Supermarket Choice with an Endogenous Number of Stores*

Preliminary and Incomplete

Howard Smith†

February 6, 2006

Abstract

The paper extends previous work that analyzes consumer shopping behaviour—using a panel survey of consumer choices and a dataset of choice sets—by extending the framework to permit an endogenous number of stores. The consumer's chosen number of stores depend on the benefits and costs of shopping, which depand on consumer attributes as well as the range of options available in the consumer's choice set. The model permits complementarities between the stores chosen in any period, so that it can predict why the consumer tends to combine certain store types and tends to avoid combining other store types. We discuss some implications for firm incentives and public policy towards supermarket competition.

*The first draft of this paper was prepared for the INRA-IDEA conference "The Empirical Industrial Organization of the Food Retailing Industry" at Toulouse (9th-10th February 2006). I am most grateful to the Nuffield Foundation for financial assistance in purchasing some of the data. Material from Crown copyright records, available through OPCS and the ESRC Data Archive has been used by permission of Her Majesty's Stationary Office. Computational work was done using Ox v3.2.

†Address: Department of Economics. Oxford Unviersity, Manor Road, Oxford, OX1 3UQ Email: howard.smith@economics.ox.ac.uk

1 Introduction

A commonly noted feature of the retailing industry is that consumers have costs of shopping. These are usually defined to mean that consumers would prefer, other things equal, to minimize the number of stores they visit. In extreme cases consumers may practice one stop shopping for any reasonably defined choice period. There has been much theoretical work developing the implications of shopping costs for retailer behaviour, including Bliss (1988), Stahl (1989), Klemperer (1992), and Smith and Hay (2005).[1]

Competition authorities have used the concept of one-stop shopping to reach a definition of the relevant market for grocery shopping. For example, the Competition Commission (2000) report into supermarket competition argued that one-stop shopping could be treated as a distinct market and that only stores over a given size threshold were included in the market. Smaller stores were not good substitutes and could not constrain prices in the one-stop grocery market.

This paper estimates a model of shopping in which consumers decide which, and how many, stores to visit. We build on previous work on supermarket choice (i.e. Smith (2004, 2006)) that are estimated using consumer choice survey data and data on store characteristics. We relax the assumption in previous papers that consumers choose an exogenously given number of stores. The model is specified so that the number of stores chosen depends both on variation in the choice sets and on taste differences between consumers. The model permits complementarities between the stores chosen in any period, so that it can predict a consumer's tendency to combine certain store types and tends to avoid combining other store types.

We treat each possible combination of stores as a distinct "choice" facing the consumer. As is common in the differentiated products literature (see e.g. Berry (1994) for a survey), we assume that the consumer's utility from each choice is a function of the characteristics of the choice—e.g. the vector of store locations, sizes, prices, the number of stores in the choice, and unobserved characteristics. A simple model would specify the utility from each store visited as a function of its own characteristics: size, distance, etc (as Smith (2004)) and the consumer considers the utility from each store independently. The utility model we use here is more general, allowing for interaction effects

[1]More recently the literature on two-sided markets has examined the implications of one-stop shopping (or "single homing") in platform choice, and Armstrong (2006) notes that supermarkets can be seen as an example of a two-sided market.

between the characteristics of the chosen stores, which permit some stores to be complementary, and other store types to be substitutes. In particular the model is capable of generating the Competition Commission's suggestion, noted above, that that small stores are not substitutes for large stores, while large stores are more likely to be substitutes.

There is a very small empirical literature on multiple-item discrete choice situations, where consumers are not constrained to choose a single product from the choice set but are allowed to opt for various combinations of the products. Some model rely on strong restrictions on the consumer's utility problem, e.g. Hendel (1999) and Dube (2005), usually by assuming that products are independent inutility, which eliminates the need for complementarity effects between the products. Our approach is similar to the more general approach of Gentzkow (2006), where the model permits complementarity effects. Gentzkow estimates a parameter for each pair of products to allow for the complementarity effect. In our model the consumers face a large number of products and we estimate interaction effects between characteristics. Thus the number of parameters rises with the square of the number of characteristics rather than the square of the number of products, which is a more manageable estimation problem.

