t_{2j} = d^0_{2j} \exp\left(-\beta^0_2 \left(\ln p^t_j - \ln p^0_j\right)\right). \tag{29}$$

These equations can be expressed in terms of m^0_j and m^t_j using:

$$\ln\left(\frac{m^0_j - 1}{m^t_j - 1}\right) \equiv \ln\left(\frac{p^t_j}{p^0_j}\right) = \ln p^t_j - \ln p^0_j$$

where the identity follows by $m_j \equiv (p_j - c_j)/p_j$. Thus (27) becomes:

$$m^t = m(M, z^t, m^0, m^t; \theta^0) \tag{30}$$

where m^0 are known. As the number of equations now equals the number of unknowns we can solve for m^t (using Newton–Raphson). The prices of the corner/other stores are assumed to remain constant. The same method is adapted to compute the effect of merger.

Consumer surplus CS^I for consumer I of type i (conditional on ζ^I) is calculated using the expression for the expected value of maximum realized V^I_j (see Anderson et al. (1992, p45)):

$$CS^I = \sigma^I \mathcal{E}\left(\max_{j \in J^i} V^I_j\right) = \sigma^I \ln \sum_{j \in J^i} \exp\left(v^I_j\right) \tag{31}$$

where σ^I converts utility into monetary terms and is given by the inverse of the marginal utility of income (this depends on chosen firm F, so we use a market share weighted average for each consumer i–type). Total consumer surplus CS is obtained by integrating out over the distribution for ζ^I, multiplying expected utility for each i–type by the number of consumers of that type, and summing over the entire set of i–types.

7.1 Demerger

The demerger experiment calculates the profit margins which individual stores would set if they operated independently of other stores with the same firm; this measures market power firms derive by internalizing cross–effects between stores in their chain. The costs of the stores are held constant; it may be objected that this is unrealistic as an independent store could not operate at the same cost as the original chain. However the stores can be thought of as enjoying the cost advantages of being part of a chain but not the market power advantages from owning locally–competing stores. Thus the experiment simulates the outcome of a structural remedy in which chains are permitted but cross-effects are minimized.

Table 14 shows the effect of demerger in each pricing region; the last column is the average effect over all pricing regions. The first two rows give the HHI and the change in the HHI caused by demerger in each pricing region.[10] The initial level of concentration, using US DOJ (1992) classifications, is either "moderately concentrated" (1000 to 1800) or "highly concentrated" (1800 and above). Demerger leads to large reductions in concentration, on average falling from 1616 to 313. The market shares of the top two firms (in rows 3 and 4) are on average 27% and 20% respectively, pointing to a concentrated market. OX is the most concentrated, BATA is the least.

Demerger leads to significant reductions in the revenue-weighted index of prices across *all* supermarkets ($\%\Delta wp$). The average reduction across regions is 1.67%. In OX, the most concentrated region, the figure is highest: 2.69%. In BATA, the least concentrated, the figure is lowest: 1.13%.

What is even more interesting is the price reductions for the biggest firms—we report the top three for each region. The price reduction for the largest firm in each region ($\%\Delta p_1$) is 3.02% on average. The highest regional price reduction for any firm is 3.74% (for Tesco in OX). The price reductions for the next largest firms (in the rows marked $\%\Delta p_2$ and $\%\Delta p_3$) exceed 2% in many regions.

The fall in gross profits ($\%\Delta\pi$) from demerger are 10%-14% for the biggest firms, as shown in the rows marked $\%\Delta\pi_1$–$\%\Delta\pi_3$. Given the importance of marginal costs in this industry, the fall in profit as a proportion of initial industry revenue $\%\Delta\pi/\mathrm{R}$ is much lower: 1.45% on average and up to 1.91% (in OX). As shown in the bottom two lines, demerger leads to an average increase in economic surplus W (the sum of profit and consumer surplus) of 1.17% of initial industry revenue. Consumers gain on average by 2.62% of initial industry revenue; the biggest regional consumer gain is 3.77%.

[10] The HHI is the sum of squared percentage market shares of all products.

