Chain-store pricing and the structure of retail markets^{*}

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Abstract

This paper examines competition between chain-stores and independent retailers in the UK retail opticians' market. We demonstrate that the pricing policy adopted by chain-stores can determine the impact their entry has on independent retailers. Crucially, in this market the chain-store retailers set an identical national price across all local markets. Our results suggest that this pricing strategy lessens the detrimental effect competition from chain-stores has on independent retailers.

JEL Classification codes: L11, L13

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1 Introduction

Chain-stores are increasingly dominating many retail markets. In the UK multiple retailers increased their market share from around 23% to 65% between 1950 and 1995¹. In addition, the Competition Commission (2008) found that since the 1950s there has been a significant decline in the number of specialist stores. Various empirical studies suggest that the expansion of chain-store retailers can have a detrimental effect on smaller independent retailers. There is therefore widespread concern in particular due to the impact on product choice and local economies². This paper examines competition between chain-stores and independent retailers in the UK retail opticians' market. In contrast, to these earlier papers, we find no evidence that chain-stores have a deterimental effect on independents in this market. As discussed below, one important reason for this is the pricing strategies adopted by chain-stores.

Deregulation of UK opticians' market in the mid 1980s brought about many significant changes, particularly the removal of restrictions on advertising and the possibility of entry by unregistered suppliers³. This immediately lead to rapid entry and growth of chain-store retailers, increasing their market share from 46% to 75% between 1985 and 1991⁴. We demonstrate that the pricing policy adopted by chain-stores can determine the impact their entry has on indepedent retailers. Crucially, in this market the chain-store retailers adopt national pricing strategies, setting an identical national price across all local markets.

A related theoretical literature considers the alternative pricing strate-

gies that chain-stores can adopt. Dobson and Waterson (2005) demonstrate that it can be profitable for chain-stores to set an identical price across all local markets because this dampens competition in markets where otherwise several chain-stores would compete intensely. In addition, a number of chain-store retailers currently adopt such national pricing strategies, for example Tesco, the largest supermarket retailer in the UK. The alternative to a national pricing policy is for chain-stores to set prices that vary across local markets. In their investigation of the UK groceries industry, the Competition Commission (2000) raised concerns over the common practice at that time of price flexing, defined as: 'setting retail prices across different geographic areas in the light of competitive conditions, such variations not being related to costs'⁵. One reason for their concern appears to have been the possibility of a link between price flexing and below-cost selling. The fear is that such strategies may in particular adversely effect smaller convenience stores (see also Association of Convenience Stores, 2006).

The starting point for our empirical analysis is a methodology developed by Bresnahan and Reiss (B&R) (1991). They use evidence on the relationship between the number of firms and the market size to make inferences about the degree of competition. We draw upon a recent literature which introduces firm heterogeneity to this methodology. Most importantly Dinlersoz (2004) introduces competition between chain-store and independent retailers using a vertical product differentiation framework. In the manner of B&R this leads to predictions on the relationship between the number of independents and market size. As discussed in the next section, the model developed by Dinlersoz fits the UK characteristics of the UK retail opticians' market with one exception. The one exception is that Dinlersoz models competition between chain-stores as Cournot competition. This implies that the price a chain-store sets will vary across local markets depending upon the the number of chain-store rivals present. However, as explained earlier, in this market chain-stores adopt national pricing strategies. In section 2.4 we modify the model to allow for national pricing strategies. This leads to a revised prediction on the relationship between the number of independents and market size. Evidence consistent with the prediction under national pricing is then found in markets where chain-stores are present.

Next we introduce markets where no chain-stores are present and also consider the determinants of chain-store entry. Following B&R we estimate separate comparable entry models for independent and chain-store retailers. Then we provide a new extension to the B&R approach which allows for inter-type competition between these two types of retail outlet. This is done by adopting an instrumental variables approach based on a methodology, described in detail in section 5.3, developed by Sajaia (2009). This approach allows us to assess and compare both intra-type competition (between retailers of the same type) and inter-type competition (between alternative types). The results suggest that chain-store retailers have no adverse effect on independent retailers. We argue that the use of national pricing policies by chain-stores provides one explanation for this finding. In addition, the results suggest that the independent retailers also benefit by differentiating their product from that offered by chain-stores.

The empirical approach we use to extend the B&R responds to two related methodological problems which have recently been highlighted in the literature. Firstly, the number of each type of retailer is endogenously determined and therefore typically cannot simply be included as an additional variable to explain the number of alternative type rivals. One exception is Griffith and Harmgart (2008) which looks at competition between 'one-stop' and 'top-up' supermarket stores, and the impact of planning regulation. Because of the asymmetric nature of competition between these two types of retailer⁶, it is argued that the number of larger supermarkets can be treated as an exogenous determinant of the number of smaller 'top-up' stores. In contrast, in our approach we allow for the number of chain-stores to be endogenously determined. Secondly, as for example Cleeren et al. (2008) explain, there is the problem of multiple equilibria. As an example, consider a market in which only one firm can profitably survive. Consequently, in the Bresnahan and Reiss (B&R) approach where the focus is on the number of firms, there is a unique prediction. However, now allow for two different types of retailer. It may be that the market will support either retailer separately, but crucially not both. This means that there are two candidate equilbria. In contrast, the use of an instrumental variables approach allows a unique equilibrium prediction to be obtained.

Recent developments in the literature have provided a number of alternative solutions to these issues. These differ from our approach by requiring additional data and/or alternative assumptions on the entry process. Mazzeo (2002) allows firms to choose their product quality and demonstrates that, with assumptions on the degree of product quality commitment, there is a unique equilibrium prediction. Cleeren *et al.* (2008) and Toivanen and Waterson (2005) exploit the sequential order of entry in the industries they study, with the latter also using the timing of entry to allow for learning effects. In contrast, Seim (2006) introduces incomplete information about rivals' profitability.

The remainder of the paper proceeds as follows: section 2 shows how the predictions of the Dinlersoz (2004) model differ when national pricing is introduced. Section 3 describes the UK retail opticians' industry. Then section 4 examines the relationship between the number of independents and market size in markets where chain-stores are present. The evidence is consistent with the national pricing strategies adopted by all the main chainstore retailers. Section 5 then also includes markets where no chain-stores are present. The determinants of chain-store entry into a local market are considered and the extent of inter-type competition between chain-stores and independents is examined. Finally, section 6 offers some brief conclusions and avenues for further research.