In problems with large numbers of products there arises a severe dimensionality problem: in the supermarket choice problem there are commonly up to 30 stores in a consumer's locality and there is no obvious way to rule any of them out a priori, implying a very large number of alternative hypotheical combinations, when allowing consumers to choose as few as four stores per period. A number of solutions to this problem of dimensionality have been suggested. For example Train (2003) points out (p68) that a logit model may be estimated consistently on a randomly simulated subset of alternatives. However, this still leaves us with the full number of alternatives to analyze at the counterfactual stage of the analysis. The solution we propose places some structure on the problem, drawing on the sequential nature of the consumer choice situation. We assume a sequential decision structure, in which the consumer first chooses a store (e.g. from the nearest 30) for primary shopping, then a store for secondary, and so on. The consumer does not act in a myopic fashion, but anticipates the final utility outcome from each stage in the sequence. We use a nested-logit error structure, and estimate the model in stages, working up the nest from the last stage in the decision sequence.

The estimated model may be used for a number of purposes including understanding the extent to which observed variation in number of stores visited is explained by consumer taste variation (as opposed to choice set variation); (exploring the effect of shopping costs on the pricing and investment incentives of firms; and analyzing the extent to which smaller stores act as a substitute for large stores (which, as we have noted, is an important policy question for competition authorities). A future version of this paper will develop some of these applications.

The current version of the paper is organised as follows. Section 2 sets out some patterns in the data which help to motivate the paper. The consumer model is developed in section 3. Section 4 presents the data and estimated parameters.

2 Some Patterns in the Data

The model is estimated with consumer data from A.C. Nielsen's *Homescan* survey. Participating households scan in their shopping purchases, recording items bought, price paid, and outlet of purchase. The data are for 26 four-weekly periods in 1998-2000 and comprise 5423 households (although the model parameters presented later are estimated on 6 periods and 3035 households). The survey is aggregated by period, so does not give trip-by-trip information, so if a unique store is visited several times in a four-week period we have a single aggregate record for that household, store, and period.

Figure 1 is a histogram giving the frequency of observing each number of unique stores (for four week periods). Strict one-stop shopping is seen for about 14% of the sample, and the most common shopping pattern is two unique stores. There is a a wide variation and it is common to see anything from one to six unique stores in a four week period.

Figure 2 shows the number of unique stores visited over the full 26 four-weekly periods. As one might expect, the number of unique stores increases but we again see a wide variation and it is common to see consumers using between about five and fifteen unique stores over this length of time.

In addition to the number of stores, the data includes information on the expenditure of consumers. We now explore how a consumer's expenditure is distributed across the N stores he chooses in any four-week period. (This helps to motivate the sequential structure we later impose on the choice model). We sort each consumer's stores by the level of expenditure. Thus, the first store (N=1) is the one where the consumer has the largest expenditure,

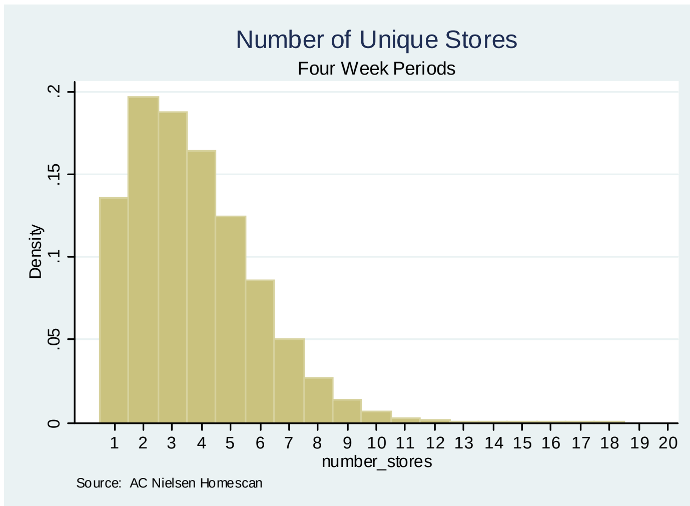

Figure 1: Number of Unique Stores (Four Week Periods)

