

Watson, Randal

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## Product variety and competition in the retail market for eyeglasses

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THE CENTER FOR THE STUDY  
OF INDUSTRIAL ORGANIZATION  
AT NORTHWESTERN UNIVERSITY

Working Paper #0047

Product Variety and Competition in the Retail  
Market for Eyeglasses

By

Randal Watson\*  
University of Texas at Austin

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## **Abstract**

I use an original dataset on the display inventories of several hundred eyewear retailers to study how firms' product-range choices depend on separation from rivals in geographically-differentiated markets. A two-stage estimation approach is used to model firms' initial location decisions and their subsequent choices of product variety. Per-firm variety varies non-monotonically with the degree of local competition. Holding fixed the total number of rivals in a market, a retailer stocks the widest variety when it is near a few other competitors. Firms with four or more rivals show substantially smaller product ranges. This suggests that business-stealing eventually dominates any clustering effects when there is intense competition in a neighbourhood.

# 1 Introduction

This paper is an empirical examination of how firms compete in the variety of products that they offer to consumers. Consider a retail market in which each store sells many horizontally differentiated varieties of a single class of good, for example, music CD's, books, clothes, or video rentals. Consumers in such markets typically have idiosyncratic preferences over the different available styles of the good. They may need to search across multiple retailers to find the outlet that sells their preferred combination of style and price, in which case they are naturally drawn to sellers with a broader range of available varieties. A store's choice of product variety is then a strategic variable, depending endogenously on the variety choices of its competitors. Thus a music store manager choosing whether to add CD's to his stock weighs the costs of additional inventory and display space against the increased probability that customers find a good match for their musical tastes here, rather than at a rival outlet elsewhere.

When consumer preferences are not directly observable, the choice of optimal inventory size in such situations may become a matter of (costly) speculation. For example the Blockbuster video rental chain reportedly spent 50 million dollars in the late 1990's on a marketing experiment that drastically increased inventories at outlets in six test markets. Management guessed that extra video tapes in stores might substantially raise revenues by matching more customers with their most desired movies. Results from the pilot project subsequently encouraged Blockbuster to implement a new business model based on expanded retail inventories and revenue sharing with movie studios.<sup>1</sup> In that particular case the key to improving the store-level availability of good matches to consumer tastes may have been the depth of inventory in popular movie titles. However the breadth of retail inventory is no doubt also an important element in such calculations. Throughout this paper I focus on this breadth variable, measured as the number of different styles of a good on display at each outlet. I use the terms 'product variety' and 'product range' to denote this measure of inventory coverage.<sup>2</sup>

How then does a retail manager adjust his product range if a new rival opens next door? What if the rival is three miles away? Does the incum-

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<sup>1</sup>Redstone (2001).

<sup>2</sup>Note that terms like product range are not meant to connote distances in an explicit space of product characteristics. Rather they refer to the number of different product lines carried by a retailer. Strategic choices of product ranges can also be thought of as competition in product availability – on the latter see Dana (2001) and Aguirregabiria (2003).

bent's response depend upon the number of other competitors already in place? Using original data the present study aims to provide answers to these questions in a particular context: the retailing of eyeglasses. I apply a two-stage model of competition among eyewear sellers to a sample of markets in the Midwestern U.S. In the first stage the entry behaviour of sellers in each market is modeled using Seim's (2001, 2004) framework for endogenous location choice. The second stage then shows how sellers' product-range choices depend upon the resulting configurations of competitors in each market. As in Mazzeo (2002b), estimates from the first stage provide corrections for the endogeneity of seller locations in the second stage.

Eyeglasses were chosen for analysis firstly because they are usually (but not always) sold at businesses dedicated to eyecare. The potential statistical interference from a store's other lines of business is thereby minimized; this interference could be a problem if, for example, books or CD's were under study. Second, eyewear sellers typically stock hundreds of different styles of spectacle frames, reflecting heterogeneity in consumer tastes for colour, shape and construction. A measure of the number of different frame styles in a seller's display inventory can then be used as an indicator of product variety.<sup>3</sup>

The estimation results indicate that the baseline effect is for this measure of product variety to fall when the distance to rival sellers is reduced. This may be interpreted as reflecting the loss of customers to the closer competition. However this response is significantly less negative when the incumbent faces relatively little local competition, with few or no proximate competitors. All else equal, the widest per-seller variety might be at stores which have two or three rivals nearby, rather than at local monopolies. Such groups of nearby sellers may make customers 'more choosy', leading each shop to boost variety. Furthermore the increased variety and lower search costs at a retail cluster could induce consumers to switch purchases to this location from elsewhere in the market, giving firms there a further incentive to expand their product ranges. Thus the evidence is consistent with a limited agglomeration incentive in firms' locational choices.<sup>4</sup>

The existing empirical literature on product-variety competition is fairly sparse. A reduced-form study in the marketing literature is Bayus and Putsis (2000), who analyze the determinants of additions to, and deletions

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<sup>3</sup>Previous empirical studies which analyze other aspects of the eyecare industry include Benham (1972), Kwoka (1984), and Haas-Wilson (1989).

<sup>4</sup>For theoretical analyses of clustering by single-variety firms see, e.g., Wolinsky (1983), Dudey (1990), Konishi (1999), and Fujita and Thisse (2002, Ch. 7). I am not aware of any equivalent spatial analyses for multi-variety firms.

from, the product lines of personal-computer makers. Draganska and Jain (2003) is a more structural marketing analysis. Studying the retailing of yoghurt, they introduce choices of product range (number of flavors) into a differentiated-goods model of interfirm competition. Berry and Waldfogel (2001) examine variety choices in radio broadcasting. They ask how the product range in local radio markets – measured as the number of different programming formats on air – is affected by mergers.<sup>5</sup>

Like Berry and Waldfogel, Alexander (1997) also looks at the relationship between product variety and industry concentration, basing his analysis on changes over several decades in a measure of variety in recorded popular music. As in the present study he finds a non-linear relationship, with variety reaching a maximum at medium levels of concentration and declining thereafter. Since Alexander uses market-level measures of variety and concentration, his focus is somewhat different to that of the present analysis.<sup>6</sup> The aim here, in contrast with the work of Alexander and the other authors mentioned above, is to elicit the relationship between product range and differentiation from the competition. I model explicitly each firm’s strategic choice of location, and then relate a measure of its product range to distance from rival sellers. This approach gives a richer picture of the competitive effects than if competition is measured by a market-level quantity, e.g., a concentration index, or total number of entrants, as in Berry-Waldfogel, Alexander or Bayus-Putsis. My results suggest that distance from rivals is indeed an important element of variety competition.

The spatial element in retail competition has recently been examined in several other studies, e.g., Thomadsen (2002), Manuszak (2000), and Davis (2001). These studies take firms’ locations as given. Thanks to the entry model of Seim (2004) the following analysis is able to address spatial competition in a model with endogenous firm locations. As far as I am aware this combination of Seim’s strategic location framework with information about firms’ post-entry interactions is novel in this literature. Collecting the data needed to effect this combination was a non-trivial task, involving visits to several hundred widely separated eyewear sellers. While time-consuming, this approach gives the researcher much greater control over sources of measurement error than would be possible with, for example, a mail survey.

The next section introduces an intuitive analysis of the behaviour of firms and consumers in a theoretical eyewear market. This discussion is not

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<sup>5</sup>See also Israelevich (2002). A simulation approach based on data from a small cross-section of video rental stores is de Palma et al. (1994).

<sup>6</sup>Furthermore Alexander holds market concentration to be exogenously determined. Market structure is endogenous in this paper.

rigorous; rather it is intended as a useful reference point for interpreting the results of the subsequent product-variety regressions. Section 3 outlines the econometric model, accounting in particular for endogeneity in the variables measuring proximity to rival sellers. The data are explained in section 4 and estimates of firm-level variety equations are in section 5. Section 6 incorporates indicators of chain affiliation into the variety regressions, and section 7 concludes.