Table 14: Equilibrium Effect of Demerger (Specification III)

	Pricing Regions									
	BATA	BHDT	BS	EXTQ	OX	PLTR	RG	SNSP	SO	Avg
HHI	1267	1547	1544	1684	1970	1429	1827	1587	1686	1616
ΔHHI	-1016	-1312	-1214	-1423	-1596	-1129	-1411	-1320	-1311	-1303
share 1	20.96	28.17	27.94	23.87	33.65	24.93	30.36	28.23	26.93	27.23
share 2	15.64	17.67	17.37	20.61	23.95	14.43	25.16	21.99	22.87	19.96
$\%\Delta wp$	-1.13	-1.79	-1.55	-1.78	-2.18	-1.54	-1.46	-1.67	-1.90	-1.67
$\%\Delta p_1$	-2.03	-3.17	-2.89	-3.76	-3.74	-3.48	-2.09	-2.79	-3.21	-3.02
$\%\Delta p_2$	-1.04	-2.04	-1.89	-2.04	-2.69	-1.14	-2.26	-2.20	-2.13	-1.94
$\%\Delta p_3$	-1.54	-1.06	-0.89	-2.09	-0.96	-1.51	-0.66	-1.57	-1.60	-1.32
$\%\Delta \pi_1$	-6.90	-9.92	-8.22	-8.91	-12.69	-6.59	-10.07	-10.14	-10.91	-9.37
$\%\Delta \pi_2$	-6.88	-15.10	-13.66	-13.95	-17.71	-12.68	-9.00	-13.12	-14.45	-12.95
$\%\Delta \pi_3$	-5.94	-13.80	-11.52	-14.01	-22.85	-9.82	-14.77	-12.04	-15.62	-13.37
$\%\Delta\pi$/R	-0.98	-1.54	-1.36	-1.52	-1.91	-1.33	-1.28	-1.48	-1.67	-1.45
$\%\Delta$CS/R	2.01	2.92	2.62	3.77	2.92	2.43	1.64	2.49	2.92	2.62
$\%\Delta$W/R	1.03	1.38	1.26	2.25	1.01	1.10	0.36	1.01	1.25	1.17

Note: share i, p_i, π_i are share, price, and gross profits of ith largest firm respectively

Table 15: Equilibrium Effect of Merger (Specification III)

	Tesco			Sainsbury		Safeway	Somerfield
	ASDA	Safeway	Sain	ASDA	Safeway	ASDA	Kwik Save
HHI	1607	1571	1616	1607	1571	1555	1575
ΔHHI	346	325	528	297	296	194	82
share 1	25.18	23.50	22.66	18.91	18.63	10.28	11.93
share 2	7.90	7.72	16.06	8.38	8.36	9.23	3.21
$\%\Delta wp$	0.65 (1.31)	0.64 (0.95)	1.48 (2.73)	0.55 (1.08)	0.48 (0.72)	0.29 (0.56)	0.17 (0.26)
$\%\Delta p_1$	1.29 (2.66)	1.35 (2.13)	3.20 (5.00)	1.39 (2.40)	1.18 (1.81)	1.21 (1.68)	0.64 (1.15)
$\%\Delta p_2$	3.77 (4.99)	3.95 (6.55)	4.44 (7.39)	2.95 (4.18)	2.49 (3.72)	1.26 (2.44)	2.34 (4.89)
$\%\Delta p_o$	0.08	0.08	0.07	0.09	0.09	0.06	0.04
$\%\Delta \pi_1$	1.96	2.04	3.46	1.53	1.20	0.40	0.45
$\%\Delta \pi_2$	-0.10	-0.22	1.32	0.12	0.09	0.37	-0.15
$\%\Delta \pi_o$	6.17	6.02	14.97	5.05	4.45	2.49	1.30
$\%\Delta\pi$/R	0.56	0.56	1.19	0.49	0.43	0.27	0.14
$\%\Delta$CS/R	-0.85	-1.09	-1.76	-0.73	-0.79	-0.49	-0.27
$\%\Delta$W/R	-0.29	-0.53	-0.57	-0.24	-0.36	-0.22	-0.13

Note: share 1, p_1, and π_1 are market share, price, and gross profits of larger merging firm p_o and π_o are for non-merging firms. Maximum regional values in parentheses.

7.2 Merger

We carry out a series of mergers of policy interest, merging all pairs of the big four firms plus Kwik Save and Somerfield (which actually merged after 1995). We assume that marginal costs and qualities remain at pre-merger levels for all stores. Post merger we do not impose uniform pricing across stores of the merged firm pair (in any pricing region); each merged firm simply takes account of cross effects previously ignored. Table 15 displays the results. The values given are the average effect across regions; regional maxima are in parentheses for price changes. The first two rows give the average HHI, and its change, across regions in which both firms are present. The next two lines give the market shares of the two merging companies.