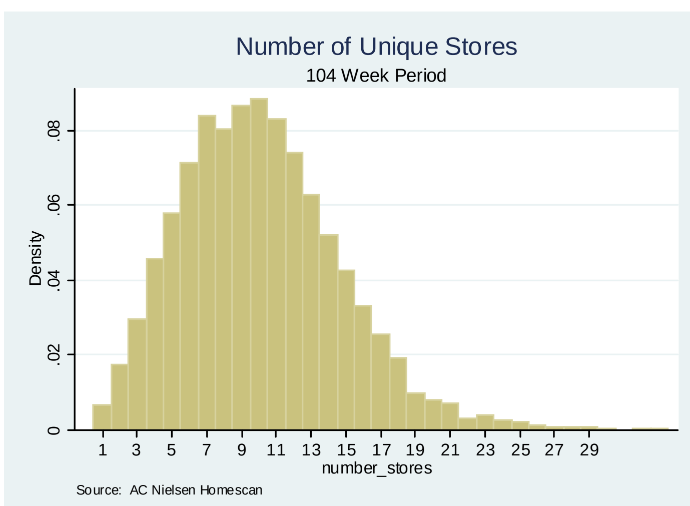

Figure 2: Number of Unique Stores: (104 Week Period)

Share of Total Expenditure in the first N stores				
N	Mean Share	Standard Deviation	Minimum	Maximum
1	0.69	0.23	0.11	1
2	0.87	0.15	0.22	1
3	0.94	0.09	0.33	1
4	0.98	0.05	0.42	1

Table 1: Distribution of Expenditure across Stores (four-week periods)

the second (N=2) the second largest, and so on. We compute the N-store expenditure ratio, which gives the share of consumer's spending in the first N stores (similar in concept to a N-firm concentration ratio).

Table 1 shows the means and standard deviations of these ratios for alternative values of N up to N=4. As we can see, the first unique store takes an average share of about 70% of shopping. This suggests an asymmetric situation in which the primary store plays a much more important role in consumer utility than the remaining stores. There is quite a wide standard deviation for this share, so that some consumers concentrate their shopping more than others. The average share of spending in the second stores is 17% while the joint average for the next two stores is only 11%. The first four stores account for on average 98% of spending, with a low standard deviation. This suggests that the importance of the 5th and subsequent stores is negligible for most shoppers. In the next section we will construct the model to take account of the asymmetric patterns found here.

An alternative way of understanding the asymmetric nature of the consumer's use of the N stores visited is to look at the range of product categories the consumer obtains from each store. For this purpose we disaggregate each consumer's total store expenditure into six broad *categories,* namely fruit and vegetables, meat fish and poultry, bakery and biscuits, liquor, dry grocery and health and household. These represent the different categories of demand that are brought together in a supermarket, but which are independent in utility (and before the advent fo supermarkets were traditionally sold in separate retail outlets).

For each unique store visited in a four week period, we measure the range of categories by a simple count the number of categories the shopper obtains from store (a number which varies from 1 to 6). This count variable indicates the range obtained: where a store used only for one category only, the store

	Range of Categories Bought in the N'th Store	
N	Number of Categories	Standard Deviation
1	5.11	0.87
2	3.13	1.94
3	1.95	1.85
4	1.22	1.59

Table 2: Number of Categories Bought at the Nth store (four week periods)

is being used for a narrow range of products, where all six-categories are bought the store is being used for the broadest possible range of categories.

Table 2 shows the range of categories bought in each successive store (where stores are as before ordered by total expenditure). It shows that the first store is typically used for the full range of categories (and the standard deviation is low so this does not vary much across consumers). The range declines successively for the remaining stores, and the third and fourth stores are used for more specialised shopping (one or two categories of demand). Consistent with the expenditure analysis in the previous table, this shows that the N stores chosen by the consumer are used in an asymmetric way.