2 A model of retail competition

Retail competition between chain-stores and independents will be examined using a vertical product differentiation model based on Dinlersoz (2004). Firstly the assumptions of the model are outlined and then the number of independent outlets that can profitably operate in a local market is examined. This is shown to crucially depend upon the pricing policy adopted by chainstore retailers.

2.1 Assumptions

This section describes the modeling assumptions made by Dinlersoz (2004), in section 2.4 the appropriateness of these assumptions for the UK opticians' market will be considered.

Competition takes place between chain-store retailers (denoted by subscript C) and independent retailers (I) within local markets which will vary in size S (measured by the number of consumers). Consumers have heterogeneous tastes for quality captured by α , which measures their marginal utility from one unit of quality. In each local market α is assumed to be uniformly distributed over an interval [$\underline{\alpha}, \overline{\alpha}$] with $\underline{\alpha} > 0$ and $\overline{\alpha} - \underline{\alpha} = 1$. In addition, each local market is assumed to be fully covered with all consumers purchasing one unit of the product from either an independent or a chain-store retailer⁷. Total market demand in a local market is therefore equal to S. For a consumer of type α , the utility derived from a product of quality θ sold at price p is:

$$u(p,\theta;\alpha) = \begin{cases} \alpha\theta - p & \text{if } \alpha\theta \ge p \\ 0 & \text{otherwise} \end{cases}$$
(1)

The quality levels of the different retail outlets (θ_I and θ_C) are identical within retailer type and exogenously determined⁸. Furthermore, the independent retailers are assumed to produce a higher quality product (i.e. $\theta_I > \theta_C$). Without loss of generality, this quality differential is normalised so that $\theta_I - \theta_C = 1$.

Fixed costs are denoted by f and variable costs c. In order to allow for their typically larger scale, chain-store outlets are assumed to have a total cost function (C_C) with increasing returns to scale,⁹ given by: $C_C(q_C) = f_C + c_C q_C$. In contrast, the independent retailers have a total cost function (C_I) given by: $C_I = f_I + c_I q_I^2$. This implies a U-shaped average cost function for the independent retailers with minimum efficient scale (MES) at

$$q_I^* = (f_I/c_I)^{1/2} \tag{2}$$

2.2 The number of independent outlets in a local market

Both the number of chain-store and independent outlets in each local market are determined by the free entry equilibrium. The independent retailers are assumed to act as price-takers in a perfectly competitive setting. They therefore compete the price down to the level where it is equal to marginal costs at the MES:

$$p_I^* = 2(f_I c_I)^{1/2} \tag{3}$$

Using (1) the consumer indifferent between the product offered by the chainstores and the independent stores has marginal utility of α^* , where

$$\alpha^* = p_I - p_C \tag{4}$$

Consequently, consumers for which $\bar{\alpha} \geq \alpha > \alpha^*$ buy from an independent retailer. Therefore, from (4) the local market demand for the independent retail sector is

$$D_I(p_I, p_C) = S(\bar{\alpha} - p_I + p_C) \tag{5}$$

In contrast, chain-stores sell to consumers with $\alpha^* \ge \alpha \ge \underline{\alpha}$ and therefore the total chain-store sector demand is given by:

$$D_C(p_C, p_I) = S(p_I - p_C - \underline{\alpha}) \tag{6}$$

Because the independent retailers each produce an output level which is invariant to market size (see (2)), the total number of independent retailers that can profitably operate in a market (N_I^*) crucially depends on the total demand for the independent sector i.e.: $N_I^* = D_I/q_I$. Using (2), (3) and (5), this can be written as:

$$N_I^* = \frac{S\left(\bar{\alpha} - 2(f_I c_I)^{1/2} + p_C\right)}{(f_I/c_I)^{1/2}}$$
(7)

This shows that the number of independent retailers in each local market will depend upon the price set by chain-stores (p_C) . As p_C falls, the proportion of the market served by chain-stores increases (α^* rises). This reduces the total demand for the independents' product and therefore the number of independent outlets that can profitably compete falls. As will now be demonstrated, this implies that the pricing strategy adopted by chain-stores has an important impact on the number of independent retailers. The next section describes the case where the price a chain-store charges differs across local markets, closely replicating Dinlersoz (2004).

2.3 Local pricing by chain-stores

Dinlersoz assumes that all chain-stores compete a la Cournot taking the price set by the independent retailers as given. From (6) the inverse demand function for the chain-store sector is

$$p_C = p_I - \underline{\alpha} - (Q_C/S) \tag{8}$$

Where Q_C is the total chain-store sector output. Under Cournot competition chain-store *i* chooses output q_{Ci} to maximize profits given by

$$\pi_{Ci} = \left(p_I - \underline{\alpha} - \left(Q_{-i}/S\right) - \left(q_{Ci}/S\right)\right) q_{Ci}$$

where $Q_{-i} = \sum_{j \neq i} q_{Cj}$. Rearranging the first order condition and noting that since all chain-stores are assumed symmetric: $Q_{-i} = (N_C - 1)q_{Ci}$ (where N_C is the number of chain-store retailers), gives the common chain-store output

$$q_C = \frac{S(p_I - \underline{\alpha} - c_C)}{(N_C + 1)} \tag{9}$$

Substituting in for $Q_C = N_C q_C$ in (8) (where q_C is given by (9)) gives:

$$p_C - c_C = \frac{(p_I - \underline{\alpha} - c_C)}{(N_C + 1)} \tag{10}$$

In the free-entry equilibrium chain-stores can enter the market until there are no profitable opportunities for further entry i.e. from (9) and (10):

$$S\left(\frac{(p_I - \underline{\alpha} - c_C)}{(N_C + 1)}\right)^2 = f_C \tag{11}$$

Rearranging (11), the equilibrium number of chain-store outlets (N_C^*) is given by:

$$N_C^* + 1 = (S/f_C)^{1/2} (p_I - \underline{\alpha} - c_C)$$
(12)

Substituting (12) back into (10) gives:

$$p_C = (f_C/S)^{1/2} + c_C \tag{13}$$

The equilibrium number of independent outlets (N_I^*) under Cournot competition between chain-stores can then be found by substituting (13) into (7), giving:

$$N_I^* = \frac{\left(\bar{\alpha} - 2(c_I f_I)^{1/2} + c_C\right)S + (f_C S)^{1/2}}{(f_I/c_I)^{1/2}}$$
(14)

Under Cournot competition the price charged by chain-store retailers depends upon the number of chain-store rivals it faces in the local market (see (10)). Chain-stores are therefore effectively adopting local pricing strategies. From (14) it can then be shown that based on the Dinlersoz (2004) model¹⁰:

Proposition 1. If chain-stores adopt local pricing the number of independent outlets in the local market will increase less than proportionately with an increase in the market size, but at an increasing rate.

