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ENTRY AND EXIT IN GROCERY RETAILING: LOCAL PRE-EMPTION AND SOCIAL EFFICIENCY

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Entry and Exit in Grocery Retailing: Local Pre-emption and Social E±ciency[¤]

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Abstract

This paper develops an asymmetric price setting oligopoly model of store opening and closure decisions in the UK supermarket industry which is estimated using a survey of consumer choices and a dataset of store characteristics. The model is used to examine the strategic local entry and exit behaviour of the ¯rms and the social e±ciency of stores numbers and store characteristics. It is found that ¯rms use store openings to pre-empt rival competition and there is a degree of local clustering. A welfare analysis of store charactersitics and store numbers shows that most existing stores and some hypothetical extra stores are welfare enhancing at the margin. Location is not optimal but location ine±ciencies are small and ¯rms have incentives to relocate in socially preferred directions. Recent trends in store characteristics | larger stores and more stores openings by large ¯rms | are welfare improving.

Key Words: concentration, entry, retailing, di®erentiated products, multi-product ¯rms, pre-emption, environmental planning.

JEL Nos: L1, L8, L13.

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1 Introduction

THE UK SUPERMARKET INDUSTRY is a multi–product oligopoly in which store characteristics, including size, number, and location, are chosen by a few asymmetric firms. This paper examines strategic local entry and exit behaviour and the social efficiency of resulting store numbers and store characteristics. We examine two specific questions suggested by the theoretical literature: do firms open stores to pre-empt competition from rivals and is the number of stores and their characteristics socially efficient?[1] We investigate the social effect of two recent trends in store characteristics: [i] firms have been opening large stores and closing small stores and [ii] the largest firms have been the most active developers of new stores.

We develop a model of chain store profitability in spatial markets and estimate parameters using a survey of consumer choices and a data set of store characteristics. We use a multi-product Nash pricing assumption to generate predictions of the gross profitability of store entry and exit under alternative assumptions about rival behaviour. The consumer model is estimated first and fixed costs are estimated in a second stage.

Fixed costs are estimated assuming that firms open profitable stores and close unprofitable stores. The unit of analysis is the individual development location at a single point in time, conditioning on existing entry, and taking as given the firm facing the decision. We estimate two simple alternative entry models. In the first the firm believes a rival would otherwise take up the opportunity. In the second the firm assumes no rival would take up the opportunity so pre-emption plays no role. Variation in the degree of incumbency across development locations identifies the extent to which firms accept lower direct returns in stores which pre-empt rival entry. We find that there is evidence of pre-emption for new store openings, and there is a degree of local clustering of stores.

To quantify social inefficiency we perturb the model, changing the number, size, and location of the stores, and redistributing the ownership of stores across firms. The is little evidence of excess entry. Results suggest that most stores are socially beneficial at the margin and that further entry is beneficial. We find that large stores, and stores of the large chains, are socially more efficient — i.e. recent trends are welfare improving.

The approach is partial in that we take as given the number and characteristics of store development opportunities. This is motivated by two considerations. The first is tractability: in spatial markets a prediction of

[1] On multi-product oligopoly see Schmalensee (1982), Gilbert and Newbery (1982), and Shaked and Sutton (1990). On the social efficiency of market outcomes see Mankiw and Whinston (1986) and Spence (1976).

equilibrium store numbers is difficult without inappropriate assumptions such as symmetry and single-product firms (see Shaked and Sutton (1990)). The second is that the market is affected by environmental planning which restricts development: we cannot assume that an undeveloped opportunity is unprofitable without a model of the planning process.

Unlike the existing empirical entry literature (Bresnahan and Reiss (1991), Berry (1991)) the paper relaxes the assumption that market demands are symmetric, does not rely on the use of isolated markets, and estimates consumer primitives explicitly rather than implicitly via assumptions about firm behaviour. We use the characteristics approach to consumer demand, which allows welfare investigations of product placements. Berry and Waldfogel (1999) use demand data but employ a symmetric demand assumption which limits their analysis to the social efficiency of firm numbers.

The paper is organized as follows. We minimize discussion of the pricing model, which is covered in Smith (1999), and concentrate on the model of store entry and exit. In section 2 we outline the model of consumer and firm behaviour. In section 3 we provide an overview of the data and the industry, and describe local market structure. Section 4 gives econometric assumptions. In section 5 we estimate the model and assess firm behaviour. Section 6 quantifies the social efficiency of market outcomes. Section 7 concludes.

2 A Model of Entry and Exit

Consumer Behaviour Consumers are of different types i; corresponding to combinations of income, location, and shopping mode. Income $y(i)$ is of three bands, location is defined using postal codes, and the two shopping modes are primary shopping, the largest weekly expenditure, and further secondary trips. Consumer l of type i has utility V_j^l for store j of firm $F(j)$:

$$\begin{aligned} V_j^l &= \left[\beta^i y(i) + \phi^{1i}_{F(j)} + \alpha^i_1 size_j - \phi^{2i}_{F(j)}\right] \cdot p_{F(j)}^{\beta^i} - \alpha^i_2 dist^i_j + \alpha^i_3 park_j + \mu^i \varepsilon^l_j \\ &= v^i_j(z_j) + \mu^i \varepsilon^l_j \qquad (1) \end{aligned}$$

where v^i_j is type i's mean utility and $\mu^i \varepsilon^l_j$ is individual deviation. Mean utility v^i_j is a function of unobservable firm specific utility $\phi^i_{F(j)} = (\phi^{1i}_{F(j)}, \phi^{2i}_{F(j)})$; a price index $p_{F(j)}$; and observable characteristics z_j; namely floorspace $size_j$; distance from the consumer $dist^i_j$, and the availability of parking $park_j$. Store size proxies variety. Parameters $\alpha^i, \beta^i, \phi^i_{F(j)}$ represent type i's valuation of observed and unobserved store attributes and vary by i up to location.

Roy's identity and (1) give demand for groceries conditional on choice of store; multiplying by price gives the conditional expenditure function:

$$e_j^i = \left[\beta^i y(i) + \xi^{1i}_{F(j)} + \alpha_1^i size_j\right]: \tag{2}$$

By construction $park_j$ and $dist_j^i$ are excluded and only a subset $\xi^{1i}_{F(j)}$ of the firm specific unobservables $\xi^i_{F(j)}$ determines expenditure.

The first term of (1) is utility from shopping in the store. $\xi^{1i}_{F(j)}$ is firm specific unobservables affecting expenditure, such as freshness, and $\xi^{2i}_{F(j)}$ is other firm specific unobservables, such as checkout efficiency. Price does not appear in the expenditure function: we assume unit elasticity for groceries, conditional on store choice. This is close to elasticities for food and alcohol as estimated for UK data in Blundell et al (1993). We do not restrict the overall elasticity of demand for groceries at the store — this depends on β^i.

Notation indicates that each firm sets common prices, although this is only within a set of defined regions. Within these mean unobserved utility $\xi^i_{F(j)}$ is also common across stores of given firm. Regional prices and quality uniformity corresponds to industry practice which is largely not localized.[2] This is consistent with casual observation: consumers associate value, quality, and amenity with firms rather than individual stores.

Given that ϵ_j^i is distributed Type–1 Extreme Value (EV), of standardized scale and location, the probability s_j^i of type i choosing store j is:[3]

$$s_j^i \equiv \Pr\left(V_j^i = \max_{k \in J^i} V_k^i\right) = \exp(v_j^i/\mu^i) \Big/ \sum_{k \in J^i} \exp(v_k^i/\mu^i); \text{ for all } j \in J^i; \tag{3}$$

where J^i is the choice set, defined as the nearest 30 stores to the consumer plus a local convenience store which corresponds to the 'corner/other' option in the survey and plays the role of the outside good.

Consumer welfare for each i type is given by the expected value of maximum realized utility. Changes in consumer welfare from a change in the number, or characteristics, of products in the choice set, are given by:[4]

$$\Delta CS^i = \left(\mu^i / \lambda^i\right) M^i \left[\ln \sum_{k \in J^{1i}} \exp\left(\frac{V_k^{1i}}{\mu^i}\right) - \ln \sum_{k \in J^{0i}} \exp\left(\frac{V_k^{0i}}{\mu^i}\right)\right] \tag{4}$$

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[2] We describe pricing regions in section 3. The practice of regional or national pricing is reported in Institute of Grocery Distribution (1995).