Finally, Table 3 looks at the data in a different way, giving the relative frequency of each number, or "breadth", of categories bought (in four week periods). The table shows that all the possible breadths of shopping are common, with peaks at one and five categories respectively. Interestingly, the table also shows the average expenditure and average store size associated with each breadth of shopping (in four week periods). It seems from the table that the stores used for broad shopping obtain the bulk of a consumer's 4-weekly spending, while stores used for one or two categories receive a small fraction of the spending. In the final column the table shows that 6-category shoppers choose stores that are 50% larger, on average, than 1-category shoppers. This intuitive finding is consistent with the Competition Commission's view, discussed above, that small stores stores are less attractive than large stores for shoppers that aim to buy a wide range of products.

The patterns found in this section suggest that consumer shopping outcomes are heterogeneous across consumers (and this could be due to variation in choice sets or variation in consumer tastes). We also see that it is reasonable to limit our interest to the first four stores, and that these stores should be treated asymmetrically, i.e. the consumer's tastes when choosing a third

Table 3: Shoppng by Number of Categories Bought (Four Week Periods)

# Categories	% of Shopping (by # Stores)	Mean Expenditure (£/period)	Mean Store Size (Square Feet)
1	0.19	£7.52	20081
2	0.14	£11.96	20355
3	0.14	£17.21	21245
4	0.16	£30.16	22933
5	0.25	£70.81	28772
6	0.12	£122.87	31364

Source: AC Nielsen Homescan

or fourth store will differ from his tastes when choosing the first store.

3 The Model

We develop a model of the (one or more) stores the consumer chooses in any four-week period. A four-week period is chosen because it is long enough period that the consumer is likely to need to purchase most of the items bought in a supermarket, so that different periods can be treated as independent. A store is chosen if it is visited at least once in the four week period (and we do not model the frequency of trips to stores within the four-week period).

In any shopping period, consumer i makes a shopping choice j, which is a combination of some of the J stores in his locality. The consumer's utility is a function of the characteristics x_j of these stores, the consumer's own tastes β_i, plus unobserved utility ε_{ij}:

$$v_{ij} = v(x_j, \beta_i) + \varepsilon_{ij}.$$

The observable characteristics of choice j include the number of stores in the choice n_j, and the n_j-vectors of: sales areas, distances, prices, and firm-dummies. We specify $u()$ so that the consumer might treat any pair of stores as complements or substitutes. For example a consumer may regard two large stores as being good substitutes, and see a large and a small store as complements. We will discuss this later in the section when we look at the functional form for $u()$.

As we saw in the previous section, it is reasonable to limit the model to the first (by revenue) four unique stores visited by consumers in a four-week period. This limitation brings is a substantial saving in the dimensionality of the problem. However, without further restrictions there are still a large number of alternative combinations to model. Assuming (as we have found empirically reasonable) that we allow J to include the nearest 30 stores in his vicinity, then a free choice of any $n_j \leq 4$ stores from these 30 implies that the number of alternatives A is

$$A = \sum_{k=1}^{4} \frac{30!}{k!(30-k)!} = 173015$$

which is an intractible number of utility evaluations (both for the consumer and the econometrician). There are a number of alternative responses to this dimensionality problem. Although it is possible to consistently estimate a choice model on a random subset of alternatives (see Train (2003) p62), we prefer to structure the model to make it simpler both for the consumer and the econometrician.

The data presented in the previous section suggest a fairly natural simplifying structure. As we noted, a consumer does not usually divide expenditure evenly across the stores but concentrates the bulk of spending in the first and second stores. We can therefore divide shopping trips into three different modes, namely primary shopping, secondary shopping and remaining shopping. We can then adopt a sequential three-level nested choice structure, in which consumers notionally select the stores in the following sequence: first the store for primary shopping, then the store for secondary shopping, and then the store (or store pair) for remaining shopping. The consumer may opt not to go to four stores and can choose any number of stores between 1 and 4. Not choosing a store at any stage is treated as a choice of the "outside option" and once this option is selected the consumer's sequence finishes. The dimensionality of the problem is now reduced to a manageable level within any decision stage. For a choice set J containing 30 stores we have the following number of alternatives: in the first two stages the number of alternatives is now no more than J (plus the outside option of no store), and in the third step, where a single store or a pair of stores can be chosen, the number of alternatives is 465 (plus the outside option of no store). A further technical point to note at this stage is that when the consumer chooses a store at the first (or second) step in the sequence, that store is then not included in the choice set for the subsequent stages in the sequence.