This is because as the market size increases chain-store entry occurs, leading to a fall in the chain-store price. Therefore, the number of chain-stores increases less than proportionately with an increase in market size. This is the intuition underlying the B&R approach described in the introduction. However, the fall in the chain-store price also effects the independent retailers' share of the market. Crucially, some consumers will switch from the independents' high quality product to the chain-stores' lower quality product. Consequently, the number of independent outlets also increases less than proportionately with an increase in the market size. As the number of chainstores entering the local market continues to increase, additional chain-store entry has less of an effect on price and therefore fewer additional consumers switch to chain-stores. Therefore, as the market size increases further the number of independent outlets can increase almost proportionately with an increase in the market size. Dinlersoz finds evidence of this relationship between the number of independent outlets and market size in the Californian retail alcoholic beverage industry.

2.4 National pricing by chain-stores

The findings of the Dinlersoz model require chain-stores to have a larger minimum efficient scale than independents¹¹ and assumes that chain-stores produce a lower quality product than independents. These two assumptions appear to fit the UK opticians' market relatively well. Evidence provided to the competition authorities during a recent merger investigation suggested that the chain-stores have a significant scale advantage over independents in this market. It was suggested that this partly arose from significant buyer power enabling them to obtain lower cost from suppliers¹². Furthermore, figures provided below in section 3 indicate that in this market chains-stores have a much higher value of sales per store than other retailers, suggesting that these are larger scale outlets. The assumption that independent retailers supply a higher quality service could be justified in terms of a more personal service, with consumers benefiting from repeated interaction with the same ophthalmic practitioner. In fact, one of the concerns of opponents of deregulation was a reduction in service quality¹³. In addition, in the recent UK merger investigation independent opticians stated that they were able to differentiate their product from that offered by chain-stores by offering a higher quality product and service¹⁴. Further evidence supporting this assumption will be provided in section 5.

However, a crucial assumption in the Dinlersoz model is that in each local market chain-stores compete *a la Cournot*. This implies that the price will vary according to the number of chain-stores present in the market. However, the main retail opticians' chains in the UK 'make strategic decisions at a national level'¹⁵ and adopt national pricing strategies. We can therefore now demonstrate the effect of altering the Dinlersoz model to allow for chain-store national pricing strategies.

Suppose that the chain-stores all set an identical nationally determined price p_{nat} . This national price will be set by a chain-store in order to maximize profits across all the local markets in which it operates. As long as the total number of markets in which the chain-store operates is sufficiently large the impact of an individual local market is negligible and therefore the national price can be modelled as exogenously determined within a given local market. The output and price of an independent store will remain unchanged from the previous section. Therefore from (7), the free entry equilibrium number of independent outlets in a local market under chain-store national pricing is now simply

$$N_I^* = \frac{S\left(\bar{\alpha} - 2(f_I c_I)^{1/2} + p_{nat}\right)}{(f_I/c_I)^{1/2}}$$

This shows that¹⁶:

Proposition 2. If chain-stores adopt national pricing strategies the number of independent outlets will increase proportionately with an increase in market size, for all sizes of market.

Because both chain-stores and independent firms now set a price that is invariant in the market size, the proportion of consumers preferring chainstores to independent outlets and vice versa is fixed for all market sizes.

Comparing Propositions 1.1 and 1.2 shows that the relationship between the number of independent retailers and market size depends upon whether chain-stores adopt national or local pricing strategies. In section 4 evidence on this relationship between the number of independent retailers and market size in the UK retail opticians' market will be provided. First, in section 3, the dataset is described.

3 Firms in the UK opticians' market

The dataset was obtained in 2004 by downloading from the main online business directory¹⁷ the names and postcodes of all opticians' outlets in England and Wales. Table 1 shows the number of outlets owned by the largest multistore firms.

[Table 1 here]

As can be seen, there are four chains owning more than 150 stores¹⁸. Henceforth, these four will be referred to as chain-stores and all remaining outlets as independents (Inds): **Definition.** Chain-store: an optician's store owned by Specsavers, Dolland and Aitchison, Boots or Vision Express.

Of course, this definition of a 'chain-store' is somewhat arbitrary, however, there are a number of reasons for differentiating these four from the smaller, multi-store firms. First, as shown in Table 2, all four have a national presence with multiple outlets in all ten regions. In addition, as stated earlier, all four chain-stores adopt national pricing strategies.

[Table 2 here]

On the other hand, with the possible exception of Optical Express the other main multi-store firms do not have a national presence. The Optical Express chain, established in 1991, has grown rapidly, and if it continues to expand as rapidly will soon join the group of main chain-store retailers¹⁹. Second, the four chain-stores, in addition to being the largest chains are also the firms in the market with a significant brand name and prominence as a high street retailer. Despite owning only 19% of stores (Table 1) these four chain-stores these four accounted for 54% of sales by value²⁰ and 75% of advertising expenditure²¹. Overall, the evidence suggests these four are the chain-stores most likely to have a significant effect on independent outlets²².

Local markets will be defined according to Local Authority Districts (LADs). These tend to be centered on town/cities and therefore represent a reasonable approximation of the area in which consumer search behaviour takes place in the opticians' market. They are also a unit of observation for which demographic data is readily available and importantly for our methodology vary considerably in size. LAD markets have also been used to define

local markets in other previous studies²³.

Table 3 describes the number of opticians for all 372 LAD in England and Wales. The number of outlets will be used to refer to the total number of stores owned by chain-stores whereas the number of fascias refers to the number of different national chains present in a market. So for example a market with two Specsavers stores and one Boots store has three outlets but only two fascias.

[Table 3 here]

A 'typical' LAD market contains 17 opticians' outlets: 3 chain-store and 14 independent outlets. Almost 75% of markets contain less than 20 outlets. Since it is possible that the very larger LADs may in fact consist of several separate local markets much of the empirical analysis that follows will focus on a subsample of the smaller LAD markets²⁴. In addition, all chain-stores have multiple outlets in one or more LAD.

Figure 1 shows the relationship between the total number of opticians' outlets present and the population of the local market. As we would expect, there is clearly a positive relationship.

