A Structural Model of Entry and Location Choice: The Differentiation–Agglomeration Trade-Off[†]

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Abstract

Extant models of entry and location choices by competing retailers focus on the benefits of differentiation, derived from locating far apart, and therefore cannot explain high degrees of store agglomeration. Unlike extant models that treat firm profits in reduced form, this paper decomposes firm profit as a function of customer choice (to allow for consumer utility from agglomeration) and competition; thus, the authors disentangle the differentiation–agglomeration trade-off that firms face. The findings reveal that (1) consumers value both format and store agglomeration; (2) consumers have high travel costs, and competition among stores decreases dramatically with distance, but ignoring agglomeration benefits biases these estimates substantially; and (3) intraformat competition reduces profitability at roughly twice the rate as interformat competition. Policy simulations demonstrate the importance of modeling the differentiation–agglomeration trade-off to arrive at correct entry and location decisions.

Keywords: Retailing, Entry, Grocery, Empirical Industrial Organization

As retailers gain market share, they seek to open new stores to achieve their growth objectives. For example, Wal-Mart has added approximately 350 new stores each year for the past five years, and Walgreens expects to increase its stores from 5,580 to 7,000 by 2010. Perhaps the most famous store expansions are those of Starbucks, which currently operates 12,000 stores worldwide and has a long-term goal of 20,000 stores in the United States and another 20,000 abroad. On a larger scale, open-air shopping centers, which currently number around 40,000, are increasing by at least 2% per year on average (Merrill Lynch, 2007). In Table 1, we provide a list of store openings during the period 2001–06, as well as the projected store openings for 2007, for a cross-section of retail categories.

A growing retailer thus faces two key questions as it embarks on a store expansion strategy: (1) Should it enter a particular market at all (entry decision), and if so, (2) where should it locate the new store (location decision)? To arrive at the optimal entry location, the retailer might analyze detailed consumer-level data regarding how consumers shop across stores in different markets that vary in terms of population, spending power, and number of stores of different formats, which vary in their distances from one another. However, this approach is difficult to implement in practice on a large scale, because such detailed consumer-level data across markets from multiple retailers are difficult to obtain, and a household-level analysis across markets can be onerous.

Researchers therefore have adopted an alternative strategy with which they infer the trade-offs firms face by endogenously modeling entry and location decisions (e.g., Bresnahan and Reiss 1991; Mazzeo 2002; Seim 2006; Zhu and Singh 2007).[1] These models assume that firm entry and location decisions are an equilibrium outcome, such that firms make their

[1] Related literature models consumer choice of spatial locations but treats outlet locations as exogenous (Duan and Mela 2007; Thomadsen 2007). Chan, Padmanabhan, and Seetharaman (2006) also model consumer choice of gasoline outlets when a social planner determines the locations of those outlets.

decisions on the basis of the profitability of their choices while accounting for conjectures about competitors' decisions. With this approach, decision makers can use readily available data about entry and location decisions and the demographic characteristics of markets at the reasonably disaggregate census block level and thus make the necessary empirical inferences.

These studies implicitly assume that spatial differentiation always benefits firms, because it helps reduce competitive intensity and increase profits. Accordingly, when two firms locate close to each other in a market, they must do so either because the potential in the market is extremely large, which enables both firms to be profitable, or because the transportation costs of customers in the market are high enough that customers are unlikely to price search across firms.

However, this implicit assumption may not be consistent with the data. To explore this issue, we compare locations in which supermarkets exist less than 0.5 miles apart and locations in which they are more than 2 miles apart. According to the average characteristics of the locations in Table 2, the average populations and incomes (total and per capita) actually are not higher in areas where stores are closer together; rather, they tend to be somewhat lower than those of areas where firms locate farther apart. Thus, it appears extant models may be missing features that allow for positive benefits to firms that locate close together.

Why might firms choose to agglomerate? A commonly cited reason is that doing so takes advantage of customers' need for "economies of scope" during multipurpose shopping trips (e.g., Arentze, Oppewal, and Timmermans 2005). That is, different types of firms may colocate to facilitate customers' ability to shop for different types of products at different stores within a single trip. If consumers value such economies of scope, they should find it more attractive to shop in locations with greater business density. In this sense, extant research considers the potential benefits of agglomeration around other retail business (exogenous to the model) (e.g., Seim 2006; Zhu and Singh 2007).