The consumer fully considers the implications of the primary choice on the utility from the remaining stores (i.e. this is similar in structure to a dynamic model, except here of course there is no time discounting as we are considering within-period shopping and the choices are is made instantaneously). As we shall see the implications of the primary choice on utility from secondary and remaining shopping arise partly because there are utility interactions between the characteristics primary, secondary, and remaining choices.

With this structure in hand the utility can now be written in the following additive structure where j continues to represent the overall choice and n denotes the stage in the three-stage decision sequence:

$$v(x_j, \beta_i) = \sum_{m=1}^{3} u(x_j^m, \beta_i^m) + \sum_{m=1}^{3}\sum_{n=2}^{3} \Gamma(x_j^m, x_j^n, \gamma_i) + \varepsilon_{ij}$$

where $\{x_j^n\}_{n=1}^3$ are the characteristics at the first, second, and third choices in in the decision sequence. (The characteristics in stages 1 and 2 are characteristics of a single store and the characteristics in the third stage are either the characteristics of single stores or store pairs).

The function $u()$ is the "stage utility"—i.e. utility from the store chosen at a choice stage before considering utility interactions with the choices at other stages in the sequence.

The function $\Gamma()$ is the interaction effects. For simplicity we consider only first order interaction effects—i.e. interaction effects between the choices at any two stages but not interactions between all thre stages at once. The interaction between the choices at stage m and n is written

$$\Gamma(x_j^m, x_j^n, \gamma_i)$$

and depends on the characteristics of the stores chosen at the two stages in interaction. (This is somewhat different from the approach taken by Gentzkow, who estimates each Γ as a free parameter for each possible pair of products. In his setting, with three products, the number of pairs is limited. Here, we have too many products to permit such an approach. We therefore recast the interactions model from interactions between products to interactions between product characteristics, which reduces the number of parameters needed to specify the model.)

Note that the taste parameters $\{\beta_i^m\}_{m=1}^3$ carry an i subscript and are therefore in principle (though not in practice in the present version of the paper) allowed to vary across consumers (and this variation can be partly random and partly related to observable consumer characteristics).

The taste parameters also carry an m superscript to show that they vary by the mode of shopping for any consumer. Thus a consumer's tastes for store attributes are different for the first, second, and remaining modes of shopping. This is quite natural in this setting (as confirmed by the data presented in the previous section): shoppers looking for a primary store are more likely to value store size, and so on. It is also a convenient assumption as it facilitates a stage-by-stage estimation of the utility parameters (as we discuss a little later).

Absent any random part of the taste parameters, the random utility is in the additively separable term ε_{ij}. In principle we can think of this as the sum of three error components, one for each stage in the three-stage sequence, as follows:

$$\varepsilon_{ij} = \sum_{m=1}^{m_j} \varepsilon_{ij}^{m}$$

where m_j is the highest stage the consumer reaches in the sequence.

In practice we assume that ε_{ij} is distributed according to a Generalised Extreme Value (GEV) distribution, which is commonly used in the well-known nested logit model of consumer choice. This distribution permits the ε_{ij} of products in certain specified "groups" of choices to be correlated. In our setting we use the structure of the sequential choice framework to determine these groups, which gives us a nested-logit model with three levels. At the bottom level there is a different group for each possible choice of primary and secondary store choice, and at the middle level there is a different group for each primary store choice. This implies a natural correlation structure in the errors, since we would expect positive correlation between the random utility of choices that have stores in common.

With this random utility specification in hand, consumer j's problem is written as follows:

$$\max_{j} \{v(x_j, \beta_i)\}$$

As show by McFadden and others, the probability of consumer i choosing choice j can be written in a structured closed form given by the nested logit model, in which the probability of later stages can be written conditional on choices made in earlier stages. Those who are familiar with this method can skip the next three paragraphs.