[Figure 1 here]

Henceforth the City of London LAD will be omitted from the empirical analysis as it is principally a business area with a very low population but a comparatively large number of opticians. This gives a total sample of 371 markets. Whilst chain-stores are present in most of these markets, there are 42 markets in which there are no chain-stores. As Table 4 shows the markets where no chain-stores are present tend to be smaller on average, but there is a significant range of smaller markets in which a chain-store may or may not be present. More specifically, in markets with population levels below 121025 it is possible that a chain-store will not be present.

[Table 4 here]

4 Testing the relationship between the number of independent retailers and market size

4.1 Econometric specification

Propositions 1.1 and 1.2 suggest that the relationship between the number of independents and market size will differ depending on whether the chain-stores in the market adopt local or national pricing. The following econometric specification will allow a simple test of this proposition:

$$\log(NInds_i) = C + \alpha \log(Population_i) + \beta(X_i) + \epsilon_i$$
(15)

where the subscript i refers to an LAD market, $NInds_i$ is the number of independent outlets, $Population_i$ is the LAD population and X_i is a vector of demand and cost control variables as described in Table 5 below. The error term ϵ_i is assumed to be independent across LAD markets. The model will be estimated using OLS and the use of the constant elasticity model means that the estimated coefficients show the proportional change in NInds for a given change in the explanatory variable. This allows a simple test for the differing predictions of Proposition 1 and 2. If $\hat{\alpha} < 1$ the number of independent outlets increases less than proportionately with an increase in market size, consistent with local pricing (Proposition 1). In contrast, if $\hat{\alpha} = 1$ the number of independent outlets increases proportionately with an increase in market size, consistent with national pricing (Proposition 2).

4.2 Demographic variables

The use of LAD markets allows the data on the number of outlets to be matched with census demographic data, including importantly population as a measure of market size, and other variables that can then be used to control for cost and other possible demand differentials between markets. Table 5 defines all the demographic variables that will be used²⁵, these will be included selectively due to the high degree of correlation between some of the variables. Table 6 then provides descriptive statistics for these variables.

[Table 5 here]

[Table 6 here]

Density allows for the possibility that more densely populated areas may attract additional opticians' outlets, perhaps as they act as centre for retail activity and thus attract customers from outside the LAD. The inclusion of age variables controls for the likelihood that the demand for opticians' services is higher, and typically more complex sight problems exist, amongst older people. The wage variable is included as a control variable but has two possible interpretations, it could either reflect firms' cost differences between markets or higher demand due to a more affluent population. Income support claimants are entitled to an NHS voucher which provides the recipient with a free sight test and discounted spectacles or contact lenses. It is therefore plausible that demand could be higher in LADs with more income support claimants. We would perhaps expect urban LADs to attract more opticians and the travel variable captures increased demand from outside the LAD and proxies for significant business and retail districts.

4.3 Results

The specification given by (15) will now be estimated for the 329 local markets where one or more chain-store is present.

[Table 7 here]

It is not possible using a t-test to reject the null hypothesis that the coefficient on log(Population) is equal to one. Therefore, consistent with chain-store national pricing strategies the evidence does not reject the hypothesis that the number of independent outlets increases proportionately with an increase in market size (see Proposition 2)²⁶.

In addition, the results show that the other demographic variables also affect the number of independent retailers. Markets with an older population have more independent outlets, suggesting demand is higher in these markets. The number of independent outlets is also increasing in both the average wage of the LAD population and the proportion of income support claimants²⁷.

As Dinlersoz (2004, pp. 221-2) discusses, his model could be extended to allow for quality enhancing investments by chain-stores. This would therefore introduce an endogenous sunk cost. As in Sutton (1991), in larger markets chain-stores could compete more intensely by escalating expenditure on quality enhancement. Dinlersoz goes on to explain that this would support the findings of his model as, like with a lower chain-store price, higher quality chain-stores result in a reduction in the segment of the market served by independents. Consequently, the predictions of the Dinlersoz model for the number of independent retailers would remain similar to those described in section 2.3. However, this impact of chain-store quality escalation could also occur under national pricing. In contrast, our above finding on the relationship between the number of independents and market size suggests that such quality escalation does not play an important role in this market. Instead the results suggest that, like prices, chain-store quality levels are determined at a national level, with little role for local differential levels of non-price competition.

5 The determinants of chain-store entry and the impact on independent retailers

The preliminary evidence from the previous section has strongly suggested that the relationship between the number of independent retailers and market size is consistent with chain-store national pricing. We can now deepen the empirical analysis. Firstly, the focus has so far been on the number of independent retailers and the determinants of chain-store numbers in local market have not been considered. Secondly, only markets with one or more chain-store present have been considered. However, there are also a number of markets with no chain-store present. Thirdly, the theoretical model from section 2 also makes more direct predictions on the impact the number of chain-stores has on the number of independent retailers. If chain-stores use local pricing then, according to the Dinlersoz model, additional chain-store entry should reduce the number of independent retailers²⁸. However, under national pricing the model predicts that the number of independent retailers will be unaffected by the number of chain-stores present in the local market. In this section we will therefore be able to examine the extent of inter-type competition between chain-stores and independents more directly.

5.1 Sample of smaller markets

Both markets with and without chain-stores will now be considered. In order to examine the impact chain-store entry has we will focus on the range of market sizes for which chain-stores may or may not be present. From the earlier discussion of Table 4, these are markets with a population below 121,025. This also reduces the number of alternative market configurations and helps to ensure that an appropriately defined market is used. Table 8 summarizes the number of independent and chain-store outlets in the 206 markets in this reduced sample.

[Table 8 here]

Given the limited range for the number of firms present in each local market the ordered probit model, as used by Bresnahan and Reiss (1991), is now the most appropriate estimator²⁹. In addition, some extreme categories contained a small number of observations and were therefore combined with others with a similar number of outlets³⁰.