[3] Unnatural substitution patterns of Type-1 EV consumers are avoided by allowing parameters to vary by consumer type. See Berry, Levinsohn and Pakes (1995).

[4] See Small and Rosen (1981) for a derivation of (4). See Trajtenberg(1989) for an early application.

where $(J^{1i}; v_k^{1i})$ and $(J^{0i}; v_k^{0i})$ represent new and old choice sets respectively and where λ^i is the marginal utility of income for type i; which normalizes the function into money terms.

Firm Behaviour Store revenue R_j is given by summing over expenditure for each type, i.e.:

$$R_j = \sum_i M^i s_j^i e_j^i \qquad (5)$$

where M^i is the number of type i consumers.

Marginal costs c_f for firm $f = F(j)$ are assumed to be uniform across stores within each pricing region, giving uniform gross profit margins $m_f = (p_f - c_f)/p_f$. Gross profit for store j is

$$\pi_j = R_j m_f. \qquad (6)$$

Fixed costs ψ_j of store j are determined by store size, firm, parking, retail rents in the location, $rent_j$, and unobservables ξ_j; i.e.:

$$\psi_j = \psi\left(F(j); rent_j; size_j; park_j; \gamma; \xi_j\right) = \psi(z_j) \qquad (7)$$

where γ is a vector of cost parameters.

We use the conventional stage structure: prices are determined in a Nash equilibrium, given other store characteristics z_j. Firms account for multi-product effects between stores of the same chain when setting $p_{F(j)}$. We assume existence of a unique Nash price equilibrium.[5] Prices and gross profits are a function of z; the J–vector of z_j terms, covering all stores in the relevant pricing region.[6] The reduced form for net profit of firm f; given z and Nash multi-product pricing, is:

$$\Pi_f = \pi_f(z) - \psi_f(z) \qquad (8)$$

where $\pi_f(z)$ and $\psi_f(z)$ are firm level aggregates.

We assume that a number of development and closure opportunities arise for each firm. The closure opportunities are the set of open stores of the

[5]Conditions for the existence and uniqueness of Nash equilibrium for heterogeneous Type-1 EV consumers and asymmetric multi-product firms are studied in Spady (1984). Existence and uniqueness conditions are less demanding in our set-up, where firms set uniform multi-product prices, than in standard multi-product situations. In the numerical computations there are no convergence difficulties, nor is there any suggestion of multiple equilibria: converged solutions show a consistent pattern.

[6]We use J to denote the number or set of stores in the pricing region, and J^i to denote the number of stores in the choice set of consumer i.

firm. The developments are restricted by the planner: undeveloped locations or unobserved sizes may be profitable. We therefore do not model location or size decisions.

Firms condition their decisions on an expected set of store characteristics operating in the market. We assume that firms expect rival stores to remain open near any store it opens. This is consistent with the situation in UK retailing where sites are scarce and the closure of a rival store is unpredictable.

We specify two simple alternative beliefs about the fate of site j in the event of it being closed or not being developed by firm f:

1. Pre-emption: the site becomes available to an unspecified rival h which develops a store on the site with the same equilibrium mean utility v_j^i (for all i) as the firm itself would offer in equilibrium.

2. Non pre-emption: the site is not developed by a rival.

The specification of the first belief is admittedly ad hoc and is one of a number of possibilities. The alternatives are costly to compute and there is no obvious simple alternative. It is consistent with the belief that a rival opens the store at equivalent price and quality levels to that which the incumbent would open. Consistent with the practice of regional pricing, it implies a minimal level of price competition: firm f loses multi-product price effects with store j and has slightly lower equilibrium prices.

Under pre-emption, for hypothetical rival h, the incentive to open a store is the increase in firm profits from opening the store compared to allowing rival h to open the store. Where firm f operates local stores, part of the incentive to open the store is to avoid having profits cannibalized by rival h: $\Delta_j \pi_f(z|h)$ is the incremental gross profit of opportunity j to firm f conditioned on the alternative of rival entry by h, i.e.:

$$\Delta_j \pi_f(z|h) = \pi_f(F(j) = f) - \pi_f(F(j) = h). \tag{9}$$

Under non pre–emption, incremental gross profits are the increase in firm profits assuming that no rival gets the store. Where the firm operates local stores the incentive to open a store is diminished by self-cannibalization. $\Delta_j \pi_f(z|\emptyset)$ is the incremental gross profit of opportunity j to firm f conditioned on the alternative of no rival entry, i.e.:

$$\Delta_j \pi_f(z|\emptyset) = \pi_f(F(j) = f) - \pi_f(F(j) = \emptyset). \tag{10}$$

To measure the extent of incumbency at any location, we define an 'incumbency variable' b_j, which has a precise interpretation, namely the factor

Table 1: Store Characteristics

	Jan 1995		1994-1996			
	Open		Closures		Openings	
	Mean	sd	Mean	sd	Mean	sd
#	2765		349		359	
Size (1000sqft)	17.5	(14.7)	6.1	(6.0)	19.8	(11.5)
Monthly Rent $/sqft	107	(36)	85	(39)	82	(30)
Park	0.6	(0.5)	0.3	(0.5)	0.7	(0.5)

Source: IGD and Jones Lang LaSalle; Standard Deviations in Parentheses

by which gross profits under the pre-emption model exceed gross profits under the non pre-emption model, i.e.:

$$b_j = \frac{\pi_f(F(j) = f) - \pi_f(F(j) = h)}{\pi_f(F(j) = f) - \pi_f(F(j) = \emptyset)} \qquad (11)$$

where $1 < b_j < 1$: The case of extreme non-incumbency is $b_j = 1$ where firm f has no local presence; $b_j = 1$ is extreme incumbency where f is the only local firm and it makes no extra gross profit from opening another store.

The conditions for store j being opened, maintained, and closed, are:

$$\Delta_j \pi_f(z_j; \emptyset) b_j^{\theta} \begin{cases} > \psi_j & \text{for open } j \\ > \sigma\psi_j & \text{for maintain } j \\ \leq \sigma\psi_j & \text{for close } j \end{cases} \qquad (12)$$

where σ is the fraction of costs which are not sunk and θ is a 'behaviour parameter' such that $\theta = 1$ for pre-emption and $\theta = 0$ for non pre-emption. If sunk costs are important and profits change unpredictably over time the conditions for opening and closure may differ from those assumed here. On a priori grounds, we believe sunk costs are small as there is an efficient resale market for the capital assets, e.g. buildings, cash registers, etc.

3 The Grocery Retail Market

Stores, Consumers, and Pricing Regions The store data set records the location, size, availability of parking, the firm, and the date of opening (and closing if appropriate) of stores open at any time in 1993–1996.[7] We also have market rent per square foot for the most desirable spot in the retail area for January 1995.[8] The rent figures are those for the nearest town or

[7] The store data set is from the Institute for Grocery Distribution, London. (IGD).

[8] The information on retail rents is from Jones Lang LaSalle Ltd, London.

Table 2: Market Shares and Expenditures

	% Share of Trips by Income Group						Expenditure Category % Relatives					
	Primary			Secondary			Primary			Secondary		
Firm:	1	2	3	1	2	3	a:b	c:d	e:f	a	b	c
ASDA	9	11	9	5	6	6	39	30	30	36	13	51
Budgen	3	3	2	2	2	2	44	31	25	46	30	24
Co-op	9	6	3	8	7	4	55	27	18	30	24	47
Somer¯eld	8	6	4	15	16	16	53	27	20	48	9	43
Iceland	2	1	0	10	8	6	64	23	13	41	16	43
KwikSave	11	6	2	8	6	3	66	24	10	54	28	18
M&S	1	1	1	8	8	11	39	20	41	29	24	47
Safeway	8	9	10	7	7	8	36	26	38	50	10	40
Sainsbury	24	26	34	13	14	16	35	25	41	48	16	35
Tesco	19	24	28	12	13	14	33	27	40	66	23	12
Waitrose	2	2	4	2	2	5	29	20	51	32	22	46
Corner	5	4	2	10	10	9	57	26	18	52	17	31

Source: Claritas. 1,2,3 and a,...,f denote income and expenditure categories respectively.

village and are not store-speci¯c. Summary statistics are in Table 1. The ¯rst row shows that the number of closures and openings amount in each case to more than 10% of open stores. The next three rows show the average values of the size, rent, and park variables. Opened stores are larger than existing stores which are larger on average than closed stores.