## 2 Variety and spatial differentiation

I hypothesize that interfirm distances affect product-range choices because these distances are related to consumer travel costs. It is convenient to think of this relationship in search-theoretic terms. Assume that different varieties of eyeglasses are a horizontally differentiated good, in the sense that consumers have an i.i.d. idiosyncratic taste for each frame style on display at a seller. Suppose that consumers *ex ante* do not know their individual tastes for the product varieties stocked by any seller; nor do they observe *ex ante* any seller's prices. Instead they must learn this information in a process of sequential search, visiting sellers in turn until they find an acceptable combination of price and (customer-specific) quality. The cost of searching at a shop is the cost of traveling to that location, which is increasing in distance.

Consumer preferences of this type would affect firms' variety choices in two ways. First, holding the actions of all other firms constant, a seller's product range is increasing in the number of consumers who visit the store. At a given price extra visitors raise the probability of sale (and therefore the marginal revenue) of any variety in stock. Second, for a fixed number of visitors a seller's product range is decreasing in consumer search costs. Higher search costs reduce the reservation value of anyone who arrives at this seller: they make visitors 'less choosy' about the seller's inventory. In the present context the search cost that enters the seller's variety optimization is the distance the customer would have to travel to visit the next alternative seller. As this distance increases so rises the consumer's opportunity cost of rejecting all varieties at the current seller and switching to the alternative store.<sup>7</sup>

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<sup>7</sup>On the cost side I assume that retailers at all locations face the same marginal cost (uniform across all varieties) of buying frames from manufacturers. In addition to this per-pair purchase cost there is a per-variety fixed cost of inventory (constant across varieties). This could be the rental cost of the extra retail space required to display additional varieties.

In the empirical analysis to follow a market corresponds to a medium-sized town comprising a finite number of spatially distinct retail locations. Consider then a setting in which a seller A has sole occupancy of one of these locations and other sellers are distributed in asymmetric clusters across the other sites in the market.<sup>8</sup> Suppose that an entirely new seller B enters the market at the same location as A. For simplicity we will assume that this incremental change in the number of sellers does not affect the total number of consumers in the market who are searching for spectacles.

Three effects may then be imagined in the move to a new equilibrium. Half of A's previous visitors now go first to B instead; some of this group stop their search at B, and therefore A gets fewer visitors:

- a. (*business-stealing within location*) the incumbent gets a smaller share of the existing number of visitors to this location, and so reduces its product variety.

On the other hand visitors to A now have a better alternative option because there is a new competitor in close proximity (meaning lower costs of switching to the next seller). Therefore:

- b. (*reduced search costs*) visitors are 'more choosy' about the varieties on display and so the incumbent raises its product variety.

Finally it seems reasonable to suppose that the entry of B will overall make this location a more desirable destination for shoppers, as the heightened competition feeds into lower prices and/or an increase in the *aggregate* variety of frames available here. In this case the entry of B may attract new visitors to this location from elsewhere in town:

- c. (*business-diversion across locations*) the location gets more visitors overall, and so the incumbent raises its product variety.

The net effect of this change ('plus (b) plus (c) minus (a)') will depend upon the specifics of the market.<sup>9</sup> An empirical finding of reduced variety in response to new entry suggests that (a) dominates the combined effect of (b) and (c), and *vice versa*. If no variety response is apparent it may be that none of the above effects is of significant magnitude, or that the effects are significant but cancel each other out. In an alternative scenario

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<sup>8</sup>In the data the number of sellers per market ranges from 4 to 23, with a mean of 13.

<sup>9</sup>B's entry also affects the variety at sellers elsewhere in town, which in turn may affect the search behaviour of visitors to A/B. I am treating such effects as second-order issues.



where B entered at some other location in town, there would be no intra-location business stealing. Effects (b) and (c) would still operate, this time in opposite directions, because some previous visitors to A could be diverted to B’s new location. Which effect dominates is again an empirical issue to be resolved by the data.

### 3 An empirical framework

The geographic markets in this study are 44 medium-sized towns (or groups of adjacent towns) in six Midwestern states.<sup>10</sup> As in Seim (2004), Census tracts are used to define the set of possible retail locations (or ‘cells’) in each market. For simplicity all stores and other features of a tract are assumed to be located at its population-weighted centroid.<sup>11</sup>

Let  $V_{mki}$  denote the equilibrium number of varieties of a good sold by the  $i$ -th firm when it is located in cell  $k$  of market  $m$ . Here  $V_{mki}$  is measured as the number of different styles of spectacle frames on display at each eyewear seller. It is assumed that the logarithm of  $V_{mki}$  is determined by the following reduced-form relationship:

$$\ln V_{mki} = \mathbf{Z}_{mki}\alpha + g(\mathbf{C}_{mk}, \psi) + \tau_m + \rho_{mk} + \omega_{mki} , \quad (1)$$

for  $m = 1, \dots, M$ ,  $k = 1, \dots, K_m$ ,  $i = 1, \dots, N_m$ , where  $M$ ,  $K_m$  and  $N_m$  are respectively the total number of markets, the number of cells in market  $m$ , and the number of sellers in market  $m$ . The vector  $\mathbf{Z}_{mki}$  contains exogenous demographic and location characteristics for cell  $mk$ ; for example, median age of residents, population within one mile, number of shopping malls within one mile. In some specifications it might also contain market-level variables and store-specific characteristics such as chain affiliation. Parameters in  $\alpha$  capture the effects of variables in  $\mathbf{Z}_{mki}$  on a firm’s choice of variety.

The function  $g(\cdot)$ , with parameters  $\psi$ , captures the effect of competition on firm  $i$ ’s profits. Here  $\mathbf{C}_{mk}$  is a vector classifying firm  $i$ ’s competitors according to their distance from cell  $mk$ . For simplicity I use just two classifications (or ‘distance bands’), setting  $\mathbf{C}_{mk} = (C_{mk}^1, C_{mk}^2)$ , where  $C_{mk}^1$

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<sup>10</sup>Illinois, Indiana, Iowa, Michigan, Minnesota, Ohio. These states were chosen for convenience of access, rather than as a random sample. The econometric inferences below are confined to the behaviour of businesses in these states only.

<sup>11</sup>Census tracts are non-overlapping irregular polygons defined to correspond roughly to a neighborhood or locale. Each tract usually contains three to five thousand inhabitants. The markets in the present data each contain 22 tracts on average.

is the number of rival sellers within one mile and  $C_{mk}^2$  is the number of rivals more than a mile away. With  $\mathcal{I}(\cdot)$  representing the indicator function, the effects of competition are specified as:

$$g = C_{mk}^1\psi_1 + C_{mk}^2\psi_2 + \psi_3\mathcal{I}(C_{mk}^1 > 0) + \psi_4 \{ \mathcal{I}(C_{mk}^1 > 1) + \mathcal{I}(C_{mk}^1 > 2) \} . \quad (2)$$

In this specification  $\psi_1$  and  $\psi_2$  respectively measure the baseline effects of an extra nearby or distant rival on a firm's product variety. Non-linear responses to the number of nearby competitors are allowed for in the terms  $\psi_3$  and  $\psi_4$ . These respectively show the extra effects on  $V_{mki}$  exerted by the closest rival and the second and third closest rivals. To illustrate, suppose that a firm initially operates alone at a particular location in a market, with no rivals in band 1. Let this firm subsequently be joined by other sellers, relocating from elsewhere in town. The incumbent's variety changes by  $\psi_1 + \psi_3 - \psi_2$  in response to the first such relocater, and by  $\psi_1 + \psi_4 - \psi_2$  in response to each of the next two. Any further relocations change variety by  $\psi_1 - \psi_2$ . Thus product variety may respond non-monotonically to changes in the degree of local competition.