5.2 Bresnahan and Reiss (1991) methodology

5.2.1 Ordered probit econometric specification

The B&R approach allows us to separately estimate comparable entry models for chain-stores and independents. In section 5.3 we then extend the B&R approach in order to also allow for inter-type competition between chains and independents. The B&R approach will firstly be described for a general setting with n firms operating in each market. In our application n will then represent either the number of chains or the number of independents. A firm's latent profit from operating in market i is given by Π_i and it is assumed that profits fall as the number of firms in the market increase. Using N to denote the maximum number of outlets observed in any market, the observed number of outlets in market i (N_i) can be related to the latent profit (Π_i) by the observability criterion:

$$N_i = n \ if \ \lambda_n \le \Pi_i < \lambda_{n+1} \tag{16}$$

where the unknown cut points are such that: $\lambda_0 < \lambda_1 < \ldots < \lambda_N < \lambda_{N+1}$, $\lambda_0 = -\infty$ and $\lambda_{N+1} = \infty$. Firms' latent profit can then be divided into two parts: a deterministic component (π_i) and a random error term (ϵ_i) which is assumed to be common across all firms in market *i*. Therefore:

$$\Pi_i = \pi_i + \epsilon_i \tag{17}$$

Using (17), (16) can be rewritten as:

$$Pr(N_i = n | \pi_i) = Pr(\lambda_n - \pi_i \le \epsilon_i < \lambda_{n+1} - \pi_i)$$

If we then assume that ϵ_i follows a standard normal distribution then the likelihood function is given by:

$$\prod_{i=1}^{L} \prod_{n=1}^{N} \left[\Phi(\lambda_{n+1} - \pi_i) - \Phi(\lambda_n - \pi_i) \right]^{z_{in}}$$

where: L is the total number of markets, $\Phi(.)$ denotes the cumulative standard normal distribution, and $z_{in} = 1$ if $N_i = n$, otherwise 0. This can then be estimated using the ordered probit model.

5.2.2 Deriving entry thresholds

Following Cleeren *et al.* (2006) we can then use the ordered probit results to derive entry threshold as first suggested by B&R. Firms' profits will be specified as³¹:

$$\pi_i = \alpha \log(Population_i) + \beta(X_i) + \epsilon_i \tag{18}$$

where as before $Population_i$ is the LAD population and X_i is a vector of demand and cost control variables. It then follows from (16) and (17) that we predict $N_i = n$ if and only if $\pi_i > \lambda_n$, or using (18):

$$\hat{\alpha}\log(Population_i) + \hat{\beta}(X_i) > \hat{\lambda}_n \tag{19}$$

Rearranging (19) allows us to solve for the predicted population required to support n firms, or in other words the n-firm entry threshold

$$S^{n} = \exp\left((\hat{\lambda}_{n} - \hat{\beta}\bar{X})/\hat{\alpha}\right)$$
(20)

where \bar{X} are the sample means of the demographic variables. We can then compute the per firm entry threshold (s^n) given by S^n/n . In order to evaluate the change in competitive conduct as the number of firms increases, Bresnahan and Reiss (1991) then calculate entry threshold ratios (R^n) comparing the n and n-1 per firm entry thresholds:

$$R^n = \frac{S^n}{n} / \frac{S^{n-1}}{n-1}$$

Using (20):

$$R^{n} = \exp\left(\frac{\hat{\lambda}^{n} - \hat{\lambda}^{n-1}}{\hat{\alpha}}\right) \frac{n-1}{n}$$

This therefore provides a unit free measure of the impact an additional firm has on the degree of competition. In order to illustrate this, consider a market where at least 4000 consumers are needed to support a monopolist. If a competitor was also present in the market we would expect prices to fall below the monopoly level. A fall in margins means a firm must sell to more consumers in order to break even. Consequently, a market with a total of more than 8000 consumers is needed to support the two competing retailers. For example, imagine a total of 9000 consumers would be required to support two identical firms. This means that the per firm entry threshold (s^n) is 4000 for a monopoly (4000/1) and 4500 for a duopoly (9000/2), giving an entry threshold ratio from 1 to 2 firms of 1.125. Alternatively, if the addition of a second retailer in the market has no effect on competition and collusive behaviour allows monopoly pricing to prevail, then a total market size of just 8000 consumers is needed to support the second retail outlet. This gives an entry threshold ratio of 1. Entry threshold ratios above 1 therefore indicate an increased intensity of competition brought about by an additional competitor in the market.

5.2.3 Ordered probit results

Table 9 reports the results from estimating separate ordered probit models for both the number of chains and independent outlets present in the sample of smaller markets³². In addition, a distinction is made between the number of chain-store outlets and fascias.

[Table 9 here]

These results suggest that market characteristics impact differently on the two types of retailers³³. Independents are more common in markets where earnings are higher whilst the opposite is true for chains. Assuming this variable captures demand rather than cost factors, then this result supports the earlier assumption that independents produce a product of higher vertical quality. In addition, the number of independents increases when the market population includes a higher proportion of elderly people. More chains are located in urban markets and those which are significant employment catchment areas. In contrast these two variables appear to have no impact on the

number of independents. This is consistent with chain-stores only entering the prime retail locations.

As discussed earlier, this B&R approach only takes into account intratype competition. Inter-type competition (between alternative types) has not so far been considered. So for example the impact chain-stores have on independents has not been allowed for. The next section describes how inter-type competition can also be taken into account.

5.3 Allowing for inter-type competition

5.3.1 Empirical methodology

In order to introduce inter-type competition a modification of the bivariate ordered probit model developed by Sajaia (2009) will be used. This allows an endogenous variable to be included as an explanatory variable in one of the two equations. So for example, the expected number of chain-stores in a market can be used to explain the number of independent retailers. We will, as before, distinguish between two types of retailers (independents and chain-stores) and to describe the general approach denote the two types as: t = j, k. Similar to before, latent profits of operating in market *i* can be written as:

$$\Pi_{ji} = \pi_{ji} + \epsilon_{ji} \tag{21}$$

$$\Pi_{ki} = \pi_{ki} + \gamma \Pi_{ji}^n + \epsilon_{ki} \tag{22}$$

where latent profits have a deterministic component (π_{ti}) and a random component (ϵ_{ti}) . However, crucially now the profits of type k retailers are allowed to depend upon the latent profits of type j retailers, but the same is not true in the opposite direction. Intra-type competition can then be examined separately in each direction by reestimating the model for the alternative scenario. As before, a series of unobserved cut points relate latent profits to the observed number of type j and k retailers (N_j and N_k respectively), such that:

$$N_j = n \text{ if } \lambda_n^j \leq \prod_{ji} < \lambda_{n+1}^j \text{ and } N_j = m \text{ if } \lambda_m^k \leq \prod_{ki} < \lambda_{m+1}^k$$

Using X = N, M respectively to denote the maximum number of type j and k firms: $\lambda_0^t < \lambda_1^t < \ldots < \lambda_X^t < \lambda_{X+1}^t, \lambda_0^t = -\infty$ and $\lambda_{X+1}^t = \infty$. Therefore:

$$Pr(N_j = n, N_k = m) = Pr\left(\lambda_n^j \le \Pi_{ji} < \lambda_{n+1}^j, \lambda_m^k \le \Pi_{ki} < \lambda_{m+1}^k\right)$$