Consumer data is from the National Shoppers Survey for January 1995.[9] The household is asked for: [i] the retailers visited; [ii] the retailer 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] the post code and annual income of the household.[10] Households are asked to tick one of a series of expenditure and income categories.[11] The data are

[9] The National Shoppers Survey is distributed to households in a variety of ways including inserts in magazines and posting through doors. It received replies from 5:4% of households in our area of study and is run by Claritas (UK) Ltd, Teddington, Middlesex.

[10] While all of the primary expenditure occurs in the consumer's main shopping, secondary expenditure is less straightforward. There are typically 2 to 3 secondary ¯rms (including `corner/other') selected by each shopper. We assume that the consumer divides his secondary expenditure equally between the selected ¯rms, and makes one secondary trip per period, thus alternating between ¯rms. We allocate households of each type to secondary ¯rms in proportion to the number of ticks the ¯rm receives.

[11] Primary shopping categories are: $0 to $15; $15 to $30; $30 to $45; $45 to $60; $60 to $75; and $75 and above. For secondary there are three: $0 to $10; $10 to $20; and $20 and above. There are six income bands in the survey. To obtain enough responses

aggregated to the level of the Postal Sector | small neighborhood size areas in which the ease of getting to any supermarket is similar for all consumers.[12][13] Summary statistics are in Table 2. The ¯rst three columns give ¯rm market shares of primary shopping by income group. Firms are asymmetric. Some ¯rms are more attractive to low income households (e.g. Kwik Save and Co-op), others to high income households (e.g. Sainsbury and Waitrose). The next three columns give market shares of secondary shopping, where some ¯rms are more dominant (e.g. M&S and Iceland). The next six columns show variation by ¯rm in the proportion of shoppers in three expenditure categories, aggregated over income groups.

We de¯ne 35 contiguous pricing regions which are based on groups of one or more Postal Areas. These are de¯ned using the ¯rst two letters of the post code and correspond to travel to work areas which are natural pricing areas for the ¯rms.[14] If a Postal Area is small we merge it with a neighbor to obtain enough observations for estimation. The overall area covers 11:5 million households.[15]

The Firms Industry analysts classify ¯rms into two categories: the Big Four (ASDA, Safeway, Sainsbury, and Tesco), characterized by large stores and a correspondingly greater range of products; and the High Street operators (Budgen, Co{op, Somer¯eld, Kwik{Save, Iceland, M&S, and Waitrose) which have smaller stores and locate mainly at High Street locations.[16] Firms coincide with `fascia' (i.e. the name on the front of the store). As we saw in Table 2, the High Street ¯rms (especially Iceland and M&S) rely more heavily on secondary shoppers. Table 3 presents the number of stores of each ¯rm, mean size and park; and the number of openings and closures during January 1993{December 1996. The table con¯rms the two trends noted in the introduction: ¯rms are opening large stores and closing small stores, and the largest four ¯rms have had the biggest net increase in store numbers.

to identify some of the ¯rm characteristics parameters we add together responses leaving three in total (up to \$9,999; \$10,000 to \$19,999; and \$20,000 and above)

[12] Postal sectors in our study have an average of 2309 households (s.d.1190).

[13] A household is assumed to be located at the average location of addresses in its Postal Sector. The data is rebalanced by the survey company compensate for di®erential response rates by income group, household size, and so on.

[14] This is no coincidence: they were drawn up as useful distribution areas for postal delivery and are centered around nodal towns in the road network.

[15] This is about 60% of the UK. We cover London and ¯ve contiguous English regions: the South East, the South West, East Anglia, the East Midlands and the West Midlands.

[16] A futher ¯rm, Morrisons, is present to a limited extent, operating 25 stores in the northern fringe of our area. We estimate consumer parameters for this ¯rm in regions where it is present but we do not otherwise include the ¯rm in our discussion.

Table 3: Characteristics of Stores

	1995					1993-1996					
	Open					Closures			Openings		
¯rm:	#	Size	s.d.	% Share	park	#	Size	park.	#	Size	park.
ASDA	85	43.3	9.9	8	0.48	1	28.4	1.00	-	-	-
Budgen	107	7.8	2.9	2	0.47	12	7.4	0.42	26	8	0.65
Co-op	536	9.9	11.4	12	0.45	190	3.3	0.13	24	12.0	0.63
Somer¯eld	410	9.3	6.3	8	0.60	42	5.4	0.55	4	13.6	0.75
Iceland	202	5.9	1.5	3	0.23	24	6.9	0.00	64	4.7	0.22
KwikSave	273	8.7	4.4	5	0.50	-	-	-	15	7.9	0.47
M&S	182	24..5	14.8	10	0.12	-	-	-	-	-	-
Safeway	209	22.0	7.6	10	0.94	13	14.6	1.00	53	29.3	1.00
Sainsbury	299	27.3	13.4	18	0.94	32	14.9	0.91	48	31.1	0.90
Tesco	325	26.7	15.1	19	0.90	25	15.5	0.76	95	24.4	0.96
Waitrose	112	14.6	5.8	04	0.96	7	11.1	1.00	19	23.7	0.95
Total	2765					349			359		

Notes: 1 Size units: 1000 square feet. 2 `% Share' is ¯rm's share of °oorspace across all 35 pricing regions

There has been a small increase in total store numbers. The `share' column shows the ¯rms' share of overall °oorspace. The market is concentrated in °oorspace terms: `°oorspace HHI' is 1213 and `°oorspace C4' is 0.59.

Local Market Structure: Clustering To ¯nd out whether stores are clustered we count the number of stores within 6 kilometers of the midpoint of each postal sector and compare this with the number of ¯rms operating the stores. 6 km is 3.73 miles or 8 minutes at urban speed restrictions. The results are in Table 4. The rows indicate the market structure in terms of the number of ¯rms in the area and the columns show the number of stores the area. The cells show the number of Postal Sectors in each category. This is done ¯rst for all stores and separately for Big Four stores.

If ¯rms practice an extreme form of pre-emption then we would see extreme clustering of the stores of each ¯rm, resulting in markets which have many stores but only one ¯rm. Looking at the left panel, which gives the market structure using all stores, there are 208 locations with four stores within 6 kms: in only 86 of these cases are all four stores of di®erent ¯rms. For locations with four stores and above, most locations have fewer than the maximum possible number of ¯rms, but there are very few monopolies. The right-hand panel shows that there is likewise a degree of local proliferation of the Big Four supermarkets. While most markets with two Big Four stores

Table 4: Market Structure by Postal Sectors

Firms	All Stores								Big 4 Stores					
	Number of Stores in 6 km radius													
	0	1	2	3	4	5	6	>6	0	1	2	3	4	>4
1	-	281	30	1	0	0	1	0	-	488	71	6	0	0
2	-	-	210	51	14	4	2	0	-	-	426	222	125	123
3	-	-	-	190	108	34	12	15	-	-	-	178	223	872
4	-	-	-	-	86	95	54	18	-	-	-	-	28	1125
5	-	-	-	-	-	73	58	194	-	-	-	-	-	-
6	-	-	-	-	-	-	72	346	-	-	-	-	-	-
7	-	-	-	-	-	-	-	369	-	-	-	-	-	-
>8	-	-	-	-	-	-	-	2128	-	-	-	-	-	-
Total	376	281	240	242	208	206	199	3070	559	488	497	406	376	2120

Numbers in each cell are the number of postal sectors in each store/firm combination category

are duopolies, most markets with three or more Big Four stores are more concentrated than the minimum possible given the number of stores. There are few cases where all are operated by the same firm. Clustering is typical but not extreme.