Thus, following the conventional nested logit structure, the probability of choosing store j_3 in the final stage, conditional on the choices of stores j_1, j_2

in stages 1 and 2, is given by the simple multinomial logit model:

$$\Pr(j_3, i \mid j_1,\ j_2) = \frac{\exp\left(u(x_j^3, \beta_i^3) + \sum_{n=1}^{2} \Gamma(x_j^3, x_j^n, \gamma_i^3)\right)}{\sum_{k\in A(J)} \left\{1 + \exp\left(u(x_k^3, \beta_i^3) + \sum_{n=1}^{2} \Gamma(x_k^3, x_k^n, \gamma_i^3)\right)\right\}}$$

where $A(J)$ is the set of alternatives in the final stage (i.e. the stores in J and all their possible pairs) and the expression in the numerator

$$u(x_j^3, \beta_i^3) + \sum_{n=1}^{2} \Gamma(x_j^3, x_j^n, \gamma_i)$$

is the utility implication of the choice at stage 3, given the choices in earlier stages.

Moving up to the second level in the nest, the probability of choosing store j_2 conditional on the choice j_1 in stage 1 is given by:

$$\Pr(j_2, i \mid j_1) = \frac{\exp\left(u(x_j^2, \beta_i^2) + \Gamma(x_j^2, x_j^1, \gamma_i^2) + \lambda^2 I_j^{(m=2)}\right)}{\sum_{k\in(J)} \left\{\exp\left(u(x_k^3, \beta_i^3) + \Gamma(x_k^2, x_k^1, \gamma_i^2) + \lambda^2 I_k^{(m=2)}\right)\right\}}$$

where

$$I_k^{(m=2)} = \log \sum_{k\in A(J)} \left\{\exp\left(u(x_k^3, \beta_i^3) + \sum_{n=1}^{2} \Gamma(x_k^1, x_k^n, \gamma_i^3)\right)\right\}$$

is the log-sum term which captures the effect of the choice on the utility from subsequent choices in stage 3. This is sometimes known as the"inclusive value" and is simply the log of the denominator in the bottom stage choice probability expression. The λ^2 term is a parameter in the error distribution and should be positive.

Finally the probability of choosing primary store j_1 is given by:

$$\Pr(j_1, i) = \frac{\exp\left(u(x_j^2, \beta_i^2) + \lambda^1 I_j^{(m=1)}\right)}{\sum_{k\in(J)} \left\{\exp\left(u(x_k^3, \beta_i^3) + \lambda^1 I_k^{(m=1)}\right)\right\}}$$

where the "inclusive value" is now defined analogously:

$$I_k^{(m=1)} = \log \sum_{k\in(J)} \left\{\exp\left(u(x_k^2, \beta_i^2) + \Gamma(x_k^2, x_k^1, \gamma_i^2) + \lambda^1 I_k^{(m=2)}\right)\right\}.$$

Similar to λ^1, the λ^2 term is a parameter in the error distribution and should be positive.

The probability of consumer i's choice $j = (j_1,\ j_2,\ j_3)$ is therefore given by

$$\Pr(j, i) = \Pr(j_1, i) \Pr(j_2, i |\ j_1,\ j_2) \Pr(j_3, i \mid j_1,\ j_2).$$

The estimation of the model can proceed all at once, by maximization of the implied log-likelihood. It is much more convenient, however, to estimate the model in stages, starting at the bottom of the decision tree and estimating the third level parameters by maximization of the conditional likelihood implied by the expression for

$$\Pr(j_3, i | j_1, j_2)$$

and so on up the tree. (Of course, as the middle and upper likelihood estimates rely on estimted parameters from the lower-levels, the standard errors will have to be adjusted to allow for the extra source of error). This three-stage estimation is facilitated by the assumption that the taste parameters are different at each level (an assumption which is also rather natural). In the specification above we have made explicit that the γ_i parameters in the interaction expression Γ vary by mode (as well as the β_k^3 parameters).