The mergers with Tesco produce the biggest increases in prices. We begin with the revenue-weighted index of prices across all supermarkets: $\%\Delta wp$ is 1.48% for merger with Sainsbury, 0.65% for merger with ASDA, and 0.64% for merger with Safeway. The maximum $\%\Delta wp$ for any region is 2.73% (for the merger with Sainsbury). The Sainsbury and Tesco merger has by far the biggest impact on $\%\Delta wp$.

If we limit our attention to the prices of the merging firms we find much higher price increases: these are labelled $\%\Delta p_1$ and $\%\Delta p_2$ for the larger and smaller firm respectively. The biggest increases are always for the smaller firm in the coalition. In the mergers with Tesco, $\%\Delta p_2$ ranges from 4.4% (for Sainsbury) to 1.2% (for Safeway). Regional maxima for $\%\Delta p_2$ are very high in the mergers with Tesco, ranging from 7.4% (for the Tesco/Sainsbury merger) to 5.0% (for the Tesco/ASDA merger). Turning to mergers of big four firms which do not involve Tesco, the $\%\Delta p_2$'s remain large in at least some regions.

The actual merger, namely that between KS and Somerfield, has a small $\%\Delta wp$ (0.17%); however the maximum regional $\%\Delta p_2$ is high (5%).

The fact that the smaller firm in any merger tends to increase prices more than the larger firm can lead to a fall in profit for the smaller firm: this happens for ASDA and Safeway in the Tesco mergers. Finally, mergers result in a large positive externality on outsider firms: notice how $\%\Delta\pi_o$ greatly exceeds either $\%\Delta\pi_1$ or $\%\Delta\pi_2$.

7.3 Robustness Analysis

To check whether the conclusions in this section are robust to changes in assumed conditional elasticity, the experiments are re-run using the alternative specifications (I, II, IV). Results are compared in Table 16. Beginning with the demerger experiment, price reductions and welfare gains increase

Table 16: Demerger and Merger: Alternative Specifications

	Demerger under alternative specifications:					Sainsbury and Tesco mergers under alternative specifications:			
	I	II	III	IV		I	II	III	IV
$\%\Delta wp$	-1.56	-1.63	-1.67	-1.72	$\%\Delta wp$	1.35	1.44	1.48	1.52
$\%\Delta p_1$	-2.76	-2.92	-3.02	-3.13	$\%\Delta p_1$	2.93	3.10	3.20	3.29
$\%\Delta p_2$	-1.77	-1.88	-1.94	-2.01	$\%\Delta p_2$	4.07	4.30	4.44	4.57
$\%\Delta p_3$	-1.16	-1.29	-1.32	-1.36	$\%\Delta p_o$	0.04	0.07	0.07	0.09
$\%\Delta \pi_1$	-9.50	-9.39	-9.37	-9.29	$\%\Delta \pi_1$	3.80	3.67	3.46	3.30
$\%\Delta \pi_2$	-12.51	-12.65	-12.95	-13.20	$\%\Delta \pi_2$	1.70	1.55	1.32	1.10
$\%\Delta \pi_3$	-12.95	-12.98	-13.37	-13.74	$\%\Delta \pi_o$	13.75	14.33	14.97	15.49
$\%\Delta\pi$/R	-1.36	-1.42	-1.45	-1.50	$\%\Delta\pi$/R	1.15	1.18	1.19	1.20
$\%\Delta$CS/R	2.19	2.49	2.62	2.86	$\%\Delta$CS/R	-1.52	-1.70	-1.76	-1.82
$\%\Delta$W/R	0.83	1.07	1.17	1.36	$\%\Delta$W/R	-0.37	-0.52	-0.57	-0.62

somewhat as we move from specification I through IV. This outcome is easily explained: as noted in section 6.2, moving from I through IV the elasticity of conditional demand falls from -1 to -0.526. This reduction in conditional elasticity is associated with an increase in β_2 which increases inter–store price elasticity, and hence the gains (to firms) from multi–store operation. The table shows, however, that results only differ little between model III and the other alternatives. (For example average weighted price falls by 1.56% in model I, 1.67% in model III, and 1.72% in model IV). Turning to the merger experiments Table 16 compares results for the Tesco and Sainsbury mergers for specifications I–IV. As for the demerger exercise, the effects of merger (on prices etc.) increase somewhat as we move from model I to model IV. However, differences between the results are small.