4 Estimation

Consumer Choice We use profit margin data rather than price data. We estimate the model by incorporating the effect of price into the ϕ_F^{2i} terms giving $\tilde{\phi}_F^{2i}$. The price parameter β^i is lost but is recovered later using observed profit margins. We estimate the model separately for each income group incorporating $\beta^i y(i)$ into ϕ_F^{1i} giving $\tilde{\phi}_F^{1i}$. These alterations give:

$$v_j^i = \left[\tilde{\phi}_{F(j)}^{1i} + \alpha_1^i \text{size}_j\right] \tilde{\phi}_{F(j)}^{2i} - \alpha_2^i \text{dist}_j^i + \alpha_3^i \text{park}_j \tag{13}$$

$$e_j^i = \tilde{\phi}_{F(j)}^{1i} + \alpha_1^i \text{size}_j. \tag{14}$$

The outside good corresponds to the 'corner/other' option in the consumer survey. We do not have reliable observations on corner stores in the store data set and assume everyone has a convenience store in their postal sector of normalized utility (we set $\tilde{\phi}_j^{2i} = 1$, $\text{park}_j = 0$; and $\text{dist}_j = 1$km).

We assume that household l observes its expenditure e_j^l with multiplicative error $\exp(\sigma^i \zeta_j^l)$; where σ^i is a scaling term and ζ_j^l is an iid logit deviate:

$$\log \tilde{e}_j^l = \log\left[\tilde{\phi}_{F(j)}^{1i} + \alpha_1^i \text{size}_j\right] + \sigma^i \zeta_j^l. \tag{15}$$

The probability the consumer reports expenditure in the specific ranges (given choice of store j) is obtained from the ordered logit model.

For each type i we observe the number of households shopping at each firm and the distribution of type i expenditures at the firm across discrete categories. The probability of a particular observed firm choice f and expenditure category l is obtained by aggregation to the firm level:

$$\Pr(e_l < \hat{e}^l_F \le e_{l+1}, \hat{F}^l = f) = \sum_{j \in J_f} \Pr\left(e_l < \hat{e}^l_j \le e_{l+1} \,\Big|\, V_j^l = \max_{k \in J^i} V_k^l \right) s_j^i \tag{16}$$

for all f; for $l = 1, \ldots, \bar{l}$; and for $I = 1, \ldots, M^i$. We maximize a separate likelihood for each income and mode combination for each pricing region. The consumer parameters are estimated in a first stage and used to predict gross incremental store profits which are used in the fixed cost estimation. To calculate gross incremental store profits, which requires a new pricing equilibrium to be solved, the price parameter must be recovered.

Price Parameter Each firm f sets uniform multi-product Nash prices across stores in each pricing region. Nash gross profit margins are:

$$m_f = m_f(z; \phi; \alpha; \beta) \approx m_f(z; \phi; \alpha; w\mu) \tag{17}$$

where β is the vector of β^i parameters, which vary by i up to location. μ is the mean value of the β^is and w is a vector of proportionate deviations of β^i from μ. The number of profit margin observations is at most the number of firms: we have more unknowns than equations. Therefore we cannot recover all β^i. (There are 11 firms and six β^i values in each of 35 regions). To overcome this problem, we assume that the marginal disutility of a price increase is the same for any two consumers (i, k) spending equal amounts in stores where the consumers have an equal mean utility of a unit of groceries:

$$\frac{\partial v_j^i}{\partial p_{F(j)}} = \frac{\nu^i \beta^i}{p_{F(j)}} e_j^i \phi_{F(j)}^{\nu i} = \frac{\nu^k \beta^k}{p_{F(j)}} e_j^k \phi_{F(j)}^{\nu k} = \frac{\partial v_j^k}{\partial p_{F(k)}} \quad \text{for } i \neq k. \tag{18}$$

This simplifies, by equality of expenditures and per-unit mean utilities, to:[17]

$$\nu^i / \nu^k = \beta^k / \beta^i. \tag{19}$$

Assuming that the scaling terms ν^i are proportional to mean expenditure of type i, so that $w = \bar{e}^i / \bar{e}$, we obtain an expression for μ by inverting equation

[17] From (13) and (14) $\phi_j^{\nu i} / p_{F(j)}$ is i's mean utility of a unit of groceries at j.

(17) for firm f:[18]

$$\mu_f = m_f^{-1}(w; m_f): \tag{20}$$

We know m_f for the Big Four firms from HSBC (1997) giving four μ_f values: We use the average to give μ.[19]

Gross Profits We use consumer parameters to compute the incremental gross profit to each firm f of adding or removing any store j. We use a hat, i.e. $\Delta_j \hat{\pi}_{F(j)}(z_j \cdot)$, to show that profits are computed from estimates. The incremental profit of an existing store j, holding other primitives constant, is given by removing j from consumers' choice sets, solving for a new Nash price equilibrium by Newton-Raphson numerical methods, and taking the difference between new and old profits. For a hypothetical store, incremental profits are computed in the same way, this time by adding the store to the model. This is the method used for the non pre-emption model.

For the pre-emption model, incremental profitability is computed by assuming that an unspecified rival would open the opportunity, if undeveloped by the incumbent, at the same mean utility levels in equilibrium, v_j^i, for each i; which the incumbent would offer. To obtain the incremental profit in this scenario we compare the incumbent's equilibrium profits if it opens the store with the equilibrium profits it gets if the store is opened by a rival at "final" (i.e. equilibrium) mean utility v_j^i, for each i.

The consumer survey is a single cross-section in January 1995. If we were to limit the model to openings and closures in January 1995 there would be very few observations. In widening the period there is a trade–off between number of observations and the plausibility of using a 1995 model as a predictor of profits. Given that supermarket profits do not fluctuate greatly, except when a store is opened nearby, we opt for a two year period on either side of 1995 and control for changes in the primitives arising from changes in the set of open stores J:[20]

[18] The analytical expression for this is derived in Smith (1999).

[19] At this point we note that the marginal utility of income is given by:

$$\lambda_j^i = \frac{\partial v_j^i}{\partial y} = \beta^i \phi^{2i}_{F(j)} \left[p_{F(j)}^{-\beta^i} \eta \right]^{-1} \left(1 - \alpha^i / e\right) \phi^{2i}_{F(j)} \tag{21}$$

from which we see that marginal utility of income depends on the chosen supermarket j. To convert consumer surplus in equation (4) into monetary units we compute the weighted average of the marginal utilities λ^i, using λ_j^i as follows $\lambda^i = \sum_j \left(\lambda_j^i s_j^i \right)$:

[20] For example, to compute the profits of a store opened on September 1996 we change the local choice set to include only stores open at that time. When a firm simultaneously closes one store and opens another in the same neighbourhood we compute profits of closed store conditional on the presenec of the opened store and compute the profit of the opened

The $\Delta_j\hat{\pi}_{F(j)}(z_j\cdot)$ are based on estimated parameters and therefore are computed with error, assumed multiplicative log-normal, i.e.:

$$\ln \Delta_j\hat{\pi}_{F(j)}(z_j\cdot) = \ln \Delta_j\pi_{F(j)}(z_j\cdot) + \eta_j \tag{22}$$

where η_j is iid normally distributed.

Fixed Costs We use a flexible hedonic form for fixed costs:

$$\begin{aligned} \ln \Phi_j &= \gamma_{F(j)} + \gamma_1 \ln size_j + \gamma_2 \ln size_j \times \ln size_j \\ &\quad + \gamma_3 \ln park_j + \gamma_4 \ln rent_j + \nu_j \\ &= \gamma_{F(j)} + \gamma \ln z_j + \nu_j \end{aligned} \tag{23}$$

where $\gamma = (\gamma_1; ...; \gamma_4)$. Firm heterogeneity is allowed via $\gamma_{F(j)}$.