Unobserved market-level effects are represented by  $\tau_m$ : these will be folded into a full set of market dummies, when such are included in the regression. These dummies would also absorb the effects of any market-level observables, and also the sums of some tract-level variables. For example the elements of the competition measure  $\mathbf{C}_{mk}$  sum to the same number  $N_m - 1$  at all tracts  $k$  in each market. (Some of the elements of  $\mathbf{Z}_{mki}$  will be seen to have the same property.) Then with market dummies included and  $g$  as in (2), the parameters  $\psi_1$  and  $\psi_2$  are not separately identified. Instead their difference is identified, by rewriting  $C_{mk}^1\psi_1 + C_{mk}^2\psi_2$  as

$$C_{mk}^1(\psi_1 - \psi_2) + \psi_2(N_m - 1) .$$

Note that  $\psi_3$  and  $\psi_4$  will be identified whether or not market dummies are included.

The terms  $\rho_{mk}$  and  $\omega_{mki}$  are unobserved error components specific to the cell and the seller, respectively. In competition models of this kind it is well known that these errors could be correlated with factors determining the market configuration represented by  $\mathbf{C}_{mk}$ . To deal with the resulting endogeneity problem I use sample-selection corrections similar to those introduced to the entry literature by Mazzeo (2002b), borrowing the framework of Seim (2004) to model a preliminary entry stage, in which all sellers simultaneously choose their locations in the market.<sup>12</sup>

<sup>12</sup>Since some cells only contain one seller it is not possible to use dummy variables to

Seim models firms' locations as arising from symmetric equilibrium in a game of simultaneous moves under incomplete information. Treat  $N_m$ , the total number of sellers in a market, as exogenous to the selection of locations. Write the profits of firm  $i$ , conditional on locating in cell  $mk$ , as:

$$\Pi_{mki} = \mathbf{X}_{mk}\beta + f(\mathbf{C}_{mk}, \theta) + \epsilon_{mki} . \quad (3)$$

Here the vector  $\mathbf{X}_{mk}$ , with parameters  $\beta$ , is some superset of the exogenous demographic and locational characteristics in  $\mathbf{Z}_{mki}$ . (It does not contain any of the firm-specific characteristics in  $\mathbf{Z}_{mki}$ .) The function  $f$  represents the effects of competition on a firm's profits. As a variation on Seim's model I allow for non-linearities in this competition relationship, giving  $f$  exactly the same form as  $g$  in (2), with  $\theta$  replacing  $\psi$ .

Unobserved profit components specific to entrant  $i$  and cell  $mk$  are represented by  $\epsilon_{mki}$ , which is assumed to follow an extreme-value distribution, i.i.d. across  $mki$ . Thus  $\epsilon_{mki}$  is a firm's privately observed type. Given the distribution of these types, the equilibrium probability with which firm  $i$  locates in cell  $mk$  is implicitly defined by

$$p_{mk}^* = \frac{\exp[\mathbf{X}_{mk}\beta + \hat{f}_{mk}]}{\sum_{l=1, \dots, K_m} \exp[\mathbf{X}_l\beta + \hat{f}_{ml}]} , \quad (4)$$

for  $m = 1, \dots, M$ ,  $k = 1, \dots, K_m$ . Here  $\hat{f}_{mk} \equiv \hat{f}(\mathbf{C}_{mk}, \theta)$  denotes an expectation of  $f$  formed over the possible realizations of  $\mathbf{C}_{mk}$ . (This expectation thus itself depends on the probabilities  $p_{mk}^*$ .) The estimation procedure is to find numerically the probabilities which solve (4) in each market  $m$ , and nest these fixed points in a maximum likelihood routine.

Two restrictions in this model are of particular relevance to the regression in (1). First, the specification of profits in (3) abstracts away from any observable differences (e.g., type of premises) between firms who locate in the same cell in a market. Introducing such differences would complicate the estimation and identification of the model; hence I maintain the assumption that, conditional on location, firms share the same values for the observables. Consistency between the two stages of the model suggests that the same restriction be applied in (1). Thus in my baseline specification  $\mathbf{Z}_{mki}$  loses subscript  $i$ , and excludes store-specific characteristics such as location inside or outside a particular department store or shopping centre. Section 6 relaxes this restriction (at the risk of introducing some endogeneity) by including chain-store dummies in  $\mathbf{Z}_{mk}$ .

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absorb the effects in  $\rho_{mk}$ .

Second, for reasons of computational tractability the entry model at present does not admit tract-specific profit effects that are common to all firms at a location but unobservable to the econometrician. Since this restriction conflicts with the presence of  $\rho_{mk}$  in the second-stage model, it is necessary to assume that the latter error is mean independent of all observables (including  $\mathbf{C}_{mk}$ ) on the RHS of (1). This would be the case, for example, if any such tract-specific shared effects are only observable to firms after they have chosen their locations.<sup>13</sup>

To model the endogeneity of  $\omega_{mki}$  I restrict this error term to be correlated only with  $\epsilon_{mki}$ . Specifically  $\omega_{mki}$  is assumed to be independent of the  $\epsilon_{mli}$  for any other cell  $l$ ,  $l \neq k$ , and independent of the  $\epsilon$ 's for any other firm. These assumptions imply that, conditional on the observables,  $\omega_{mki}$  is uncorrelated with the location chosen by any other firm in the first period. Let  $\epsilon_{mi} \equiv (\epsilon_{m1i}, \dots, \epsilon_{mKi})$ , and let  $\epsilon_m \equiv (\epsilon_{m1}, \dots, \epsilon_{mN_m})$  be the  $N_m K$ -vector of all entrants' idiosyncratic profit terms. For the rest of this section it will be convenient to drop the market subscript  $m$  unless otherwise stated. Then let  $B_{ki}$  be the set of  $\epsilon_i$  such that firm  $i$  chooses cell  $k$ , where the conditioning of this set on the exogenous observables  $N$  and  $(\mathbf{X}_1, \dots, \mathbf{X}_K)$  is left implicit. Also let  $A_{ki}(\mathbf{C}_k)$  be the set of  $\epsilon$  such that  $i$  chooses cell  $k$ , and such that  $C_k^1$  rivals locate in band 1 and  $C_k^2$  are in band 2.

Assume for the present that the  $\tau$  terms are absorbed into a set of market dummies in  $Z_k$ , and rewrite (1) as:<sup>14</sup>

$$\ln V_{ki} = \mathbf{Z}_k \alpha + g(\mathbf{C}_k, \psi) + \text{E}[\omega_{ki} \mid \epsilon_i \in B_{ki}] + \eta_{ki} + \rho_k, \quad (5)$$

where

$$\begin{aligned} \eta_{ki} &\equiv \omega_{ki} - \text{E}[\omega_{ki} \mid \epsilon_i \in B_{ki}] \\ &= \omega_{ki} - \text{E}[\omega_{ki} \mid \epsilon \in A_{ki}(\mathbf{C}_k)]. \end{aligned} \quad (6)$$

The second equality in (6) follows from the assumed independence of  $\omega_{ki}$  and  $\epsilon_j$ ,  $j \neq i$ . It follows that

$$\text{E}[\eta_{ki} \mid \mathbf{C}_k] = \text{E}[\omega_{ki} \mid \epsilon \in A_{ki}(\mathbf{C}_k)] = 0.$$

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<sup>13</sup>Within-tract correlation in  $\epsilon_{mki}$  would put us in a world where firms are partially informed about each other's unobservables. In the present context  $K_m$ , the number of locations in a market, is too large for such a model to be tractable – see Mazzeo (2002a). Readers are referred to Seim (2004) for further exposition of the original entry model, and to Watson (2004) for details of computation and identification pertinent to the application here.