But do consumers value agglomeration of stores within the same category selling similar products (e.g., grocery stores)—and should we expect an endogenous agglomeration of stores belonging to the same category? Because different grocery formats (e.g., supermarkets, superstores) may provide different types of products at different prices, scope economies of shopping may make it more attractive for customers to shop in locations that host stores of different formats. Consumers thus may value "format agglomeration." Even within stores of similar formats, consumers may prefer some subset of products at one store. For example, a shopper may prefer the bread at one store and the vegetables and meat at another store with a similar format. In this case, the consumer also values "store agglomeration" within the format. Bester (1998) and Fischer and Harrington (1996) provide such arguments based on the product heterogeneity across stores.

Finally, another benefit of colocation for consumers involves resolving the hold-up problem (Wernerfelt, 1994), which can lead to higher prices. When a competitor is close by, a store is unlikely to raise its prices too much for fear that customers will simply switch to the competitor. However, when the competitor is farther away, stores have an incentive to "hold-up" consumers and charge a higher price, because customers in the store will find it costly to visit a competitor relative to purchasing at the store. A customer fearing higher prices due to hold-up likely frequents locations with multiple colocated stores, so store or format agglomeration may represent a means to avoid the hold-up problem.[2] Generally, we expect greater benefits of hold-

[2] The arguments underlying Wernerfelt (1994) were also made by Stahl (1982), who notes that consumers value the reduction in search costs due to store co-location and Dudley (1990) who notes that customers' expectations of lower prices in clustered stores can serve as an incentive for stores to colocate.

up avoidance associated with store agglomeration than with format agglomeration, because stores of the same format are closer substitutes than stores of different formats.

To model these theories, we follow Seim (2006) and assume idiosyncratic differences in profitability among firms, which competitors know only in distribution. The asymmetric information specification offers the practical advantage of allowing the model to accommodate a large dimensional set of product types (in our case, locations and formats) because it simplifies the computation of equilibrium strategies.

The key modeling issue thus becomes how to disentangle the differentiation–agglomeration trade-off. We decompose the reduced form profit model into separate components that account for *consumer* and *competitive* effects and thus offer an innovative approach to this problem. By explicitly modeling how transportation costs due to the distance between stores and the agglomeration of different stores and formats affect consumer utility (and thus location choice), we clarify the differentiation–agglomeration trade-off. Furthermore, we aggregate the probabilities that consumers will shop at a particular location, on the basis of the utility model, by appropriately weighing both the number of these consumers and their spending potential, as represented by their per capita income, to arrive at the total profit potential of that location.

On the supply side, unlike existing entry literature that assumes firms are symmetric (cf. Zhu and Singh 2007), we allow for the observable profitability of firms to differ according to format (i.e., cost or efficiency differences). Thus, entry and location decisions are functions of the format of the store. For example, a Wal-Mart supercenter may have a cost advantage over other grocery formats. Furthermore, we model the effects of competition in a flexible, semiparametric manner by allowing profit potential to split differentially across firms as a function of the format and distance. Thus, two stores of the same format within a one-mile radius may compete much more than do two stores of the same format that are two miles apart. Similarly, two stores of different formats may compete less than do two stores of the same format at the same distance. For example, consider the grocery market in Southern Connecticut, in which two major supermarkets, Stop and Shop and Shaw's, compete against Wal-Mart supercenters and a variety of smaller stores. Using symmetric models, Stop and Shop would simply consider the number of competitors in the market; in our model, the extent of competition depends on which competitor. For example, when controlling for distance, Stop and Shop could engage in greater competition with Shaw's because of its similar format than it does with Wal-Mart.