The net profit rate $RATE_j$ of store j; as a proportion of fixed costs, is:

$$RATE_j \equiv \Delta_j\pi_{F(j)}(z_j;\cdot)b_j^{\theta} / \Phi_j: \tag{24}$$

Taking logs we obtain $r_j \equiv \ln RATE_j$:

$$r_j \equiv \ln RATE_j = \ln \Delta_j\pi_{F(j)}(z_j;\cdot) + \theta \ln b_j - \ln \Phi_j: \tag{25}$$

Re-writing the opening and closure conditions in (12) in terms of r_j we get:

$$r_j \begin{cases} > 0 & \text{for open } j \\ > \ln\sigma & \text{for maintain } j \\ \leq \ln\sigma & \text{for close } j: \end{cases} \tag{26}$$

There is a problem of simultaneity with a conventional probit approach: it is believed by industry analysts that stores of greater size and of particular firms have higher net profit rates (see HSBC (1997)), in which case $size_j$ and $F(j)$ are correlated with r_j and a probit model would result in biased parameters $(\gamma_1; \gamma_2; \gamma_{F(j)})$. Unreported results suggest the problem is serious. To avoid it, we note that there is no obvious reason for correlation between the characteristics of recently closed stores and net profit rate. We use this absence of correlation to identify structural fixed cost parameters on store characteristics using only store closure observations.

We specify the log of net profit rate for closed stores as having mean ρ^{cl} plus a disturbance ε_j i.e.:

$$r_j = \rho^{cl} + \varepsilon_j. \tag{27}$$

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store conditional on the absence of the closed store. In slightly more than half of the cases of store openings and closures, there were no other local store changes from January 1995 during the relevant period.

From which we obtain, for closed stores:

$$\begin{aligned}\ln \Delta_j \pi_{F(j)}(z_j;\cdot) &= -\theta \ln b_j + \left[\gamma_{F(j)} + \ln \sigma + \rho_1^{cl}\right] + \gamma Z_j + \xi_j + \varepsilon_j + \eta_j \\ &= -\theta \ln b_j + \alpha^{cl}_{F(j)} + \gamma \ln z_j + \xi_j + \varepsilon_j + \eta_j. \qquad (28)\end{aligned}$$

We assume that the random term ε_j is mean zero, uncorrelated with the incumbency variable b_j, and uncorrelated with store characteristics z_j including $F(j)$; allowing estimation of the parameters of interest using closed stores, assuming an appropriate distribution for ε_j.[21]

Terms ρ_1^{cl}; $\ln \sigma$; and $\gamma_{F(j)}$ are estimated as a composite constant $\alpha_{F(j)}$:

$$\alpha^{cl}_{F(j)} = \gamma_{F(j)} + \rho_1^{cl} + \ln \sigma. \qquad (29)$$

The parameters γ on Z in (28) are interpreted as structural parameters of the fixed cost equation. The parameter θ has a behavioural interpretation as given in equation (12). We estimate three versions of the model: $\theta = 0$; $\theta = 1$; and leaving θ as a free parameter. Inference is by conventional methods.

Behaviour θ is identified by variation in incumbency b_j across j. In equation (28), $\ln \Delta_j \pi_{F(j)}(z_j;\cdot)$ is a function of b_j and other controls. If firms are not concerned about pre-empting rival entry then the level of incumbency does not reduce the incremental profits which are needed for store viability and $\theta = 0$. If firms pre-empt rival entry, then a high b_j reduces the $\ln \Delta_j \pi_{F(j)}(z_j;\cdot)$ required for viability and $\theta > 0$.

We use the same idea to determine the strategic model which explains store opening behaviour: a gross incremental profit equation is estimated using the incumbency variable b_j and other controls. In contrast to closures, the net profit rate for opened stores is specified to depend on store characteristics z_j including $F(j)$:

$$r_j = \rho^{op}_{F(j)} + \rho^{op} Z_j + \varepsilon_j. \qquad (30)$$

This allows the possibility that stores in given size categories are more profitable. We use the same flexible form as for fixed costs, so that net profits need not be monotonic in size. As before we assume that the random term ε_j is uncorrelated with incumbency b_j, uncorrelated with store characterstics z_j including $F(j)$, and is mean zero.[22] The equation to be estimated is:

$$\begin{aligned}\ln \Delta_j \pi_{F(j)}(z_j;\cdot) &= -\theta \ln b_j + \left[\gamma_{F(j)} + \rho^{op}_{F(j)}\right] + [\gamma + \rho^{op}] \ln z_j + \xi_j + \varepsilon_j + \eta_j \\ &= -\theta \ln b_j + \gamma^{op}_{F(j)} + \gamma^{op} \ln z_j + \xi_j + \varepsilon_j + \eta_j. \qquad (31)\end{aligned}$$

[21] While a degree of skewness may be expected, because of the truncation implied by the closure decision, we find in the next section that the composite errors in (28) i.e. $\xi_j + \varepsilon_j + \eta_j$ do not differ significantly from normal.

[22] ε_j may be skewed because open stores have non-negative net profit.

Table 5: Average Value of Utility Parameters

	Primary						Secondary					
	Low		Medium		High		Low		Medium		High	
Var	Parm	S.E.	Parm	S.E.	Parm	S.E.	Parm	S.E.	Parm	S.E.	Parm	S.E.
ϕ_F^{1i}	30.64	0.19	41.53	0.24	50.05	0.28	6.58	0.07	6.93	0.08	7.75	0.08
sd	[1.55]		[1.66]		[4.10]		[0.64]		[0.64]		[0.76]	
ϕ_F^{2i}	0.889	0.01	0.95	0.01	0.95	0.01	1.08	0.01	1.13	0.01	1.13	0.01
sd	[0.57]		[0.04]		[0.06]		[0.09]		[0.10]		[0.26]	
Size	2.27	0.06	3.06	0.07	3.95	0.08	1.21	0.04	1.63	0.04	1.93	0.01
Dist	0.37	0.00	0.36	0.00	0.36	0.00	0.20	0.00	0.19	0.00	0.18	0.01
Park	0.38	0.02	0.41	0.03	0.51	0.03	0.04	0.01	0.04	0.01	0.04	0.04
φ_i	3.29	0.01	3.75	0.01	3.88	0.01	3.07	0.02	3.17	0.02	2.73	0.00
LLF	-1148.04		-1115.56		-1155.1		-1252.55		-2019.83		-2613.33	
NOBS	13516		8953		12956		21285		20116		20835	

Notes: Parm columns give average of 35 regional estimates; s.e. give average value of standard errors over regions.

The estimation identifies composite parameters $(\gamma^{op}_{F(j)}, \gamma^{op})$ on the second line but not the bracketed fixed cost and net profit components in the first line.

The welfare analysis requires some knowledge of fixed costs. We do not separate the parts of composite constant $\nu_{F(j)}$ so we do not estimate fixed costs precisely. However, we believe that mean normal profits ρ^{cl}_1 of closed stores are non-positive and that therefore $\nu_{F(j)} \leq \gamma_{F(j)}$. Thus the fitted value of equation (28) using parameters estimated using closures, gives a lower bound to fixed costs for any store with characteristics z_j and firm $F(j)$. Since store openings are profitable, the fitted values of equation (31) using parameters estimated on new store openings gives an upper bound to fixed costs for any store with characteristics z_j. Formally, we have for any store j:

$$\psi_j\left(z_j; \gamma^{cl}_{F(j)}, \gamma; \xi_j\right) \leq \psi_j\left(z_j; \xi_j\right) \leq \psi_j\left(z_j; \gamma^{op}_{F(j)}, \gamma^{op}; \xi_j\right). \quad (32)$$

These bounds are used in the welfare analysis of section 6.