<sup>14</sup>Conditioning on  $\mathbf{Z}_k$  is left implicit.

For the conditional expectation in (5) write

$$\begin{aligned} E[\omega_{ki} \mid \epsilon_i \in B_{ki}] &= E[E[\omega_{ki} \mid \epsilon_i] \mid \epsilon_i \in B_{ki}] \\ &= E[E[\omega_{ki} \mid \epsilon_{ki}] \mid \epsilon_i \in B_{ki}] , \end{aligned}$$

where the second equality follows from the fact that  $\omega_{ki}$  and  $\epsilon_{li}$  are independent,  $l \neq k$ . Adopting a linear specification for the inner expectation we get

$$E[\omega_{ki} \mid \epsilon_i \in B_{ki}] = aE[\epsilon_{ki} \mid \epsilon_i \in B_{ki}] , \quad (7)$$

where  $a$  is a parameter. The conditional expectation for the error in a multinomial logit model is known to be:

$$E[\epsilon_{ki} \mid \epsilon_i \in B_{ki}] = \gamma - \ln p_k^* ,$$

where  $\gamma \approx 0.577215$ .<sup>15</sup> After substitution for (7) equation (5) then becomes

$$\ln V_{ki} = \mathbf{Z}_k \alpha + g(\mathbf{C}_k, \psi) + a(\gamma - \ln p_k^*) + \eta_{ki} + \rho_k . \quad (8)$$

To operationalize (8) I use the consistent estimates of  $p_k^*$  obtained from the first-stage estimation.

By construction the composite error  $\eta_{ki} + \rho_k$  in (8) is mean-independent of the explanatory variables. It may be heteroscedastic, through  $\eta_{ki}$ , and also correlated across firms in the same tract, because of the group effect  $\rho_k$ . I estimate (8) by OLS and then base the hypothesis tests on an estimated covariance matrix that is robust to heteroscedasticity and correlation within clusters: see Wooldridge (2002, p.152).

Seim's original framework for the entry model adds an equation which determines the number of firms per market as a function of  $(\mathbf{X}_{m1}, \dots, \mathbf{X}_{mK})$  and a market-level unobservable profit effect  $\xi_m$ . Since  $\xi_m$  is assumed independent of the  $\epsilon_m$ 's the selection of  $N_m$  is still exogenous w.r.t firms' choices of location. If the determination of  $N_m$  is modeled in this way there is an alternative treatment of the market-level effect  $\tau_m$  in (1). Its conditional expectation can be modeled as a linear function of  $\xi_m$  (similar to (7)), with parameter  $b$ . Then the term  $b\xi_m$  is added to (8), and in the estimation  $\xi_m$  is replaced by its first-stage estimate  $\hat{\xi}_m$ . Below I report estimates for both this specification and the dummy-variable treatment of  $\tau_m$ . The former is more restrictive, but has the advantage of separately identifying the effects on variety of market-level variables. In particular the competition parameters  $\psi_1$  and  $\psi_2$  can be separately identified when  $\tau_m$  is treated in this way.<sup>16</sup>

<sup>15</sup>See, e.g., Dubin and McFadden (1984).

<sup>16</sup>See Seim (2004) for details of the equation determining  $\xi_m$ .

## 4 Data

Similar criteria to those in Seim (2004) are used to define the set of markets. A town or group of towns was initially included in the sample if it comprised a continuous built-up area with total population in the range 25,000–200,000, located entirely within (one or more of) the six states under study. I dropped a market from this set if any one of its principal business centers was less than 20 miles from a business center in a separate built-up area of population 25,000 or greater. Thus the sample excludes markets close to big metropolises in favour of regional centers at least 20 miles from the next major town.<sup>17</sup> Within each market a Census tract is counted in the set of possible locations if its population-weighted centroid is within ten miles of the center of the market’s main urban area. Table 1 lists all the markets in the study area and table 2 summarizes some of their characteristics.

Table 3 classifies the 572 sellers of eyeglasses in the 44 sample markets by category of outlet.<sup>18</sup> Most (467) are ‘specialist’ sellers, operating out of premises dedicated to eyecare, i.e., in their own shopfront or professional office, but about 18% are located inside large department stores (or ‘discount’ stores).<sup>19</sup> A small number of the specialist sellers are opticians; a somewhat larger number operate out of the offices of ophthalmologists (MD’s). The remaining outlets, comprising about 80% of the total (including all premises inside department stores), provide eyecare through an optometrist.

Like department-store optical shops, around 20% of specialist sellers are linked by their chain identity (Lenscrafters, Pearle Vision, etc.) to outlets in a number of other markets in the sample – see table 4. For reasons of tractability the entry model abstracts away from such links, assuming that every separate outlet makes a location decision independent of that for any other shop. This means that sister outlets operating in the *same* market are also treated independently. Pairs (and triples, etc.) of such outlets are unusual in the data – about 90% of shops in the sample have no such sister operation in the same market. Developing the econometric techniques to account for such links in the entry model is a useful topic for future work.

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<sup>17</sup>The Rand McNally Marketing Atlas (2001) was used to define built-up areas and locate business centers.

<sup>18</sup>Sellers were initially located from listings in telephone directories (American Business Disk, [www.yahoo.jp.com](http://www.yahoo.jp.com)), and were then telephoned to confirm location and current operation.

<sup>19</sup>There are six such stores: Sears, JC Penney, Shop Ko, Super Target, and two kinds of Walmart – ordinary Walmart and Walmart Supercenter.

Over the summer of 2001 I visited each market to conduct an in-person survey of the variety of spectacle frames stocked by sellers. This survey concentrated on obtaining inventory data from a randomly chosen 50% of the sellers in each market. In the 11 Illinois markets the survey aimed for 100% coverage, resulting in a target subsample of 342 out of 572 total sellers. Tables 3 and 4 categorize this subsample into the different classes of seller defined above. At each of these businesses the measure of product variety is a simple count (usually done by the author) of the number of different frames on display for adult prescription lenses (excluding sun glasses and safety glasses). About 5% of the observations in the frames subsample are missing due to seller non-response. For any such outlet the number of frames is imputed to be the average for similar sellers in the same town.

Tables 5 and 6, and figure 1, summarize the numbers of eyeglass frames stocked by each kind of seller in the subsample. From the figure the distribution of frame counts appears to be approximately log normal. Specialist eyecare chain stores have the broadest product variety, while department stores typically have low variety. The main distinction in specialists' qualifications, between optometrists and ophthalmologists, does not appear to produce major differences in the variety distribution. In the entry stage this distinction in qualifications is allowed for by including the number of ophthalmology practices in each Census tract as an explanatory variable. This is something of a stylization as in reality at most one seller is attached to any given ophthalmologist – the implicit assumption is that proximity to these MD's exerts the same influence on the product variety of all sellers in a tract. Since independent opticians are few in number I regard them as identical to optometrists for estimation purposes.

Department-store sellers exhibit not only low variety in absolute terms, but also low variation in display inventories from store to store. The interquartile range in the product variety of department stores as a group is about 27% of their median, compared with 60% for the specialist eyecare outlets. Moreover department-store inventories are even more tightly distributed when viewed at the individual brand level: the two most widespread sellers, Sears and Walmart Supercenter, respectively have proportional interquartile ranges of 20% and 10%. This suggests that department stores, whether for reasons of marketing or cost control, value uniformity of content in their optical shops.

Furthermore the data on locations show that a set of four department stores (the 'SWTS' or 'exogenous' group – Sears, Walmart Supercenter, Super Target, Shop Ko) have optical shops in almost all (95%) of their outlets. Since variety and entry decisions for these sellers seem to be fixed

at the corporate level, the sample for the regressions only includes the non-SWTS firms. However the locations of the SWTS sellers still enter the regressions as explanators of other firms' product ranges. JC Penney and ordinary Walmart stores are included in the regression sample. There is usable variation in their entry behavior because only about half of their outlets contain optical shops.<sup>20</sup> In total there are then 301 observations to be used in the variety regressions.