When estimating multi-agent, discrete, strategic games, an important challenge relates to the possibility of multiple equilibria. Specifically, with an incomplete information set-up, for a given vector of model parameters θ, if there exists more than one set of equilibrium probabilities of firms' actions, the likelihood function cannot be well defined. In general, the probabilistic nature of firms' conjectures in the incomplete information set-up makes uniqueness easier to attain than it would be in a complete information set-up, because the necessary conditions for uniqueness are weaker in the former (Aradillas-Lopez 2005). To deal with this problem, one approach provides sufficient conditions for uniqueness of equilibria that the model parameters θ must satisfy. For example, Siem (2006) and Zhu and Singh (2007) discuss sufficient conditions for uniqueness for special cases of payoff functions they use in their estimations. In this article, we check ex-post whether conditions for the uniqueness of equilibrium are satisfied at the estimated parameter values. Alternatively, we could circumvent the requirement that there be unique equilibria, as do Ciliberto and Tamer (2006) and Bajari and colleagues (2006), as well as Ellickson and Misra (2007), who extend Bajari and colleagues' approach in their study of choice of pricing format (e.g., everyday low price versus high–low pricing). Recently, Su and Judd (2007) have developed mathematical programming with equilibrium constraints approaches that are both efficient and avoid the multiple equilibria problem.

Although several stores in our data set are chain stores, we assume that entry and location choices in different markets are independent. This assumption appears in all extant literature, except Jia (2007), who allows for interdependencies across markets for chain stores. Jia (2007) also allows for the scale economies that Wal-Mart enjoys by operating multiple stores in nearby regions. However, with the data we were able to obtain, this issue is beyond the scope of this article.

Our subsequent analysis leads to several interesting insights. First, consumers value both format and store agglomeration. Second, consumers experience high travel costs, and competition between stores decreases dramatically as the distance between them increases. However, if we ignore the agglomeration benefits, as does extant research, the estimates of travel cost and the relationship between competition and distance are substantially downward biased. Third, as we expected, intraformat competition reduces profitability roughly twice as much as does interformat competition; that is, similar store formats compete more intensely than do differentiated formats. Fourth and finally, we use counterfactual simulations to show that failing to account for the differentiation–agglomeration trade-off in consumer utility can lead to erroneous entry and location decisions. That is, biases in estimates adversely affect managerial decision making.

The rest of this article is organized as follows: In the next section, we present the model for joint entry, format and location choices of firms and describe the estimation approach. After we describe the data, we detail the results and their implications. We conclude with a discussion and some directions for further research.

Model Set-Up

We develop a model of simultaneous entry and location choices that can disentangle the agglomeration–differentiation trade-off. Most research in entry and location literature models profit potential at a location as a reduced form that subsumes consumer and competitive effects. However, because we want to distinguish agglomeration benefits that arise from consumer shopping behavior and the differentiation benefits that result from competition moderation, we decompose the profit potential into consumer and competition components.

Consumers' Location Choice

Each geographic market m (m = 1, …, M) consists of a set of smaller locations (l = 1, …, L^m). Consumers in these locations may shop at any of the grocery stores in the market. Let α_0 be the base utility a consumer obtains from shopping at a grocery store and α_1 be the travel cost per unit of distance. Thus, the intrinsic utility of shopping at a grocery store at location l for a customer at location i equals $\alpha_0 - \alpha_1 d_{il}$, where d_{il} is the distance the customer must travel.

If economies of scope result from multipurpose shopping areas, a location becomes more favorable if it has a greater business density in connection with retail stores that cater to the consumers' nongrocery needs (e.g., electronics, clothing). To capture such scope economies of shopping, we consider the number of retail stores in location l; to capture scope economies of shopping within the grocery sector specifically, we also integrate the effect of the presence of grocery stores of different formats in that location (i.e., format agglomeration effect) on consumers' utility. Furthermore, because a customer who fears hold-up likely frequents locations where stores colocate, we include the number of other grocery stores within 1 mile of location *l* (i.e., store agglomeration effect).