5 Results: Entry, Exit, and Pre-Emption

Consumer Parameters There is a set of choice parameters for each of the 35 pricing regions. Averages are in Table 5. All parameters are significant at the 5% level. The first parameter in each column is the mean of the 'expenditure' firm dummies ϕ_F^{1i} over 11 firms and 35 regions. The next

Table 6: Pro¯ts, Prices, and Self-Cannibalisation

	Jan 1995					1994-1996					
	Open					Closed			Opened		
	#	¼	sc	¢ p_f	¢ p_w	#	¼	sc	#	¼	sc
ASDA	83	11.6	8%	0.52%	-0.13%	1	57.6	3%	{	{	{
Budgen	87	6.3	2%	0.13%	-0.02%	9	5.2	4%	19	8.4	2%
Co-op	399	12.0	11%	0.07%	-0.01%	87	8.5	11%	18	11.7	13%
Somer¯eld	377	19.2	14%	0.13%	-0.01%	29	15.8	14%	4	20.4	18%
Iceland	148	10.2	4%	0.10%	-0.01%	24	9.5	4%	54	9.5	4%
Kwik Save	273	14.7	14%	0.09%	-0.01%	{	{	{	15	10.3	11%
M&S	182	11.3	4%	0.04%	-0.01%	{	{	{	{	{	{
Safeway	175	43.4	12%	0.18%	-0.08%	8	29.0	17%	47	48.3	10%
Sainsbury	263	109.8	28%	0.41%	-0.03%	19	67.3	37%	44	101.1	31%
Tesco	272	98.1	26%	0.33%	-0.04%	17	48.1	36%	78	82.6	29%
Waitrose	96	23.1	4%	0.11%	-0.06%	6	21.5	11%	13	31.9	8%
total	2355					200			292		

Note: `sc' is mean self cannibalisation over the 35 regions; ¼ is mean gross store pro¯t in $1995K/week
¢ p_a and ¢ p_w are mean changes in ¯rm prices and sales weighted market prices respectively

row, in brackets, shows the standard deviation of the individual estimates for this parameter. The next row is the mean of the `non{expenditure' ¯rm dummies $Á^{2i}_F$; followed in brackets by the standard deviation of these parameters. Unreported parameter variation in ¯rm dummies by income and shopping mode implies that vertical and horizontal product di®erentiation e®ects are important for the unobserved ¯rm characteristics. Other parameters are on °oorspace, parking, and distance, and the scaling parameter $'^i$ on the expenditure disturbance.

Equilibrium Incremental Store E®ects The estimated parameters and Nash pricing assumption imply a value of 0:265 for the price parameter. With this in hand, we compute incremental pro¯ts for each of the stores by removing the store (or adding it if not open in January 1995) and solving for a new Nash equilibrium. Table 6 gives results for stores open at January 1995, and for stores opened and closed in 1993{1997.[23] Closed stores have lower gross pro¯ts than open stores. Recently developed sites are less prof-

[23] We remove stores over 2000 square feet from the remaining analysis as their predicted levels of expenditure per square foot seem implausibly high compared to ¯gures reported in company Annual Reports. Otherwise, the predictions for expenditure per square foot closely match ¯gures reported in company Annual Reports.

Table 7: Self- and Cross- Cannibalisation E®ects

	ASDA	Budg	Co-op	Some	Icel	KS	MS	Safe	Sain	Tesc	Wait
Own	8%	2%	11%	14%	4%	14%	4%	12%	28%	26%	5%
High Street	10%	3%	7%	11%	3%	4%	3%	11%	31%	17%	3%
Big Four	9%	2%	6%	7%	2%	4%	2%	9%	32%	31%	3%

Each cell gives mean percentage cannibalisation e®ect of column ¯rm by stores of row ¯rm type

itable than the average, perhaps because of the tightening in UK planning policy in the early 1990s which restricted large out-of-town developments. Columns four and ¯ve show small incremental e®ects of current stores on ¯rm and weighted market prices respectively. The third column shows % self cannibalization | i.e. the di®erence in ¯rm $F(j)$'s pro¯ts in the two equilibria in stores other than store j as a proportion of store j's direct gross pro¯ts. Firms with many stores self cannibalize by large average amounts.

The ¯nal six columns show statistics for the stores opened and closed in 1994{1997. Self cannibalization is lower for open stores. There are two explanations. First, pro¯t maximizing ¯rms choose the location of new stores to minimize the self cannibalization needed for pre-emption; older stores cannot be relocated easily and their level of self-cannibalization may rise over time as new stores are added. Second, some stores are closed because the ¯rm has opened a new store nearby, increasing the cannibalization of the old store to levels which reduce its pro¯ts to subnormal levels.

A comparison of self- and cross-cannibalization e®ects is informative about store placement strategy. The pro¯t reduction, in market equilibrium, which each store j has on each ¯rm f is calculated as a percentage of ¼$_j$. Results, averaged across incremental stores j by category, are shown in Table 7. The ¯rst row gives the average e®ect of stores j on the pro¯ts of other stores of the same ¯rm as a percentage of ¼$_j$: The second and third rows give the average e®ect of the stores of High Street and Big Four type respectively | excluding column ¯rm if it is of row type | on the pro¯ts of the column ¯rm. Thus, on average, Tesco stores cannibalize other Tesco pro¯ts by 26% of store pro¯t. High Street stores cannibalize Tesco on average by 17% of the High Street stores mean pro¯t, and Big Four stores, other than Tesco's, cannibalize Tesco pro¯ts by 31% of store pro¯t. Results show that there only a small di®erence between mean self cannibalization and cannibalization by stores of other ¯rms of the same type.[24] This suggests that there is neither extreme clustering e®ect nor strong avoidance of self-cannibalization. The result is

[24] The only exception is for Co-op, Somer¯eld and Kwik Save. The clustering e®ects for the second of these may be a result of the succession of takeovers in the ¯rm's history.

consistent with the predictions of the pre-emption model where local price competition is absent: firms are prepared to cannibalize themselves up to the extent that they are cannibalized by rivals.[25]

Fixed Cost Equations Table 8 shows results from regressions using computed gross incremental profits $\ln \Delta_j \pi_{F(j)}(z_j;\,)$ as the dependent variable. For closed stores, columns 1-3 show results setting $\theta = 1$; $\theta = 0$; and free θ respectively. The final row shows the Bera and Jarque (1980) $\chi^2_{(2)}$ test for normality. The statistic is less than the 5% critical value (5:99) so we reject the hypothesis of non-normality of composite unobservables.

The parameter on $(\ln \text{size})^2$ is insignificant and we drop it from the estimation for closed stores. The parameter on $(\ln \text{size})$ implies a size elasticity of fixed cost of 0:42. Rent has a significant positive effect. To evaluate closure behaviour we use likelihood ratio tests, where the free parameter model is the unrestricted estimation. The hypothesis that the pre-emption model is correct is rejected: the $\chi^2_{(1)}$ test statistic — twice the difference between the LLFs — is greater than the 5% critical value (3:84). We cannot reject the non pre-emption model. Support for the non pre-emption model is reinforced by the finding that estimated θ is not significantly different from zero. The finding that pre-emption plays no role in store closures may be understood by noting that were pre-emption effects to operate, they would be most important for the Big Four firms, as these have the greatest levels of self-cannibalization. For a Big Four firm, however, the assumption that a rival of equal attractiveness would open a store in a site which it would wish to close is improbable — large firms are more interested in opening large stores and not in opening the small stores being closed by a rival.

On *a priori* grounds, pre-emption is more plausible for the opening decision, where it is more likely that a rival of similar type would develop a store on the site. This intuition is supported by the regression analysis. Columns 4, 5, and 6 report estimates with $\ln \Delta_j \pi_{F(j)}(z_j;\,)$ as the dependent variable under $\theta = 0$; $\theta = 1$; and free θ respectively. We use the normality assumption: the hypothesis of non normality is rejected for the second and third estimation and for the first the level of skewness is very small. The estimated parameters imply a profits elasticity with respect to size of 0:7 for a store of 20; 000 square feet. The elasticity is increasing in store size. The rent and park variables are significant and positive, as expected. We find that estimated θ is significantly different from zero, which suggests that there is a level of pre-emption occurring — firms are prepared to accept lower

[25] Where price effects are very small, as here, then they are prepared to cannibalise by a slightly greater amount than they would be by a rival.