Summary statistics for the explanatory variables in these regressions are shown in table 7. Proximity to a shopping mall is likely to be positively correlated with a seller's product range, since malls are prime locations for the specialist chains. About a third of sellers are within a mile of an enclosed shopping mall; for these sellers the average size of such malls is 600,000 square feet.<sup>21</sup> Data from the 2000 Census show that tracts with centroids within one mile of a seller (including the seller's own tract) contain about 9,000 residents on average.<sup>22</sup> From the same Census data the mean logarithm of these nearby residents' per capita annual incomes is seen to correspond to a figure in levels of around \$19,000.

The competition measures, showing numbers of nearby and distant rivals, are divided into two categories, for the SWTS and non-SWTS groups of sellers. As noted previously, counts of rivals in the former group are treated as exogenous variables in both stages of the model. Counts of rivals in the latter group are determined endogenously in the first stage, thereby necessitating the sample-selection correction introduced above. Sellers on average face 2.3 non-SWTS rivals within one mile. About 80% of sellers have at least one such rival in band 1; 60% have at least two rivals, and 40% have three or more. (The maximum number of non-SWTS rivals in band 1 is seven.)

In the course of the eyeglasses survey I collected data on sellers' Yellow Pages advertising for 25 of the 44 markets in the sample.<sup>23</sup> About 52% of the total of 356 sellers in these markets took out display advertisements in their local telephone directory. Of this subset 38% (70 sellers) used the display space to mention (among other store features) their 'wide selection'

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<sup>20</sup>Locations of department stores are held to be exogenously fixed in the entry model. For stores in the SWTS group these locations are almost perfect predictors for the presence of their optical shops.

<sup>21</sup>Shopping mall data were collected from National Research Bureau (1998).

<sup>22</sup>This figure is for the non-institutionalized population. It does not mean that 9,000 people live within one mile of the seller, since the actual boundaries of these tracts may extend beyond a mile.

<sup>23</sup>For logistical reasons there is a slight bias against smaller markets in the selection of this subset of 25.



of spectacle frames. Conditioning on having a display ad, the average (and standard deviations of) frames counts at sellers who did and did not mention this feature were 857 (s.d. 443), and 693 (s.d. 325), respectively.<sup>24</sup> The difference between the means is significant in a t-test, confirming that my frames counts are indeed related to a variable of strategic interest to managers.

In addition to prescription spectacles eyewear shops also sell eye examinations, contact lenses, and non-prescription sunglasses (plus other less significant items like non-prescription reading glasses). I have little information about sales of these goods. To abstract away from competition in eye exams I assume that these are sold in fixed proportions to eyeglasses, with no variation in quality across sellers. The latter assumption is somewhat restrictive, although the former may not be far from the truth. Competition in sales of contact lenses and sunglasses is similarly ignored. Contact lenses might be regarded as a homogeneous good sold under conditions of perfect competition, perhaps reflecting the fact that this good can also be purchased through the Internet. Sunglasses were specifically excluded from the inventory survey because they are carried not just by eyecare specialists but also by kiosks in malls, clothing shops, sellers of sporting goods, and so on. Accounting for (and locating) this variety of retail outlets would complicate the analysis considerably.

## 5 Results

Table 8 shows OLS regression results for the variety equation (8), with market dummies. Some explanatory variables from the first stage of the model showed little significance in the variety regressions and were dropped from the analysis.<sup>25</sup> Competition effects in  $g(\cdot)$  are calculated with respect to the endogenous (non-SWTS) sellers. There is a dummy for the effect of the closest exogenous (SWTS) seller, to allow competition from these rivals to affect a firm's product variety non-linearly.<sup>26</sup> In Illinois markets there is a product-range observation for all sellers in the endogenous category;

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<sup>24</sup>These averages are taken over all sellers in these 25 markets who: a) had a display ad, and b) were included in the subset visited during the frames survey.

<sup>25</sup>These omitted variables include tract-level indicators of median age, median rent, number of ophthalmologists, density of other (non-eyecare) businesses, population density, and number of open-air shopping plazas. Estimation results for the first-stage entry model may be found in Watson (2004).

<sup>26</sup>Because of the small numbers in this group only the closest SWTS rival is allocated a dummy variable.

in markets elsewhere the coverage is a random 50%. A dummy for Illinois accounts for any bias due to the oversampling in this state.

Recall that in this regression the effects of market aggregates are collinear with the fixed effects  $\tau_m$ . Therefore a coefficient on the number of (exogenous or endogenous) rivals in band 1, for example, actually measures the effect of moving a rival nearby from far away. Likewise the population effect in this model measures the change in variety due to a (hypothetical) relocation of residents from elsewhere in the market to a seller's immediate vicinity.

As a group the independent variables in the regression are significant at the 1% level. Income of nearby residents and size of shopping mall both have positive effects on sellers' product ranges, significant at the 5% and 10% levels, respectively. An increase of 50% in the per-capita income of people in tracts in band 1 would raise a seller's variety by about 12%. Sellers near a medium-sized mall of 500,000 square feet would have about 16% more variety than if they were near a small mall of 200,000 square feet. A more distant mall is also estimated to have a large impact on variety – the estimate is imprecise because the sum of this variable and the nearby mall dummy is almost collinear with the market effects.

To interpret the effects of competition consider the impact on an incumbent firm of three exogenous changes in market configuration. First, a new entrant to the market may commence operation close to the seller. Alternatively a new entrant could set up at a more distant location in the market. Lastly an existing seller could relocate close to the incumbent from a more distant location. The outcomes of each of these experiments may depend on how many rivals are already operating close to the seller in question. In section 2 it was suggested that the direction of an incumbent's variety response to such changes would depend on the following underlying effects (indicated along with their signs):

- a. (*new entry nearby*) in-tract business stealing (-), consumer search costs (+), cross-tract business diversion (+)
- b. (*new entry far away*) in-tract business stealing (0), consumer search costs (+), cross-tract business diversion (-)
- c. (*relocation from far away*) in-tract business stealing (-), consumer search costs (+), cross-tract business diversion (+)

Note that experiment (c) is equal to (a) minus (b): somebody leaves a far location and joins a nearby location.

The results in table 8 suggest that a seller facing more competition in a neighborhood will eventually start cutting product variety. However the first

three rivals to move near a seller may induce opposite effects. To see this consider an experiment of type (c): an initially isolated incumbent faces a succession of (endogenous) rivals relocating close by. For the first such relocation the incumbent’s variety response is  $\hat{\psi}_3 + \hat{\psi}_1 - \hat{\psi}_2 \approx +9\%$ , and for each of the second and third such moves it is  $\hat{\psi}_4 + \hat{\psi}_1 - \hat{\psi}_2 \approx +6\%$ . The joint hypothesis that both of these net effects are zero can be rejected with 90% confidence. Any subsequent relocation induces an opposite variety response of  $\hat{\psi}_1 - \hat{\psi}_2 \approx -8\%$ . With a p-value of 0.15 this latter effect has marginal significance. The t-statistic of 1.8 for  $\hat{\psi}_3$  indicates that we can reject the hypothesis that a firm’s variety responds in the same way to the first nearby rival as it would to later competitors.

Variety responses to sellers in the the SWTS group show a similar non-linear pattern. Relocation of a single SWTS rival (an entire department store) into the neighborhood of a seller is estimated to raise variety by 23%, significant at the 5% level. For more than one such store the impact of each further relocation is estimated to be negative, although not significantly so. We can reject with 95% confidence the hypothesis that the initial SWTS rival has the same effect as each subsequent competitor from this group.