Formally, for a consumer in location *i*, the utility of shopping at location *l* is specified as:

$$U_{il} = \alpha_0 - \alpha_1 d_{il} + \alpha_2 ret_l + \alpha_3 N_l + \alpha_4 I_l^{MF} + \omega_{il}\,, \qquad (1)$$

where

α_0	base utility of shopping at a grocery store;
d_{il}	linear distance between locations *i* and *l*;
$\alpha_1\, d_{il}$	disutility of traveling to location *l*;
ret_l	number of retail businesses in location *l*;
$\alpha_2\, ret_l$	utility of shopping at a location *l* with ret_l businesses;
N_l	number of grocery stores within 1 mile of location *l*;
$\alpha_3\, N_l$	store agglomeration utility of shopping in a cluster at location *l*;
I_l^{MF}	indicator of the presence of multiple formats within 1 mile of location *l*;
$\alpha_4\, I_l^{MF}$	format agglomeration utility from shopping at a location with multiple formats; and
ω_{il}	unobserved characteristics of locations (e.g., traffic patterns, longer travel times due to geographic characteristics)

We cannot infer the actual value of U_{il} but can determine the difference in utilities of two options. Specifically, for the consumer at location *i*, we consider the difference in the utility associated with shopping at location *l* and the utility derived from shopping at location *i*, $U_{il} - U_{ii}$. Assuming i.i.d. Type 1 extreme value distribution for the unobserved errors, the probability that a consumer at location *i* will visit location *l* is

$$p_{il}^{c} = \frac{\exp(\alpha_1 d_{il} + \alpha_2 (ret_l - ret_i) + \alpha_3 (N_l - N_i) + \alpha_4 (I_l^{MF} - I_i^{MF})}{1 + \sum_{j \neq i} \exp(\alpha_1 d_{ij} + \alpha_2 (ret_j - ret_i) + \alpha_3 (N_j - N_i) + \alpha_4 (I_j^{MF} - I_i^{MF}))} . \quad (2)$$

This equation indicates the share of consumers living in location *i* who will shop at location *l*.

Linking Consumer Location Choice to Location Profit Potential

To arrive at the profit potential of location *l*, we aggregate the contribution of consumers of each location who will shop at location *l*. We first specify the total income that consumers from location *i* have available for spending in location *l,* (Inc_{il}). In particular, we weigh the location choice probabilities of consumers, derived from the utility model, by the number of such consumers and their spending potential, as represented by their per capita income:

$$Inc_{il} = p_{il}^{c} Pop_i PCI_i , \quad (3)$$

where

Pop_i population of location *i*;

$p_{il}^{c} Pop_i$ number of consumers of location *i* who visit location *l*; and

PCI_i per capita income of consumers at location *i*.

To obtain the total income available for spending in location *l*, we sum the contributions from all locations in the market:

$$Inc_l = \sum_{i=1}^{L^m} Inc_{il} . \quad (4)$$

If we denote the market characteristics of retail businesses, population, and per capita income by X^m, the profit potential of location *l*, which we denote as $f(X^m, N_l^m, I_l^{MF}; \alpha)$, then can be specified as

$$f(X^m, N_l^m, I_l^{MF}; \alpha) = Inc_l^{\alpha_5} . \quad (5)$$

Competitive Effect

If a firm *f* with format *k* ($k = 1, \ldots, K$) chooses to enter location *l*, it must share the profit potential at location *l* with its rivals in the market because of the competitive effect. We model this effect in a flexible, semi-parametric manner so that we can split the profit potential differentially across firms as a function of their format and distance. For distance, we follow Seim (2006) and model competition in terms of discrete circular distance bands ($b = 1, \ldots, B$) from the location *l*. However, unlike existing entry literature, we allow for asymmetric competitive effects between store formats, such that the intraformat competitive effect may be different than the interformat competitive effect. Thus, two stores of different formats may compete less with each other than would two stores of the same format. Furthermore, the intraformat competitive effect may differ for different formats.

Let N_{tl}^{bm} denote the number of rivals of format or type *t* ($t = 1, \ldots, K$) in distance band *b* around location *l* within market *m*. If we denote the competitive effect as $h(N_k^m, \ldots, N_{k'}^m, \ldots, N_K^m; \beta)$, where N_t^m is the number of rivals of format *t* in the market, the competitive effect for firm *f* can be specified as:

$$h(N_k^m, \ldots, N_{k'}^m, \ldots, N_K^m; \beta) = \prod_b (1 + N_{kl}^{bm})^{\beta_{kb}} \prod_b \prod_{k' \neq k} (1 + N_{k'l}^{bm})^{\beta_{k'b}} . \qquad (6)$$

The first component on the right-hand side of Equation 6 is the intraformat competitive effect; the second component is the interformat competitive effect. We use this multiplicative specification to demonstrate that the competitive effect of an additional rival should decrease with the number of rivals. Adding 1 to the number of rivals captures the idea that in the absence of rivals within a particular distance band *b*, there is no competitive effect for firm *f* in that distance band.