Table 8: Fixed Cost and Gross Pro¯t Parameters

	Closures			Openings			All open	
Var	P-E	NonP-E	Free	P-E	NonP-E	Free	P-E	Free
μ	1	0	0.25	1	0	0.48	1	0.26
			(0.29)			(0.21)		(0.08)
Asda	3.64	3.54	3.56	{	{	{	3.88	3.86
	(0.55)	(0.54)	(0.54)				(0.12)	(0.11)
Coop	2.27	2.10	2.14	2.59	2.63	2.62	2.43	2.43
	(0.24)	(0.23)	(0.24)	(0.33)	(0.33)	(0.33)	(0.11)	(0.11)
Some	2.85	2.62	2.68	3.49	3.45	3.47	3.06	3.02
	(0.27)	(0.26)	(0.27)	(0.39)	(0.39)	(0.39)	(0.11)	(0.11)
Safe	3.15	2.90	2.96	3.74	3.78	3.76	3.46	3.46
	(0.33)	(0.32)	(0.33)	(0.32)	(0.33)	(0.33)	(0.12)	(0.11)
Sain	3.90	3.36	3.49	4.44	4.22	4.32	4.22	4.04
	(0.30)	(0.30)	(0.34)	(0.33)	(0.33)	(0.33)	(0.11)	(0.11)
Tesc	3.65	3.15	3.27	4.32	4.09	4.20	4.04	3.90
	(0.29)	(0.29)	(0.32)	(0.32)	(0.32)	(0.32)	(0.11)	(0.11)
Wait	2.86	2.68	2.72	3.46	3.52	3.49	3.04	3.09
	(0.32)	(0.31)	(0.31)	(0.35)	(0.35)	(0.34)	(0.12)	(0.12)
ln(size)	0.41	0.43	0.42	-0.79	-0.85	-0.82	-0.26	-0.33
	(0.06)	(0.06)	(0.06)	(0.22)	(0.22)	(0.21)	(0.07)	(0.08)
ln(size)^2	{	{	{	0.25	0.26	0.26	0.15	0.16
				(0.04)	(0.04)	(0.04)	(0.01)	(0.02)
ln(park)	0.07	0.04	0.05	0.25	0.25	0.25	0.16	0.16
	(0.09)	(0.09)	(0.09)	(0.08)	(0.08)	(0.08)	(0.02)	(0.02)
ln(rent)	0.38	0.36	0.37	0.14	0.19	0.17	0.21	0.22
	(0.09)	(0.09)	(0.09)	(0.07)	(0.07)	(0.07)	(0.02)	(0.02)
>93	{	{	{	{	{	{	{	-0.16
								(0.04)
>89	{	{	{	{	{	{	{	-0.00
								(0.03)
>85	{	{	{	{	{	{	{	0.05
								(0.04)
>81	{	{	{	{	{	{	{	0.00
								(0.03)
LLF	-368.3	-365.2	-364.8	-582.1	-581.6	-578.8	-7582.0	-7531.5
OBS	200	200	200	292	292	292	2452	2452
skew	-0.17	-0.21	-0.19	-0.03	0.04	0.01	-0.12	-0.14
B-J	1.9	4.9	3.9	7.3	2.7	5.1	72.7	94.5

Some ¯rm dummies are suppressed. Standard errors in parentheses, B-J is Bera-Jarque normailty statistic.

Table 9: Bounds to Fixed Costs

	Closure		Opening		Opens		HSBC	
Size (sqft):	20000	25000	20000	25000	20000	25000	20000	25000
ASDA	$11.8	$10.4	NA	NA	$13.3	$12.3	$16	$15
Safeway	$6.5	$5.7	$7.1	$6.7	$8.9	$8.3	$16	$15
Sainsbury	$10.7	$9.4	$14.2	$13.5	$18.0	$16.7	$16	$15
Tesco	$8.8	$7.7	$12.9	$12.2	$14.7	$13.6	$16	$15
Size (sqft):	10000	15000	10000	15000	10000	15000	10000	15000
Somer¯eld	$8.7	$6.9	$9.6	$7.7	$10.1	$8.1	$10	$9

Note: Units are weekly $1995/square foot

incremental store pro¯ts in areas where they are incumbents. However, since µ = 0:48; the degree to which lower pro¯ts are accepted is less than for the full pre-emption model, where µ = 1. The likelihood ratio $\hat{A}^2_{(1)}$ test statistics for both models, compared to the null of the unrestricted model, exceeds 3:84 | the critical value at the 5% level | so that both pre-emption and non pre-emption models are rejected. The ¯nding that µ is \somewhere between" the two models suggests that while pre-emption is occurring, its form is not as strong as the pre-emption model. This is unsurprising given the ad hoc speci¯cation of the model, noted in section 2. We conclude that a degree of pre-emption is evident.

Summarizing, we ¯nd evidence for pre-emption for store openings (but not store closures) from [i] the pattern of self- and cross- cannibalization e®ects from current stores, [ii] the likelihood values of the ¯xed costs equations for the alternative models, and [iii] the negative and signi¯cant µ parameter on the store openings. However, although pre-emption occurs, it does not lead to extreme clustering, as seen in the cross-cannibalization analysis of Table 7 and the \6 km markets" analysis of Table 4.

The ¯nal two columns in Table 9 are results for all open stores, including those opened in 1994-1997. We ¯nd that normality is rejected, but deviation from normality in the level of skewness (in the skew row) are small. The estimated µ is 0:26 and is signi¯cantly di®erent from zero. We included some \date of opening" dummies in the unrestricted equation for four yearly periods. These show stores opened since 1993 are signi¯cantly less pro¯table than older stores, after controlling for other e®ects. This is explained, in part, by the tightening of planning restrictions during the 1990s. It is interesting, however, that stores opened since 1981, well before the tightening of restrictions, are not, on average, more pro¯table than older stores, allowing for other controls on pro¯tability such as store size. This suggests a very limited role for sunk costs: if sunk costs were important the incremental profit of existing stores would be expected to decline, on average, as profits fall for some stores to levels below which it is worth opening the store but above which it is still viable to retain the store.

For robust welfare analysis we predict upper and lower bounds to fixed costs. Examples are in Table 9 in terms of weekly expenditure in $1995 per square foot. The first two columns use the non pre-emption closure model, a lower bound to fixed costs. The next two columns use the non pre-emption opening model. This predicts higher fixed costs than the pre-emption model so is a conservative upper bound. The next two columns show figures for the opens model. These are higher than for the openings model. We believe they are inflated by super-normal profit, so we do not use them as an upper bound, except for ASDA, for which there are no observed openings. As a check on the estimates, the final two columns give analyst figures (HSBC (1997)): the predictions from the openings regression are close but the closure results give fixed costs which are rather low. To ensure robustness, we use upper and lower bounds, and the analyst figures, in the social efficiency analysis which follows. A further point of interest is the extent to which opened store profits exceed closed store profits. This difference is at most about 35% and includes three components: sunk costs, super normal profit of opened stores, sub-normal profit of closed stores. Given that profit effects are likely to be important 35% provides a very conservative upper bound to the proportion of fixed costs which are sunk.

6 Social Efficiency

In this section we quantify the social inefficiency of store characteristics in January 1995 by perturbing the model with respect to store numbers, store size, ownership, and store location. We take pricing conduct as given: we do not, for example, calculate the social costs of multi-product Nash pricing (this is done in Smith (1999)). The welfare analysis allows for competition between supermarkets and corner stores via the outside good.

Table 10 shows the mean incremental effect of stores open in January 1995. The figures are the effect of adding the store to a price equilibrium where it is absent. Figures are in $1995 per week. The effects of the stores on gross industry profits and consumer surplus are in the first two rows.