Finally in this section, we discuss the functional forms for $u()$ and $\Gamma()$. In the present version of the model we impose common taste parameters for consumers so (β_i, γ_i) are common for all i. We therefore leave the i subscript off hereafter.

The stage utility function $u()$ is a quadratic form in the observable characteristics of the store namely: sales area (size_j), distance from consumer (dist_{ij}), price of a standardised basket of goods (p_j), and the number of stores. For stages 1 and 2 (i.e. $m = 1, 2$) the exact form used is:

$$u_j^m = \beta_0^m + \beta_1^m \mathrm{size}_{ij} + \beta_2^m \mathrm{size}_{ij}^2 + \beta_4^{im} \mathrm{dist}_{ij} + \beta_5^m \mathrm{dist}_{ij}^2 - \beta_6^m \mathrm{p}_j$$

In stage three the consumer may choose one store or a pair of stores. If the consumer chooses one store then the utility is given by the above expression. If the consumer chooses a pair of stores (ja and jb) we simply sum over the utilities of the two stores as follows:

$$\begin{aligned} u_j^3 &= u_{ja}^3 + u_{jb}^3 \\ &= \sum_{k=(a,b)} \left(\beta_0^3 + \beta_1^3 \mathrm{size}_{ik} + \beta_2^3 \mathrm{size}_{ik}^2 + \beta_4^3 \mathrm{dist}_{ik} + \beta_5^3 \mathrm{dist}_{ik}^2 - \beta_6^3 \mathrm{p}_k\right) \end{aligned}$$

The above specification could be extended to include "firm" as a characteristic (there are 15 main firms); this would capture unobserved quality associated with that firm's products (and reduce the problem of endogeneity of the price variable).

For the interaction term $\Gamma(x_j^m, x_j^n, \gamma_i)$ we use the following simple form:

$$\Gamma(x_j^m, x_j^n, \gamma_i) = \gamma_1 \text{size}_j^m * \text{size}_j^n$$

If the sign of γ_1 is negative, then large stores are "substitutes" in the sense that the larger is store m the less the utility the consumer attaches to the size of store n. Other types of interactions possible, the most obvious being distance (a consumer is likely to combine neighbourly stores) and firm (two specific firms may offer very similar product lines).

There are two types of outside option in the model (for each consumer and period). The first is the outside good corresponding to going to a store outside J (the nearest 30). We assign a constant utility β_0 to this outside option. The second is the outside good corresponding to not going to a store at all in that period. The utility of this outside option is normalised to zero.

4 Data and Results

The data are taken from A. C. Nielsen's *Homescan* survey. Households scan in their shopping purchases, recording items bought, price paid, and outlet of purchase. The grocery demand data is supplied monthly, aggregated into six categories—fruit and vegetables, health, grocery, meat etc. The data are for 26 four-weekly periods in 1998-2000 and comprise 5423 households (although the model parameters presented later are estimated on 6 periods and 3035 households). We have detailed household characteristics information (although these are not yet incorporated into the model). The same survey provides price data (at a company level) for 100 items by firm and month. (We don't have price data for some of the smaller firms so in these cases we have to incorporate their effects into a no-price dummy variable). Store characteristics data, from the *Institute of Grocery Distribution* (London, UK) are obtained for all stores in the UK and used to construct the choice set J for each consumer. For each store we have location, size, firm, and parking.

Table 4 presents the parameters from the estimated model along with some details of the number of observations, periods, and respondents. The