As noted, the inclusion of market dummies in the preceding regression means that the effects of market-level aggregates are not separately identified. To identify such effects we can drop the dummies and instead account for the potential endogeneity in  $\tau_m$  by assuming

$$E[\tau_m \mid \mathbf{C}_{mk}, \mathbf{Z}_{mk}] = b\xi_m.$$

Here  $b$  is a parameter and  $\xi_m$ , as mentioned in section 3, is the unobserved shared market-level profit effect in an extended version of the Seim framework which models the determination of  $N_m$ . We can then include  $b\hat{\xi}_m$  as an additional sample-selection correction on the right-hand side of the variety regression (8), where  $\hat{\xi}_m$  is a consistent estimate of  $\xi_m$  obtained from the first stage of the model.

Table 9 presents estimates for this version of the variety model. Here the main interest is in the estimates of  $\psi_1$  and  $\psi_2$ , i.e., the effects on variety of *new* entry into the market, which were not identified previously. New entry nearby by endogenous competitors has a baseline impact on an incumbent’s product variety of  $\hat{\psi}_1 = -9\%$  per entrant, significant at the 1% level. Entry further away is also estimated to reduce variety, by 4% for each such entrant, significant at the 5% level. For entry by department stores in the SWTS set the corresponding effects are  $-3\%$  and  $+4\%$ , respectively, but neither has statistical significance.

With respect to market characteristics the results in table 9 are generally similar to those in the preceding regression. Population effects for both bands 1 and 2 are now separately identified: neither is statistically significant. The effect on variety of the number of distant malls is found to be positive with more significance than previously. This may reflect the existence of a second mall in a town, which happens in 15 out of 44 markets. Second malls may reduce a consumer’s cost of switching to search at a rival seller, and they may bring more customers to town from outlying areas. Five state dummies are included: only that for Ohio is significant. Its negative sign may reflect a difference in regulatory environment: Ohio is the only state in the sample which requires the licensing of opticians.<sup>27</sup>

None of the parameters for the endogeneity corrections in tables 8 and 9 is statistically significant. If the corrections are omitted the estimated magnitudes of the competition effects are essentially unchanged. Since omitting the endogeneity corrections seems not to alter the discussion greatly, it appears that the number of firms in each market, and their locations, are well explained by the observable explanatory variables in the model.<sup>28</sup>

Which of the three effects of competition on product variety discussed in section 2 can be seen in these regressions? First, the significantly negative value for  $\psi_1$  in table 9 (representing experiment (a), with several other competitors already present nearby) shows that as extra firms are added to a site they will eventually steal business from the other sellers there. Second, more competition at a location attracts business from other points in the product space. This conclusion follows from the negative sign on  $\psi_2$  in table 9 (which means a negative response to experiment (b) above). The third influence on variety, that of consumer search costs, may not be separately identified from these estimates. We have seen that the arrival of relocating firms yields positive variety responses when few other firms are present at a location. This points to the dominant influence of some combination of lower search costs for consumers and the diversion of business

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<sup>27</sup>The exact mechanism by which such regulations might produce lower per-firm variety is nevertheless not immediately clear. Intuitively one would expect that it might raise the cost of a labor input essential to the sale of eyeglasses, thereby reducing the profitability of entry. However, as we have seen reductions in the degree of competition do not necessarily have monotonic effects on per-firm variety.

<sup>28</sup>The log transformation of the dependent variable makes one of the sellers in the sample (with just 50 different frame styles) an outlier. (This is not measurement error – the seller has an elderly clientele.) Dropping this observation from the regression in table 8 results in minor changes: the p-value for  $H_0 : \psi_1 = \psi_2$  becomes slightly less significant (0.21) while those for  $H_0 : \psi_3 = 0$  and  $H_0 : \psi_1 + \psi_3 = \psi_1 + \psi_4 = 0$  are somewhat more significant.

from other locations. Together these effects countervail the negative impact of business stealing within the location. Unfortunately the contribution of search costs to this combination is unknown. In particular even if greater competition at a location has no directly positive effect on variety through lower search costs, it might still produce lower prices, which would explain the attraction of some customers from elsewhere in town. In general it would be possible to identify the search-cost effect in a structural model that took consumer preferences over the space of product characteristics as primitives and explicitly modelled consumers' travel costs. Such an approach is complicated in the present instance by the absence of data on the prices of eyeglasses or quantities sold at each firm.<sup>29</sup>

Cross-tract business diversion effects are of interest in themselves because they dilute the incentives of firms to differentiate their products. In its strongest form this kind of effect could lead firms to tolerate a certain amount of clustering in equilibrium, instead of each developing de facto monopoly power in an isolated region of the product space. Of course some grouping of sellers is seen in the data because of the desirability of particular locations like shopping malls. Clustering might benefit firms even in the absence of special locational characteristics if it served to concentrate more eyewear customers at a location. Further work on this issue would seem to be warranted.

## 6 Chain stores and variety competition

The summary statistics on product ranges in table 6 point to significant behavioural disparities between specialist chains and other eyewear retailers. Further evidence presented in Watson (2003, chapter 3) indicates that, relative to other specialist sellers, eyewear chains choose prime retail locations, have bigger stores, are open longer, charge lower prices for eye exams, advertise more, and emphasize distinctive features in their advertising. To analyze these differences in a structural manner is beyond the scope of the present model. Indeed, the framework here abstracts away from cross-market links between firms, and therefore ignores the defining feature of chain retailing. Nevertheless some exploratory regressions can give an initial indication of whether chain identity explains the pattern of competition effects seen above.

Table 10 adds dummies for chain affiliation to the model in table 9, and

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<sup>29</sup>See Davis (2001), Manuszak (2000) and Thomadsen (2002) for structural models of competition in geographically differentiated markets.

breaks down the responses to competition (for the endogenous firms) into effects for chains and for non-chains. One dummy is for outlets of Lenscrafters and Pearle Vision, a second is for the other chain-affiliated outlets. (Market dummies are omitted for simplicity.) Here a chain is defined to be any specialist (i.e., non-department-store) eyewear seller operating in two or more markets in the sample. There are 61 such operations out of 301 total sellers in the frames subsample.<sup>30</sup> In view of the additional competition parameters to be estimated I augment these observations with data on an extra 20 outlets of Lenscrafters and Pearle Vision in the markets under study. Adding these stores (which were visited during the survey but were subsequently excluded from the frames subsample) implies oversampling from the set of chain sellers. The chain dummies would correct for this oversampling if chain identity is held to be exogenous with respect to firms' locations, an assumption implicit in this regression.<sup>31</sup>

As expected the regression shows that affiliation with Lenscrafters or Pearle Vision has a large positive effect on an outlet's product variety, of the order of 50%. The estimated effect of affiliation with another chain is not statistically significant. Relative to the basic model of table 9 the size of a nearby shopping mall loses significance, highlighting the tendency of chain stores to locate in prime retail centres.<sup>32</sup> A shopping mall at some more distant location still has a significant positive impact on product ranges.

Within each subcategory (chains and non-chains), the form of the competitive responses allowed in table 10 is the same as the original function  $g$ .<sup>33</sup> With respect to endogenous rivals the pattern of estimated competition effects is broadly the same for both subcategories, and mirrors that observed in the basic model of table 9. Variety responses to extra nearby rivals are ultimately negative. However a seller in close proximity to a few rivals may have more variety than an isolated firm, all else equal. The joint hypothesis

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<sup>30</sup>Thus the definition of a chain here is somewhat broader than in tables 4 and 6, which categorize chains as sellers with branches in four or more markets in the sample.

<sup>31</sup>With the extra observations the dataset covers all Lenscrafters and Pearle Vision outlets in the sample markets. At the time the data in this study were collected these two outlet brands were under separate ownership. In October 2004 Cole National, the parent corporation of Pearle Vision, was acquired by Luxottica, the owner of Lenscrafters.