The external effect of the stores measure the divergence of social and private incentives in opening a store. We use two concepts. Store externality (st_ext) is the effect of the store on the sum of consumer welfare and the profits of all other stores, including stores of the same firm. Firm externality

Table 10: Average Incremental Effect of Current Stores

	ASDA	Budg	Coop	Some	Icel	KS	Safe	Sain	Tesc	Wait
$\Delta\Pi$	-13340	-3614	-2273	-4498	-2342	-3355	-13161	5544	5887	-12860
ΔCS	138550	9965	14778	23138	12051	18216	59578	99099	90368	36859
st_ext	9101	-141	-4	-168	-41	154	2642	-2781	389	484
fm_ext	18653	15	1192	2489	331	2184	7583	27648	25701	1761
[st_ext > 0]	78%	29%	47%	41%	58%	57%	69%	36%	49%	55%
[fm_ext > 0]	95%	43%	79%	93%	69%	85%	89%	100%	100%	72%
$\Delta W_1/R$	11.6%	7.7%	8.6%	8.7%	7.8%	16.0%	10.6%	13.4%	16.9%	7.0%
$\Delta W_2/R$	10.9%	6.0%	8.5%	6.6%	7.1%	7.5%	8.5%	8.1%	9.9%	6.4%
$\Delta W_3/R$	4.1%	–	–	4.7%	–	–	1.6%	4.1%	4.2%	–
$[W_1 > 0]$	100%	93%	95%	99%	99%	100%	100%	100%	100%	100%
$[W_2 > 0]$	100%	88%	95%	98%	99%	98%	100%	99%	99%	100%
$[W_3 > 0]$	83%	–	–	75%	–	–	71%	76%	72%	–

Note: Results from all 35 pricing regions; figures in $1995K/week

Table 11: Hypothetical Stores

	ASDA	Sainsbury
Δp_a	-0.09%	-0.02%
Δp_f	0.17%	0.27%
$\%[\Delta W_1 > 0 \mid \Delta\pi_F > 0]$	97%	92%
$\%[\Delta W_2 > 0 \mid \Delta\pi_F > 0]$	82%	83%

(fm_ext) is the familiar external effect on consumers and all other firms. The store externality effect is relevant if firms are pre-emptive. The table shows that store externality effects are of varied sign and firm externality effects are usually positive.

The remaining rows show the incremental effect of stores on welfare. We give the mean effect as a proportion of mean store revenue R. W_1 and W_2 use the lower and upper bound for fixed costs.[26] The mean effect on welfare is positive for each firm, between 6% and 17% of store revenues. The biggest benefits come from the Big Four firms. If analyst estimates are used then the social benefit of each store is positive and between 1% and 5% of store revenues (W_3). The final three rows show that there are some stores with a negative effect on welfare but that for every firm the median effect on economic welfare is positive.

[26] For W_1 and W_2, the fixed costs are expected fixed costs, given that the store is open — i.e. we compute a truncated expectation for the value of the composite error in equations (28) and (31) so that no open stores are unprofitable.

Table 12: Store Size

	$\frac{dCS}{dsize_j}$	$\frac{d¦}{dsize_j}$	$\frac{d¼}{dsize_j}$	fm_ext	[fm_ext<0]
Big Four	203792	16402	167801	52393	8%
High Street	39400	-2411	33021	3968	33%

Note: Figures in $1995K/week

Table 13: Ownership Conversions

from:	to:	¢P	¢CS	¢¦	¢W	$\frac{¢W_1}{R}$
Safeway	ASDA	0.05%	5062	5626	10687	5%
Sainsbury	ASDA	-0.01%	-15193	-6750	-21943	-4.8%
Tesco	ASDA	-0.02%	-15234	-15837	-31071	-8.4%
ASDA	Sainsbury	0.24%	-33842	24666	-9176	1.6%
Safeway	Sainsbury	0.07%	14944	10848	25792	12.0%
TESCO	Sainsbury	0.10%	-18784	-2115	-20900	-5.6%
ASDA	Tesco	0.34%	-30474	59974	29501	5.2%
Safeway	Tesco	0.15%	2451	24753	27204	12.6%
Sainsbury	Tesco	0.19%	-18743	27620	8878	2.4%
Budgen	Somer¯eld	-0.02%	11589	-3670	7919	21.7%
Co-op	Somer¯eld	0.01%	2024	736	2760	4.5%
Kwk Sve	Somer¯eld	0.01%	3028	3153	-1904	-2.2%
Waitrose	Somer¯eld	0.04%	-10820	3088	-7732	-3.3%

Note: ¯gures in $1995K/week

To examine whether further entry is bene¯cial we add hypothetical stores. We do this for 1000 locations for ASDA and Sainsbury.[27] Stores are of approximately average size for the ¯rm: 45000 and 30000 square feet for ASDA and Sainsbury respectively. Most hypothetical stores are unpro¯table. Results for pro¯table stores are shown in Table 11. The ¯nal two rows give the proportion of pro¯table stores that have a positive e®ect on welfare, using lower and upper bounds respectively. Most pro¯table hypothetical stores also increase economic welfare. The potential for unexploited pro¯table and socially e±cient opportunities is implied by the planning system which restricts store openings for environmental reasons not incorporated in the model.

The e®ect of store size is shown in Table 12. The columns show the average value of the ¯rst derivative of consumer surplus, pro¯ts, and economic welfare with respect to store size.[28] The table suggests that increases in ¯rm

[27] The locations are the mid point of 1000 randomly selected Postal Sectors.

[28] Where, by the envelope theorem, the e®ect via prices is zero.

Table 14: 2km Relocations

	% > 0		¢CS	¢ ¦	¢W / R		¢ ¦ F(j) / R	
	¢W	¢ ¦ F(j)			mean	sd	mean	sd
Big Four	61.5%	61.5%	2513	1333	0.5%	1.6%	0.3%	4.5%
High Street	60.9%	60.9%	283	101	0.4%	1.6%	0.0%	0.5%

Note: ¯gures in $1995K/week

size are welfare improving, on average: the mean and median externality e®ects are positive for both types of stores.

The e®ect of changes in ownership are shown in Table 13 using the closures estimates for ¯xed costs. Each cell reports the mean e®ect of the indicated conversion. A conversion involves converting the prices and quality levels to those of the new ¯rm and solving for a new pricing equilibrium. We do not present conversions of High Street stores into Big Four ¯rms. Such conversions lead to large increases in social e±ciency. We limit the table to ownership conversions within the two categories: Big Four and High Street. Conversions to Tesco are always mean welfare improving and large, even though prices do not fall. Conversions to Sainsbury are mean welfare improving except for conversions of Tesco stores. The e®ects of conversions to Somer¯eld are mixed. The overall picture is that there are social gains, often large, to be had from reallocating stores to ¯rms.

Finally we examine the e®ect of store relocation. We randomly select a quarter of the stores of each ¯rm and move each two kilometers in the four compass directions, solving for new Nash equilibria. We select the compass direction which most increases social welfare. Store size, unobserved quality, rent, and car parking remain constant. The ¯rst two columns of Table 14 show the proportion of cases in which a relocation increases welfare and ¯rm pro¯ts respectively. Most stores can be relocated to improve economic welfare but in all cases the relocation improves the pro¯t of the ¯rm. Thus, the suboptimal location is not a result of pro¯t incentives diverging from consumer preferences, as in the Hotelling model, which predicts \too little" spatial di®erentiation when price competition is weak. The analysis suggests that ¯rms have incentives to position new stores in socially preferred locations. Ine±ciencies are small as a proportion of store revenues.

The results of this section suggest that recent trends in store characteristics are welfare improving at the margin. The increase in the number of Big Four relative to High Street stores is bene¯cial: current Big Four stores have a higher mean e®ect on social welfare than High Street stores. The increase in mean store size is also welfare improving.

7 Conclusions

The paper ¯nds that ¯rms use store openings to pre-empt rival entry and that store characteristics are socially ine±cient taking as given multi-product Nash pricing. Recent trends in store characteristics | larger stores and more store openings by large ¯rms | have reduced some of these ine±ciencies. The incremental social bene¯t of current stores is about 5% to 15% of store revenues holding other stores and their characteristics constant. Individual planning restrictions are only justi¯ed if negative environmental externalities are of this magnitude. Price e®ects of individual stores are small. We have not examined multiple store additions and subtractions which may have a greater cumulative e®ect on prices. Smith (1999) shows that local multi-product e®ects have a large regional e®ects on Nash prices. Pre-emption e®ects exacerbate this problem by increasing local concentration. Assuming that planning restrictions on store developments are justi¯ed by environmental externalities, intervention to limit local concentration may be desirable.

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