The likelihood function (see Sajaia (2009) for more detail) is then given by:

$$\prod_{i=1}^{L} \prod_{n=1}^{N} \prod_{m=1}^{M} \Pr[N_j = n, N_k = m]^{z_{inm}}$$

Where: L is the total number of markets, and $z_{inm} = 1$ if $N_j = n$ and $N_k = m$, otherwise 0. Assuming ϵ_{ji} and ϵ_{ji} are distributed according to a bivariate standard normal distribution function with correlation ρ (a parameter to be estimated), this can be estimated using a bivariate ordered probit model. However, as Sajaia (2009) demonstrates (see p. 3), the linear system in (21) and (22) is identified only when some variables in π_{ji} are not present in π_{ki} . Instrumental variables that affect Π_{ji} but are not correlated with ϵ_{ji} will therefore be included only in π_{ji} . This then allows us to obtain consistent estimates of π_{ji} , γ (the measure of inter-type competition) and ρ .

5.3.2 Results

In order to consider the impact chain-stores have on independents, we now estimate this bivariate ordered probit model with the expected number of chain-store outlets included as an explanatory variable for the number of independents (Table 10). Based on the earlier ordered probit results the rural and distance traveled to work variables will only be included as explanatory variables in the chain-store outlets equation. These two variables therefore serve as instruments for the number of chain-store outlets.

[Table 10 here]

The γ term is negative but insignificant, this suggests that the number of chain-store outlets has no significant impact on the independent retailers³⁴. In Table 11 an alternative specification was estimated, testing the impact of independents on the number of chain-store outlets. Here, based on the evidence from Table 10, the elderly population variable is excluded from the chain-stores equation and is therefore the instrument for the number of independents.

[Table 11 here]

The impact of the number of independents on chain-store outlets is insignificant and furthermore actually positive. Overall therefore, these results provide no evidence of inter-type competition. Consistent with the model described earlier, this may be as a result of national pricing strategies adopted by chain-stores. Furthermore, the evidence that market characteristics impact differently on the two types of retailer, provides an additional explanation for this finding.

In both cases γ is not significantly different from zero, this therefore suggests that a seemingly unrelated approach should be used. However, in addition in both cases a likelihood ratio test cannot reject the null hypothesis that $\rho = 0^{35}$. The number of chains and independents can therefore be estimated, as earlier in Table 9, using a univariate ordered probit model for each equation (see Sajaia, 2009). In addition, comparing these earlier results with the bivariate ordered probit results (Table 10) shows that there is very little change in the estimated coefficients. Therefore, the earlier results from Table 9 were used to calculate entry threshold ratios by adopting the approach described in section 5.2.

5.4 Entry threshold ratios

As explained earlier, entry threshold ratios above unity indicate an increased intensity of competition. Consequently, here stars will be used to indicate significant differences from one according to a Wald test. Firstly Table 12 provides entry threshold ratios for chains, as before distinguishing between an additional chain-store outlet and the presence of a different chain-store fascia in the market.

[Table 12 here]

In almost all cases the entry threshold ratios are not significantly different from one. This result supports the earlier findings as it is consistent with chain-store national pricing strategies. In addition, this also suggests an absence of local non-price competition, for example through local promotions or sales effort. Interestingly, the entry threshold ratio is weakly less than one for the second outlet in the market³⁶. An entry threshold ratio less than one implies that the intensity of competition decreases following the entry of a second outlet. This result is only significant for a second outlet, not for a second fascia in the market. This may suggest agglomeration effects from operating a second outlet in the market. Alternatively, a second outlet may be used strategically to preempt and deter entry by a rival. Next, Table 13 reports entry threshold ratios for the independent retailers.

[Table 13 here]

Generally, consistent with the findings of section 4.3, the entry threshold ratios are not significantly different from one. In contrast, there is some weak evidence of an increased intensity of competition when the 7th and 8th independent enters.

6 Conclusion

This paper has found no evidence to suggest that in the UK retail opticians' market chain-stores have a detrimental effect on the number of independent retailers in local markets. Two complementary explanations for this somewhat surprising finding are provided³⁷. Firstly, the national pricing strategies adopted by chain-stores would appear to dampen the impact their entry has on independents. Secondly, the results suggest that in this market chain-stores and independent retailers appeal to different segments of the market.

In particular, independents appeal more to both the elderly and higher earning consumers.

The first of these explanations implies that the chain-stores' decisions to adopt national pricing policies result in an increased variety of retailers and therefore may be beneficial to consumers. However, one explanation for national pricing strategies not allowed for in the theoretical literature so far, is the possibility that it facilitates price coordination, in particular by increasing price transparency³⁸. If this is the case in this market then the benefits to consumers from national pricing become far less clear. Consider the following description of pricing behaviour in the industry from the Office of Fair Trading:

"...local opticians typically base their pricing on the national decisions taken by Specsavers, which is described by the parties as well as by other multiples and independent industry reports as the market leader and, as a result of its aggressive pricing strategy, the principal price-setter".³⁹

Despite its pricing being described as aggressive, the national price set by the leading chain may in fact act as a focal price and facilitate coordination. Relatedly, Busse (2000) uses detailed price data to suggest that by setting identical prices across certain markets mobile telephone sellers in the US are able to establish focal prices and coordinate their actions. Whilst the evidence on firm numbers and market size in the UK opticians' market provides some evidence on the intensity of competition, it would be interesting to examine further whether national pricing aids coordination in this market.

The entry threshold results from the previous section also raise interesting questions about the strategic decision by a chain-store to operate numerous outlets within the same local market. This potentially raises local market concentration and may result in higher national prices even absent coordinated behaviour. Evidence on the timing of entry decisions in local markets, as used by Toivanen and Waterson (2005), would allow further consideration of strategic entry decisions.

Notes

¹Burt and Sparks (2003).

 2 See for example Daunfeldt *et al.* (2005), New Economics Foundation (2005) and House of Commons, All Party Small Shops Group (2006).

³See Davies *et al.* (2004, chapter 2) for a discussion of the impact deregulation had on competition.

⁴Figures from Fulop and Warren (1993) p. 267.

⁵Competition Commission (2000), para. 2.409, p. 90.

⁶Typically consumers make their main purchases from larger 'one-stop' stores with smaller stores receiving any residual demand. Consequently, Griffith and Harmgart (2008) model a large stores entry decision as independent of the number of smaller stores, with smaller stores then taking the number of larger stores as fixed.