Table 4: Estimated Utility Parameters

	Upper Level (Choice of Store 1)		Middle Level (Choice of Store 2)		Bottom Level (Choice 3rd & 4th Store)	
Size_j	1.067	(0.007)	0.631	(0.009)	0.483	(0.013)
Size_j^2	-0.093	(0.001)	-0.049	(0.001)	-0.046	(0.001)
Size_k*Size_l	–		-0.006	(0.001)	0.007	(0.001)
Distance_{ij}	-45.165	(0.125)	-33.049	(0.136)	-30.830	(0.158)
Distance_{ij}^2	31.910	(0.103)	26.825	(0.108)	20.277	(0.133)
Price_j	0.098	(0.012)	0.025	(0.016)	-0.056	(0.001)
No-price dummy	1.639	(0.314)	0.297	(0.410)	-1.472	(0.014)
Constant (N=2)	–	–	-3.949	(0.411)	–	–
Constant (N=3 or 4)	–	–	–	–	-1.403	(0.016)
Outside Store	5.905	(0.319)	-1.944	(0.017)	-2.117	(0.025)
Inclusive Value	1.450	(0.018)	0.984	(0.009)	—	—
LLF	-45242.63		-42529.30		-23343.17	
#Observations	20103		20096		10129	
Respondents	3035		3035		2151	
Periods	6		6		6	
#Alternatives	$30+2^*$		$30+2^*$		$30+\frac{30!}{(30-2)!2!}+2^*$	

*Number of alternatives includes two "outside good" options: distant stores and no purchase.

first column gives the utility parameters for the upper level of the utility problem, and the remaining two columns give parameters for the lower stages. As noted in the previous section the parameters for stages one and two use estimated parameters from the lower stages in the likelihood, and the standard errors are not (yet) adjusted for this. Therefore only the standard errors from the stage three utility model are strictly correct.

The signs of the parameters in the $u()$ functions are consistent with intuition. Consumers prefer larger stores, but at a declining rate. Consumers dislike distance, but at a declining rate. One problem is that the sign of the price term is positive, but this is quite likely a result of the endogeneity of prices. This may be corrected in a future version of the paper, when firm dummy terms are included to control for firm-level unobserved quality.

The parameter on inclusive value is positive and significant.

The parameter in the $\Gamma()$ function is also significant. It is negative for interactions with the secondary store and positive for interactions with the third and fourth store. The negative value is consistent with intuition: a consumer who visits a large store for primary shopping valuse store size less when choosing secondary store.

5 Analysis

To be done.

6 Conclusions

To be written.

References

[1] Armstrong, M. (2006) "Competition in Two-Sided Markets" *RAND Journal* (forthcoming).

[2] Berry, S. (1994) "Estimating Discrete-Choice Models of Product Differentiation" *RAND Journal of Economics* 25:242–62.

[3] Bliss, C. (1988) "A Theory of Retail Pricing" *Journal of Industrial Economics,* 36: 375-391.

[4] Competition Commission (2000), *Supermarkets: A Report on the Supply of Groceries from Multiple Stores in the United Kingdom* The Stationary Office, London, UK.

[5] Dube J-P. (2005) “Product Differentiation and Mergers in the Carbonated Soft Drink Industry” *Journal of Economics and Management Strategy* 14: 879-904.

[6] Gentzkow, M. (2006) *Valuing New Goods in a Model with Complementarity: Online Newspapers* Working Paper, University of Chicago

[7] Hendel I., (1999) “Estimating Multiple-Discrete Choice Models: An Application to Computerization Returns,” *Review of Economic Studies* 66: 423-446.

[8] Klemperer (1992) “Equilibrium Product Lines: Competing Head-to-Head May Be Less Competitive” *American Economic Review* Vol82 pp740-755

[9] Rust, J. (1987) “Optimal Replacement of GMC Bus Engines: An Empirical Model of Harold Zurchner, *Econometrica* 55: 993-1033

[10] Smith, H. W. (2004) “Supermarket Choice and Supermarket Competition in Market Equilibrium” *Review of Economic Studies* Vol. 71 pp.235-263.

[11] Smith, H. W. (2006) “Characteristics in Retail Oligopoly” *RAND Journal of Economics* (forthcoming)

[12] Smith H. W. and Hay, D. A. (2005) Streets, Malls and Supermarkets *Journal of Economics and Management Strategy* Vol 14 pp25-29.

[13] Stahl, K. (1987) “Urban Business Location”, in E. S. Mills *Handbook of Regional and Urban Economics Vol II* Elsevier Science Publications EV.

[14] Train, K. (2003) *Discrete Choice Methods with Simulation*, Cambridge University Press.