8 Conclusions

The effect of break-up or merger depends critically on the extent to which firms enjoy market power from operating multiple stores. The demerger experiments conducted in this paper show that current market structures confer significant market power on the top four firms via multiple store effects. The picture varies from region to region: in some regions the market power is rather modest, in others it is more serious. The experiment points to store reallocations in selected regions as a practical means to reduce inefficiency from market power, bringing price reductions of 2%-3.8% for the largest firms and similar increases in consumer welfare as a percentage of industry revenue.

The results of the merger experiment caution against merger between the big four firms; even the merger of the smallest two of the big four firms would have significant effects on the prices of these firms in particular regions. Finally, market shares of the merging or demerging firms in each pricing region, and the change in HHI, are useful approximate guides to the effect of a merger or demerger on consumer welfare and prices.

We conclude with two caveats. First, this is an analysis of pricing *given* primitives such as marginal costs, store numbers, and firm characteristics. These are unlikely to change much in the short run, but in the long term a demerger or merger may affect investment incentives, altering the primitives. Second, we assume single-stage multi-store Nash pricing to estimate the price parameter. We believe this is the most plausible assumption, given that CC (2000) found little evidence of collusive pricing. However, if firms were engaging in a softer form of price competition, such as tacit collusion between some of the firms, then observed profit margins would be rationalized by a higher price parameter β_2 than estimated here, representing greater price sensitivity on the part of consumers. In this case a demerger would lead to larger price reductions than found here.

A Pricing

Substituting (13) into (14) and rearranging gives δ_F (conditional on ζ^I):

$$\delta_F\left(M, z, p, \zeta^I; \theta\right) = \frac{\sum_i M^i \sum\limits_{j \in J_F} s_j^i x_j^i}{\sum\limits_i M^i \sum\limits_{j \in J_F} \left\{ s_j^i \left(1 - \sum\limits_{k \in J_F} s_k^i\right) \frac{\partial v_j^i}{\partial p_F} x_j^i - \frac{\partial x_j^i}{\partial p_F} s_j^i \right\}}. \quad (32)$$

Profit margins m_F are therefore:

$$m_F \equiv \frac{\delta_F}{p_F} = \frac{\sum_i M^i \sum\limits_{j \in J_F} s_j^i x_j^i}{p_F \sum\limits_i M^i \sum\limits_{j \in J_F} \left\{ s_j^i \left(1 - \sum\limits_{k \in J_F} s_k^i\right) \frac{\partial v_j^i}{\partial p_F} x_j^i + s_j^i \frac{\partial x_j^i}{\partial p_F} \right\}} \quad (33)$$

where M, z, and θ are comprised of M^i, z^i and $\theta^{g(i)}$ for all i in the pricing region. The derivatives in (33) with respect to price are available from utility (4) and conditional demand (5):

$$\frac{\partial x_j^i}{\partial p_F} = \frac{1}{p_F}\left(\frac{\beta_1^g}{p_F} - x_j^i\right) \quad (34)$$

and

$$\frac{\partial v^i_j}{\partial p_F} = \frac{\mu^g}{p_F}\beta^g_2 e^i_j d^g_{2F} \tag{35}$$

where

$$d^g_{2F} \equiv \exp(\phi^g_{2F} - \beta^g_2 \ln p_F).$$

Substituting (34) and (35) into (33) we obtain:

$$m_F\left(M, z, p, \zeta^I; \theta\right) = \frac{\sum_i M^i \sum_{j\in J_F} s^i_j x^i_j}{\sum\limits_i M^i \sum\limits_{j\in J_F} \left\{ s^i_j (1 - \sum\limits_{k\in J_F} s^i_k) \mu^g \beta^g_2 e^i_j d^g_{2F} x^i_j + s^i_j (\frac{\beta^g_1}{p_F} - x^i_j) \right\}}. \tag{36}$$

This is equation (15) in section 4.

To eliminate the (unobserved) price variable from any appearance outside the d^g_{2F} parameter and the expressions for expenditure and market share, we multiply top and bottom lines by p_F which replaces x^i_j with e^i_j. Rearranging the bottom line we obtain:

$$m_F\left(M, z, p, \zeta^I; \theta\right) = \frac{\sum_i M^i \sum_{j\in J_F} s^i_j e^i_j}{\sum\limits_i M^i \sum\limits_{j\in J_F} \left\{ \beta^g_2 s^i_j \left[(1 - \sum\limits_{k\in J_F} s^i_k) \mu^g e^i_j d^g_{2F} e^i_j + \frac{\beta^g_1}{\beta^g_2} \right] - s^i_j e^i_j \right\}}. \tag{37}$$

When we incorporate prices into the firm parameters in the expressions for expenditure and market share, in section 5, price is eliminated as an argument in (37). Then, having eliminated prices, integrating the associated first order condition over ζ^I gives an expression for margins in terms of observables and parameters to be estimated $(M, z; \theta)$—i.e. equation (24) in section 5.