⁷This requires the quality level of a chain-store to be sufficiently high (but not as high as independents) so that even consumers with the lowest marginal utility ($\underline{\alpha}$) choose to buy the product.

⁸See section 4.3 for a discussion of the impact of allowing chain-stores to set their quality level strategically.

⁹In the Dinlersoz model this cost function is not necessary for the results. However, the minimum efficient scale for chain-stores must be sufficiently greater that of the independent retailers (see Dinlersoz, 2004, p. 216). Under Cournot competition (see section 2.3) this allows the chain-stores to expand output as the market size increases. See section 2.4 for evidence supporting the assumed costs functions for the opticians' market. Furthermore,

once national pricing is introduced the predictions are unaffected by the specific chain-store cost function.

¹⁰It is straightforward to prove that N_I^*/S is decreasing in S, but at a decreasing rate.

¹¹Although increasing returns to scale are assumed (see note 9).

¹²OFT (2009), para. 22-3.

¹³See for example Fulop and Warren (1993) pp. 262-64.

¹⁴OFT (2009), para. 25.

 15 See OFT (2009), para. 31.

 ${}^{16}N_I^*/S$ is constant.

¹⁷http://www.yell.com

¹⁸In addition, in 2009 Dolland and Aitchison and Boots were allowed to merger by the Office of Fair Trading (see OFT, 2009).

¹⁹Figures from OFT (2009, para 39.) show that in recent years Optical Express has continued to gain market share whilst the four chain-stores have all lost market share. However, even by 2007 Optical Express still had a market share by value of 4.3%, which was over a third lower than the 4th largest chain (Boots) and therefore arguably still remains outside the main players.

 20 OFT (2009), para. 39.

 $^{21}\mathrm{UK}$ main media advertising expenditure on opticians and eye clinics in 2001, Keynote (2002).

 22 The definition of a chain-store will also be widened to check for robustness of the results, see note 26.

 23 For example Toivanen and Waterson (2005).

 24 See also note 26.

²⁵All variables are for 2001 except the wage data for 2005. Data Sources: Wage variable: Annual Survey of Hours and Earnings 2005, http://www.statistics.gov.uk/ downloads/theme_labour/ASHE_2005/2005_res_la.pdf. Rural variable: DEFRA Local Authority pre April 2009 classification (Only available for the 348 LADs in England), http://archive.defra.gov.uk/evidence/statistics/rural/rural-definition.htm. All other variables: Census 2001, http://www.statistics.gov.uk/census2001/census2001. asp

 26 This result is robust to various sensitivity tests: excluding Scrivens, Optical Express and Rayner outlets from the definition of independent retailers, excluding the largest 10% or 25% of markets, or excluding all London LADs.

²⁷Similar results are obtained if the old variable is included in place of log(Age). In addition, if either the density, travel or rural variables are included their coefficients were insignificant.

²⁸This can be seen in section 2 from (7) and noting that (10) shows that under local pricing p_c is decreasing in N_c . This is however no longer the case under national pricing.

²⁹In contrast, across the entire range of markets the number of independents is close to a continuous variable and therefore in section 4.3 OLS estimation was appropriate.

³⁰As shown in Table 8, the two markets with a single independent are included in a 1-2 independents category, and the 14 markets with 14-19 independents in a 13 or more category. Likewise, the 12 markets with 5-7 chain-store outlets are included in a 4 or more category. The entire range of possibilities from 0 to all 4 chain-store fascias in the market continue to be included in this sample.

³¹Unlike Bresnahan and Reiss (1991) this specification does not separately identify the determinants of variable profits and fixed costs (see Cleeren *et al.*, 2006).

³²Because the rural variable is only available for LADs in England this leaves a sample of 194 markets.

³³The income support variable was omitted since in all cases the coefficient was insignificant.

³⁴Similar results were obtained instead using a count of the number of chain-store fascias. In addition, we have also experimented by replacing these counts with a binary variable for whether a chain-store was present or instead, motivated by the discussion in section 6, a binary variable for whether Specsavers was present. Again the parameter capturing inter-type competition was insignificant.

³⁵This can also be confirmed by estimating the seemingly unrelated model.

³⁶This result is more significant when calculated (but not reported here) for the full sample of markets.

³⁷This finding is also supported by the OFT (2009, para 26) who conclude that there is no evidence to indicate that over time competition from chain-stores has lead to a reduction in the number of independent opticians. Evidence is even provided that the other opticians have gained market share at the expense of the four main players (para. 39).

³⁸A similar concern was also raised in a more recent Competition Commission investigation of the UK groceries market since, contrary to the period of the earlier investigation discussed in the introduction, most of the main players had by then adopted national pricing strategies (see Competition Commission (2008), paras. 4.98 and 8.25).

³⁹OFT (2009), para. 31.

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Table 1: The largest multi-store opticians in England and Wales

Retailer	Number of outlets
Specsavers	412
Dolland and Aitchison	338
Boots	271
Vision Express	169
Scrivens	105
Optical Express	104
Rayner	97
Batemans	54
Leightons	41
Others	4633
	6224

Retailer	Number of regions in which		
	1 or more outlet	3 or more outlets	
Specsavers	10	10	
Dolland and Aitchison	10	10	
Boots	10	10	
Vision Express	10	10	
Scrivens	7	7	
Optical Express	10	9	
Rayner	9	7	
Batemans	2	2	
Leightons	4	3	

Table 2: Retailer presence across regions of England and Wales

Table 3: The number of opticians' outlets by LAD market

	Mean	Std Dev	Min	Max
Total	16.73	13.82	1	161
Chain-store fascias	1.90	1.31	0	4
Chain-store outlets	3.20	2.40	0	21
Inds	13.53	12.17	1	140
Specsavers	1.11	0.81	0	5
Dolland and Aitchison	0.91	1.04	0	9
Boots	0.73	0.71	0	4
Vision Express	0.45	0.55	0	3

Table 4: Markets with and without chain-store outlets

N Chain-stores	LAD Mkts	Mean	Min	Max	Std Dev
> 0	329	147614	25949	977087	93822
0	42	75216	24457	121024	24862
All	371	139418	24457	977087	91649

Table 5: Description of demographic variables

Variable	Description
Population	LAD population (number of people)
Density	Number of people per hectare
Age	Mean age of LAD population (years)
Old	% of the population 65+ years old
Wage	Mean weekly wage of LAD population excluding overtime (\pounds)
Inc support	% of LAD population claiming income support
Travel	% of people working in the LAD that travel 20+km to work
Rural	% of the population living in rural areas (incl. large market towns)