<sup>32</sup>About three quarters of the specialist chains have a shopping mall within one mile, compared to around one quarter of other non-department-store sellers.

<sup>33</sup>As this regression is primarily intended for illustrative purposes I retain here the endogeneity corrections  $\hat{\xi}$  and  $\gamma - \ln \hat{p}_k^*$  from the previous section. It is possible to extend firms' choices in the entry model to include in each cell the option 'affiliate with a chain'. Since the extension presents some additional problems of identification and computation I omit it here. See Seim (2001), and an application to the eyewear data in Watson (2003).

that each non-chain competition response to an endogenous competitor is equal to the equivalent effect for a chain seller cannot be rejected at ordinary significance levels.

On the other hand the same hypothesis is rejected, with 90% confidence, when competition with the exogenous rivals is considered. Furthermore these estimated responses show some differences with patterns seen earlier. For example an extra nearby SWTS store produces a positive baseline response of 12% in a chain's product range. Similarly, a new SWTS store in band 2 is estimated to raise a non-chain's product range by 5%. Reasons for these discrepancies with the responses to endogenous competitors are not immediately clear. However with p-values of 0.19 and 0.18, respectively, these effects have only marginal significance. The most significant of the competition responses for SWTS rivals – the extra effect of an initial nearby competitor on a non-chain – has a sign in accord with the earlier results. Thus, while the results for competition from the exogenous big stores are ambiguous, with respect to the endogenous rivals this regression suggests that the preceding inferences on competition and product variety might still hold in a model which endogenizes, or instruments for, sellers' chain affiliation.

## 7 Conclusions

Recent structural models due to Thomadsen (2002), Manuszak (2000) and Davis (2001) derive demand functions for retail firms facing complex spatial interactions with rival sellers, taking as primitives consumer preferences over distances and store characteristics. These papers hold the locations of sellers to be exogenously determined. The present approach represents the spatial effects in a more reduced-form manner, choosing instead to endogenize sellers' location choices. It turns out that on present evidence the endogeneity does not significantly affect the final results.<sup>34</sup> Nevertheless it is hoped that the combination of an extensive survey of firms' post-entry behavior with an explicit entry model constitutes a small contribution to the understanding of competition in differentiated-good markets.

Estimation results presented above suggest first that geographic differentiation matters in competition between eyewear sellers. Moving rival sellers closer to a given firm has statistically significant effects on that firm's product range. These effects are non-uniform in that their directions depend on

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<sup>34</sup>This contrasts with the motel markets studied by Mazzeo (2002b), where the endogeneity of firms' quality choices does prove to be significant.

the current configuration of sellers in a market. The baseline effect is for a new entrant (or a relocating firm) to steal business from nearby sellers, who therefore reduce their product ranges. However a relocating firm (or group of firms) which joins with a previously isolated seller may cause that incumbent to raise product variety. This could be due to a competition effect, whereby firms respond to the reduction in shoppers' search costs. It also seems to reflect in part the attraction of customers away from other locations in the market.

The analysis confirms earlier indications that data on product ranges can be used to study competition in retail markets.<sup>35</sup> This is of interest because information on firms' other choice variables such as prices and quantities is often unavailable for reasons of confidentiality. A researcher can more easily observe basic information about the number and types of good sold by each firm. Ease of observation is particularly important when data are needed from a cross section of markets.

Quality differences between firms are an issue worthy of further investigation. Interpretation of the variety regressions here assumed that there was no systematic variation in consumer tastes across retailers. In truth consumers in these markets would on average most likely rate some sellers as having better eyeglasses than others. Then specialization into different quality levels could be an alternative explanation for the eventual negative relationship between competition and product variety.

In future work it would also be of interest to analyze the role of chain stores more closely. Mergers between eyewear chains in the U.S. market have recently attracted the attention of regulatory authorities.<sup>36</sup> Exploratory regressions in this paper indicated that chain affiliation is associated with a significant rise in the product range of an eyecare specialist. However within the specialist category chain affiliation does not seem to produce substantial changes in the responses to more competition: the estimates for both chain and non-chain specialists in competition with each other showed no major deviations from the general patterns seen in the model without chain effects. Responses to competition from large department stores may constitute an exception: the results there were suggestive of differences between chains and independents, but were too ambiguous to allow firm conclusions.

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<sup>35</sup>Bayus and Putsis (2000), Draganska and Jain (2003).

<sup>36</sup>O'Donnell (2004).



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Table 1: List of markets in sample

<b>State</b>	<b>Markets</b>
Illinois	Bloomington, Carbondale, Danville, Decatur, De Kalb, Freeport, Galesburg, Kankakee, Quincy, Springfield, Urbana
Indiana	Bloomington, Columbus, Kokomo, Lafayette, Marion, Richmond, Terre Haute
Iowa	Ames, Burlington, Cedar Rapids, Clinton, Dubuque, Fort Dodge, Iowa City, Mason City, Waterloo
Michigan	Battle Creek, Benton Harbor, Holland, Jackson, Muskegon
Minnesota	Mankato, Rochester, St. Cloud
Ohio	Ashtabula, Findlay, Lancaster, Lima, Mansfield, Marion, Newark, Sandusky, Zanesville

Table 2: Market characteristics

<b>Description</b>	<b>Min</b>	<b>Mean</b>	<b>Max</b>
No. of tracts in market	8	22	48
Total non-institutional popn. of market (thousands)	32	87	172
No. of eyeglass sellers in market	4	13	23
No. of malls in market $\geq 150,000\text{ft}^2$	0	1.3	2

Note 1. Areas for malls are gross leasable areas.

Note 2. Tract and population data are from the 2000 Census.

Note 3. Shopping centre data are from National Research Bureau (1998).

Note 4. Counts of eyeglass sellers are from directories and a telephone survey.

Table 3: Sellers of eyeglasses by category

<b>Category</b>	<b>Number of sellers</b>	
	<b>Overall</b>	<b>In frames subsample</b>
Eyecare specialists:		
Optician	18	11
Optometrist	361	212
Ophthalmologist	88	55
Specialists total	467	278
Department store	105	64
<b>Total all categories</b>	<b>572</b>	<b>342</b>

Note 1. The frames subsample has 100% of sellers in IL, 50% elsewhere.

Table 4: Eyecare specialists, by affiliation

Affiliation	Number of sellers	
	Overall	In frames subsample
Lenscrafters, Pearle Vision	40	22
Other wide-area chain	55	25
Local chain or unaffiliated	371	231

Note 1. The frames subsample has 100% of sellers in IL, 50% elsewhere.

Note 2. ‘Wide-area’ means operating in more than three markets in the sample.

Table 5: No. of frames per seller, by category

Category	No. of frames per seller		
	1st quartile	Median	3rd quartile
Eyecare specialists:			
Optician	385	484	613
Optometrist	450	603	809
Ophthalmologist	396	612	793
All specialists	438	600	795
Department stores	385	434	501
<b>All sellers</b>	<b>410</b>	<b>537</b>	<b>750</b>

Note 1. Frames data is for the subsample with 100% of sellers in IL, 50% elsewhere.

Table 6: No. of frames at eyecare specialists, by affiliation

Affiliation	No. of frames per seller		
	1st quartile	Median	3rd quartile
Lenscrafters, Pearle Vision	836	1099	1411
Other wide-area chain	578	670	835
Local chain or unaffiliated	410	548	738

Note 1. Frames data is for the subsample with 100% of sellers in IL, 50% elsewhere.

Note 2. ‘Wide-area’ means operating in more than three markets in the sample.