Firm Profits

Firms make entry and location decisions on the basis of the profitability of their choices, consumers' shopping behavior, and their conjectures about competitors' entry and location decisions. They also choose whether to colocate with a rival of the same format or a different format depending on the resulting total profit potential, *f*(.), of a location and the effect of competition, *h*(.), on profits. Whereas the benefits of agglomeration occur through increased profit potential, the benefits of differentiation emerge from acquiring a greater share of that potential as a result of decreased competition.

Formally, a firm *f* from an exogenous potential pool of *F* entrants ($f = 1, \ldots, F$) decides whether to enter market *m* with format *k*, and if it decides to enter, it decides whether to choose location *l*. Upon entry into location *l*, firm *f*'s profit is

$$\Pi_{fkl}^{m} = f(X^{m}, N_{l}^{m}, I_{l}^{MF}; \alpha) h(N_{k}^{m}, \ldots, N_{k'}^{m}, \ldots, N_{K}^{m}; \beta) \tau_{k} \eta_{fl} \xi^{m}, \tag{7}$$

where τ_k is a format-specific scaling factor, η_{fl} is an idiosyncratic firm- and location-specific scaling factor, and ξ^m is a market-specific scaling factor. We assume that η_{fl} is idiosyncratic and known only to the firm, and rivals know it only in distribution. Therefore, we introduce information asymmetry into the model, which we exploit for computing the equilibrium. The market-specific scaling factor ξ^m controls for the unobserved attractiveness of the entire market and thus partly determines the number of firms a market can support. Unlike existing entry literature, which assumes that firms are symmetric (cf. Zhu and Singh 2007), we allow for asymmetric competitive effects. Further, we allow the intrinsic profitability of firms to differ in their format (i.e., due to either cost or efficiency differences) according to a format-specific parameter τ_k. We normalize this parameter to 1 for one of the formats for identification.

The proposed model nests simpler models with no agglomeration effects or those with homogeneous stores. Without agglomeration effects, the profit potential of a location is driven completely by exogenous characteristics X^m, as has been assumed in previous literature. Thus, the effect of the number of neighboring stores N_l^m and the presence of multiple formats I_l^{MF} would not be needed in the potential function *f*(.). The resulting specification for Π_{fkl}^m would be

$$\Pi_{fkl}^m = f(X^m;\alpha)h(N_k^m,...,N_{k'}^m,...,N_K^m;\beta)\tau_k\eta_{fl}\xi^m . \quad (8)$$

If stores cannot be distinguished by formats, all stores are homogenous, and the competitive effect *h*(.) is due only to the total number of rivals that enter the market N^m, and the format-specific scaling factor (τ_k) is not needed. The resulting specification for Π_{fkl}^m would be

$$\Pi_{fkl}^m = f(X^m;\alpha)h(N^m;\beta)\eta_{fl}\xi^m . \quad (9)$$

Thus, the simpler models are embedded in our model.

Equilibrium Choice Probabilities of Firms

Because we consider a joint entry and location choice model, when the decision makers make that choice, the profitability of a store operating in a location is a function of the expected number of rivals of various formats that might enter the market and choose a certain location. A firm cannot observe its rival's idiosyncratic component of profitability but can recognize its distribution, so it can form a conjecture or assign a probability to a rival's choice of a location.