	Mean	Std Dev	Min	Max
Population	139418	91669	24457	977087
Density	13.44	19.75	0.23	131.02
Age	39.28	2.30	31.75	46.85
Old	16.62	3.16	8.95	29.58
Wage	410.19	93.5	237.4	1136.5
Inc support	0.061	0.024	0.019	0.150
Rural	38.02	36.63	0	100
Travel	11.69	4.37	2.83	31.74

Table 6: Descriptive statistics for demographic variables

Table 7: The relationship between the number of independent outlets and market size

	$\log(NInds)$
Constant	-20.720***
	(2.092)
$\log(Population)$	1.083^{***}
	(0.049)
$\log(Age)$	2.020***
	(0.414)
$\log(Wage)$	0.455^{***}
	(0.121)
Inc support	4.433***
	(1.066)
N	329
$AdjR^2$	0.705

***Significantly different from 0 at 1% level, ** significantly different from 0 at 5% level and * significantly different from 0 at 10% level. Standard errors in parenthesis.

Inds	Freq.	Chain-store	Freq.	Chain-store	Freq.
		outlets		fascias	
≤ 2	7	0	42	0	42
3	11	1	43	1	48
4	13	2	43	2	52
5	23	3	34	3	27
6	20	≥ 4	44	4	37
7	29				
8	30				
9	16				
10	15				
11	9				
12	14				
≥ 13	19				
Total	206		206		206

Table 8: The number of independents and chains in the smallest 206 markets

	I		I	[I	Ι
	Chain		Chain		Inds	
	-store		-store			
	outlets		fascias			
Log (Population)	1.375***	(0.298)	1.348***	(0.298)	2.264***	(0.292)
Log(Wage)	-1.878***	(0.562)	-1.753***	(0.562)	2.063***	(0.532)
Old	0.003	(0.030)	0.022	(0.030)	0.125^{***}	(0.029)
Rural	-0.011***	(0.002)	-0.012***	(0.002)	-0.001	(0.002)
Log(Travel)	0.094***	(0.023)	0.102***	(0.023)	-0.025	(0.020)
λ_1	3.950	(4.361)	4.730	(4.372)		
λ_2	4.625	(4.365)	5.479	(4.376)		
λ_3	5.285	(4.367)	6.309	(4.380)	37.572	(4.556)
λ_4	5.922	(4.368)	6.861	(4.382)	38.152	(4.561)
λ_5					38.558	(4.568)
λ_6					39.062	(4.581)
λ_7					39.442	(4.592)
λ_8					39.912	(4.604)
λ_9					40.373	(4.617)
λ_{10}					40.656	(4.623)
λ_{11}					40.976	(4.630)
λ_{12}					41.214	(4.635)
λ_{13}					41.642	(4.646)
N		194		194		194
Log-L		-276.605		-270.860		-422.620
Pseudo \mathbb{R}^2		0.112		0.122		0.095

Table 9: Separate ordered probit results for chains and independent retailers

***Significantly different from 0 at 1% level, ** significantly different from 0 at 5% level and * significantly different from 0 at 10% level. Standard errors in parenthesis.

	Chain-store		Inds	
	outlets			
Log(Population)	1.379***	(0.298)	2.471***	(0.377)
Log(Wage)	-1.897***	(0.563)	1.650***	(0.496)
Old	0.003	(0.030)	0.124***	(0.029)
Rural	-0.011***	(0.002)		
Travel	0.096^{***}	(0.023)		
γ			-0.096	(0.160)
λ_1	3.917	(4.360)		
λ_2	4.590	(4.364)		
λ_3	5.253	(4.367)	37.286	(4.496)
λ_4	5.890	(4.367)	37.876	(4.502)
λ_5			38.282	(4.508)
λ_6			38.782	(4.520)
λ_7			39.159	(4.530)
λ_8			39.626	(4.542)
λ_9			40.084	(4.554)
λ_{10}			40.365	(4.560)
λ_{11}			40.681	(4.566)
λ_{12}			40.918	(4.571)
λ_{13}			41.347	(4.582)
ρ			0.045	(0.180)
Log-L				-699.720
Ν				194

Table 10: Bivariate ordered probit results assessing the impact of the number of chain-store outlets on independents

***Significantly different from 0 at 1% level, ** significantly different from 0 at 5% level and * significantly different from 0 at 10% level. Standard errors in parenthesis.

	Chain-store		Inds	
	fascias			
Log(Population)	1.314**	(1.793)	2.310***	(0.282)
Log(Wage)	-1.906***	(0.651)	1.737***	(0.470)
Old			0.130***	(0.027)
Rural	-0.011***	(0.002)		
Travel	0.093***	(0.023)		
γ	0.024	(0.228)		
λ_1	3.967	(4.336)		
λ_2	4.639	(4.337)		
λ_3	5.300	(4.337)	36.559	(4.393)
λ_4	5.937	(4.335)	37.151	(4.340)
λ_5			37.557	(4.407)
λ_6			38.055	(4.419)
λ_7			38.431	(4.430)
λ_8			38.898	(4.442)
λ_9			39.356	(4.455)
λ_{10}			39.636	(4.462)
λ_{11}			39.951	(4.468)
λ_{12}			40.187	(4.473)
λ_{13}			40.616	(4.484)
ρ			-0.076	(0.242)
Log-L				-699.899
Ν				194

Table 11: Bivariate ordered probit results assessing the impact of the number of independents on chain-store outlets

***Significantly different from 0 at 1% level, ** significantly different from 0 at 5% level and * significantly different from 0 at 10% level. Standard errors in parenthesis.

Table 12: Chain entry threshold ratios

	Chain-store	Chain-store
	outlets	fascias
1 to 2	0.817^{*}	0.871
2 to 3	1.078	1.234
3 to 4	1.192	1.129

^{***}Significantly different from 1 at 1% level, ** significantly different from 1 at 5% level and * significantly different from 1 at 10% level.

	Independents
3 to 4	0.969
4 to 5	0.957
5 to 6	1.041
6 to 7	1.014
7 to 8	1.077^{*}
8 to 9	1.090^{*}
$9\ {\rm to}\ 10$	1.020
10 to 11	1.047
11 to 12	1.018
12 to 13	1.115^{*}

Table 13: Independent entry threshold ratios

***Significantly different from 1 at 1% level, ** significantly different from 1 at 5% level and * significantly different from 1 at 10% level.