Table 7: Explanatory variables for variety regressions

<b>Description</b>	<b>Mean</b>	<b>St. dev.</b>
<i>Tract-level variables</i>		
Dummy for first SWTS store in band 1	0.35	0.48
Number of SWTS stores in band 1	0.46	0.71
Number of SWTS stores in band 2	1.3	1.1
Dummy for enclosed mall in band 1	0.37	0.48
GLA of malls in band 1 (100,000 ft <sup>2</sup> )	6.1	2.1
No. of malls in band 2	0.97	0.66
Pop. of tracts in band 1, 2000 (10,000)	0.87	0.51
Pop. of tracts in band 2, 2000 (10,000)	8.8	3.6
Log(per cap. income in band 1, \$10,000)	2.9	0.30
No. of endogenous rivals in band 1	2.3	2.0
No. of endogenous rivals in band 2	8.9	3.9
Dummy for closest rival in band 1	0.78	0.41
(*)Dummy for 2nd-closest rival in band 1	0.56	0.50
(*)Dummy for 3rd-closest rival in band 1	0.41	0.49

Note 1. Variables are averaged over the sellers in the variety regression subsample.

Note 2. GLA means gross leasable area. The average and std. dev. are taken only over those sellers with a mall in band 1.

Note 3. Population and income data are from the 2000 Census. Population counts refer to non-institutionalized population.

Note 4. ‘Band 1’ refers to the band 0-1 miles, ‘band 2’ to anything further.

Note 5. ‘SWTS’ means Sears, Walmart Super, Target, ShopKo.

Note 6. By assumption asterisked variables have the same coefficient:  $\psi_4$ .

Table 8: OLS variety regression for non-SWTS sellers, with market dummies  
 Dependent variable: log(number of frames).

<b>RHS parameters</b>	<b>Estimate</b>	<b>Std. error</b>
<i>Effects of tract-level variables</i>		
Diff. in popn. effects, (bd.1 - bd.2) (10,000)	0.070	0.082
Log(per cap. income in band 1, \$10,000)	0.23*	0.11
Dummy for enclosed mall in band 1	0.18	0.34
GLA of malls in band 1 (100,000 ft <sup>2</sup> )	0.054‡	0.030
No. of malls in band 2	0.43	0.29
Tract-level (logit) endogeneity correction	0.042	0.035
<i>Effects of SWTS competitors</i>		
Diff. in base effects, (band 1 - band 2)	-0.088	0.10
Extra effect for first SWTS band-1 rival	0.32*	0.13
<i>Effects of endogenous competitors</i>		
Diff. in base effects, bands 1,2 ( $\psi_1 - \psi_2$ )	-0.075	0.052
Extra effect for first band-1 rival ( $\psi_3$ )	0.17‡	0.092
Extra effect for 2nd or 3rd band-1 rival ( $\psi_4$ )	0.14	0.10
Constant	5.2	0.39

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$$R^2 = 0.25, F(54, 246) = 9.34, \Pr[> F] = 0.0000, N = 301$$

Note 1. Std. errs. robust to heteroskedasticity and within-tract correlation.

Note 2. 'SWTS' means Sears, Walmart Super, Target, ShopKo.

Note 3. GLA means gross leasable area.

Note 4. Regression includes market and state dummies (not shown). Six market dummies were dropped to avoid collinearity.

(\*\*) significant at 1% level. (\*) significant at 5% level. (‡) significant at 10% level.

Table 9: OLS variety regression for non-SWTS sellers, no market dummies  
 Dependent variable: log(number of frames).

<b>RHS parameters</b>	<b>Estimate</b>	<b>Std. error</b>
<i>Effects of tract-level variables</i>		
Population in band 1 (10,000)	0.053	0.072
Population in band 2 (10,000)	0.00069	0.017
Log(per cap. income in band 1, \$10,000)	0.19	0.12
Dummy for enclosed mall in band 1	-0.14	0.17
GLA of malls in band 1 (100,000 ft <sup>2</sup> )	0.058*	0.026
No. of malls in band 2	0.14*	0.066
Tract-level (logit) endogeneity correction	0.013	0.036
<i>Effects of SWTS competitors</i>		
Base effect, band 1	-0.026	0.093
Base effect, band 2	0.035	0.037
Extra effect for first SWTS band-1 rival	0.22 <sup>‡</sup>	0.13
<i>Effects of endogenous competitors</i>		
Base effect, band 1 ( $\psi_1$ )	-0.092**	0.034
Base effect, band 2 ( $\psi_2$ )	-0.039*	0.018
Extra effect for first band-1 rival ( $\psi_3$ )	0.11	0.092
Extra effect for 2nd or 3rd band-1 rival ( $\psi_4$ )	0.077	0.077
<i>Effects of market-level variables</i>		
Illinois dummy	-0.068	0.088
Ohio dummy	-0.18*	0.089
Indiana dummy	0.070	0.085
Michigan dummy	0.060	0.099
Minnesota dummy	-0.13	0.14
Market-level endogeneity correction ( $\xi$ )	0.038	0.11
Constant	6.1	0.85

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$$R^2 = 0.14, F(20, 280) = 2.8, \Pr[> F] = 0.0001, N = 301$$

Note 1. Std. errs. robust to heteroskedasticity and within-tract correlation.

Note 2. 'SWTS' means Sears, Walmart Super, Target, ShopKo.

Note 3. GLA means gross leasable area.

(\*\*) significant at 1% level. (\*) significant at 5% level. (‡) significant at 10% level.



Table 10: OLS variety regression for non-SWTS sellers, responses of chains vs. responses of non-chains, no market dummies  
 Dependent variable: log(number of frames).

<b>RHS parameters</b>	<b>Estimate</b>	<b>Std. error</b>
<i>Effects of tract-level variables</i>		
Population in band 1 (10,000)	0.045	0.068
Population in band 2 (10,000)	0.0028	0.015
Log(per cap. income in band 1, \$10,000)	0.19 <sup>‡</sup>	0.11
Dummy for enclosed mall in band 1	-0.12	0.16
GLA of malls in band 1 (100,000 ft <sup>2</sup> )	0.036	0.024
No. of malls in band 2	0.12 <sup>‡</sup>	0.062
Tract-level (logit) endogeneity correction	0.0039	0.035
<i>Effects of SWTS rivals on non-chains</i>		
Base effect, band 1	-0.094	0.11
Base effect, band 2	0.050	0.037
Extra effect for first SWTS band-1 rival	0.27 <sup>‡</sup>	0.14
<i>Effects of SWTS rivals on chains</i>		
Base effect, band 1	0.12	0.088
Base effect, band 2	-0.035	0.044
Extra effect for first SWTS band-1 rival	-0.097	0.15
<i>Effects of endogenous rivals on non-chains</i>		
Base effect, band 1 ( $\psi_1$ )	-0.093**	0.034
Base effect, band 2 ( $\psi_2$ )	-0.042*	0.018
Extra effect for first band-1 rival ( $\psi_3$ )	0.056	0.099
Extra effect for 2nd or 3rd band-1 rival ( $\psi_4$ )	0.10	0.080
<i>Effects of endogenous rivals on chains</i>		
Base effect, band 1 ( $\psi_1$ )	-0.060	0.044
Base effect, band 2 ( $\psi_2$ )	-0.016	0.022
Extra effect for first band-1 rival ( $\psi_3$ )	0.16	0.15
Extra effect for 2nd or 3rd band-1 rival ( $\psi_4$ )	0.013	0.086
<i>Chain dummies</i>		
Dummy for Lenscrafters/Pearle Vision	0.47*	0.24
Dummy for other chain	-0.0084	0.22
<i>Effects of market-level variables, constant</i>		
(Not shown.)		

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$R^2 = 0.33$ ,  $F(29, 291) = 6.29$ ,  $\Pr[> F] = 0.0000$ ,  $N = 321$

Note 1. Regression includes a dummy for each state (not shown).

(\*\*) significant at 1% level. (\*) significant at 5% level. (‡) significant at 10% level.

Figure 1: Distribution of sellers, by type and number of frames