B Further Predictions of the Model

This appendix presents some further results from the model as a check on its predictions. The effect of floorspace on cross-price elasticity of demand between stores is shown in Table 17, using data on store pairs where both stores fall into the same floorspace categories. The table shows that floorspace has an impact on elasticities for stores which are up to 5 km apart. The standard deviation figures in the second panel show that for large stores less than 5 km apart there is considerable variation in cross elasticities suggesting that other attributes, such as the firm, also impact elasticity.

Cross price elasticities at a firm level are in Table 18 where figures are averaged over the pricing regions. Looking row–wise in the table the largest elasticities are with respect to the prices of the big four, particularly Tesco

Table 17: Store Pair Cross Elasticities (Specification III)

Store Size ('000 sq ft)	Distance between stores (km) 0-5	5-10	10-20	20-30	30-40
	Mean Cross-Price Elasticity				
0-10	0.350	0.198	0.152	0.116	0.064
10-20	0.367	0.232	0.207	0.118	0.105
20-30	0.456	0.209	0.135	0.134	0.128
	Standard Deviation				
0-10	0.147	0.040	0.284	0.194	0.095
10-20	0.228	0.074	0.693	0.057	0.625
20-30	2.755	0.075	0.155	0.371	1.050

Table 18: Elasticity and Expenditure Predictions of the Model

	ASDA	Safe	Sain	Tesc	Budg	Co–op	Icel	KS	M&S	Some	Wait
	Own & Cross price elasticities (specification III)										
ASDA	-9.096	0.947	1.012	0.976	0.734	0.751	0.623	0.884	0.644	0.702	0.959
Safe	0.895	-8.758	0.878	0.980	0.695	0.738	0.578	0.773	0.634	0.867	0.834
Sain	2.247	1.864	-8.279	2.256	2.515	1.714	1.333	1.600	1.429	1.749	2.150
Tesc	2.710	2.748	2.860	-7.879	2.431	2.192	2.035	1.621	2.888	1.491	1.963
Budg	0.088	0.058	0.087	0.081	-8.141	0.083	0.092	0.088	0.084	0.231	0.076
Coop	0.443	0.435	0.474	0.476	0.378	-7.503	0.429	0.546	0.474	0.490	0.353
Icel	0.160	0.161	0.159	0.139	0.269	0.206	-7.408	0.247	0.435	0.244	0.233
KS	0.289	0.270	0.248	0.251	0.230	0.313	0.295	-7.757	0.234	0.294	0.225
M&S	0.199	0.216	0.214	0.188	0.295	0.286	0.559	0.261	-7.880	0.283	0.324
Some	0.583	0.874	0.747	0.754	0.618	0.895	0.773	0.847	0.715	-7.477	0.691
Wait	0.458	0.414	0.400	0.470	0.431	0.355	0.324	0.332	0.391	0.394	-9.186
spec	Own Price Elasticities: Alternative Specifications										
I	-9.464	-8.978	-8.771	-8.354	-7.548	-7.317	-7.017	-7.740	-7.531	-7.351	-9.052
II	-9.108	-8.766	-8.393	-7.983	-7.879	-7.409	-7.395	-7.741	-7.915	-7.406	-9.063
IV	-9.018	-8.694	-8.130	-7.733	-8.297	-7.543	-7.557	-7.743	-8.059	-7.507	-9.252
	National (N) and Predicted (P) Expenditure Per Square Foot (£1995; Specification III).										
N[a]	12.38	13.51	21.41	17.36	8.00	9.62	7.38	8.10	8.03	10.02	12.40
P	13.42	11.03	20.62	20.34	4.39	8.40	11.81	11.29	6.24	13.39	11.92

Note: elasticity of demand for column w.r.t row's price; elasticities are averages across pricing regions.

a: N from company Annual Reports.

and Sainsbury. To check robustness, we present own-price elasticities from alternative models I–IV; there is relatively little variation.

Predictions of weekly expenditure per square foot are in Table 18. Row (N) gives the national figure from 1995 Annual Reports; row (P) gives the model's prediction. We do not expect an exact match, as we estimate the model on a subset of the UK. Most firms expenditure per square foot are closely predicted.

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