The expected competitive effect of different rivals in different distance bands is given by:

$$h(.) = \prod_b (1+E[N_{kl}^{bm}])^{\beta_{kb}} \prod_b \prod_{k'\neq k} (1+E[N_{k'l}^{bm}])^{\beta_{k'b}} , \quad (10)$$

where

$$E[N_{kl}^{bm}] = N^m * \sum_{j\in L^{bm}} p_{kj}^m \quad (11)$$

is the expected number of rivals of format *k* that choose a location in distance band *b* when N^m rivals enter the market, and p_{kj}^m is the probability of a choice of location *j* (which lies in distance band *b*) in market *m* by a firm of format *k*.

Similarly, on the basis of its conjectures about rivals' and its own actions, the firm calculates an expected potential of the location using expected consumer behavior. Hence, Equation 1 transforms into:

$$U_{il} = \alpha_0 - \alpha_1 d_{il} + \alpha_2 ret_l + \alpha_3 E[N_l] + \alpha_4 E[I_l^{MF}] + \omega_{il} . \qquad (12)$$

In equilibrium, when a firm makes its optimal choices, the resulting strategy, in terms of choice probabilities, matches the strategy of rivals of the same type in each format. Therefore, in equilibrium, the conjectures of each firm about the strategies of all rival firms matches those rival firms' actual equilibrium strategies. This matching demands a nested fixed-point problem in the form of a mapping of the firm's strategy (which is a function of the competitors' strategies) onto competitors' strategies (which is a function of the firm's strategy).

To illustrate the fixed point problem, we take the log transformation of the firms' profit function (Equation 7):

$$\ln(\Pi_{fkl}^m) = \alpha_5 \ln(Inc_l) + \sum_b \beta_{kb} \ln(1 + N_{kl}^{bm}) + \sum_b \sum_{k' \neq k} \beta_{k'b} \ln(1 + N_{k'l}^{bm}) + \ln(\tau_k) + \ln(\eta_{fl}) + \ln(\xi^m) . \qquad (13a)$$

For ease of exposition, we denote the left-hand side as $\tilde{\Pi}_{fkl}^m$ and group the potential and competitive effects together, denoted as $\tilde{\tilde{\Pi}}_{kl}^m$, such that

$$\tilde{\tilde{\Pi}}_{kl}^m = \alpha_5 \ln(Inc_l) + \sum_b \beta_{kb} \ln(1 + N_{kl}^{bm}) + \sum_b \sum_{k' \neq k} \beta_{k'b} \ln(1 + N_{k'l}^{bm}) + \ln(\tau_k) . \qquad (13b)$$

Also, by denoting the idiosyncratic component as υ_{fl} and the market-specific component as $\overline{\xi}^{m}$, we can rewrite Equation 13a as

$$\widetilde{\Pi}_{fkl}^{m} = \widetilde{\overline{\Pi}}_{kl}^{m} + \upsilon_{fl} + \overline{\xi}^{m}. \tag{13c}$$

We assume that the idiosyncratic component follows a Type 1 extreme value distribution and is independent across firm-location combinations.[3] Moreover, we normalize the profitability of not entering the market to 1 (i.e., log transformation equals 0).[4] Let the vector of the equilibrium location choice probabilities [$p_{k1}^{m}, p_{k2}^{m}, ..., p_{kL^m}^{m}$]' of rivals of type *k* (*k'*) be denoted by P_{k}^{m*} ($P_{k'}^{m*}$). Because the market-level unobserved effect $\overline{\xi}^{m}$ is common to all locations, it does not influence the choice of locations after the firm has decided to enter the market. The probability of the choice of a location *l* by a firm entering as type *k* thus is given by the logit form:

$$p_{kl}^{m} = \left(\frac{\exp(\widetilde{\overline{\Pi}}_{kl}^{m})}{\sum_{k=1}^{K} \sum_{g=1}^{L^m} \exp(\widetilde{\overline{\Pi}}_{kg}^{m})} \right) \forall l = 1,..., L^{m}, \forall k = 1,..., K. \tag{14}$$

This system of (K*L^m) equations define the equilibrium location choice probabilities as a fixed point problem. The probabilities of choosing a format and location, conditional on entry, must add up to , we essentially have a system of $K*L^m$ *1* equations in $K*L^m$ *1* unknowns. firm's strategies are continuous in its rivals' strategies, by Brouwer's fixed point theorem, at least one solution exists for this system of equations. Note that since the market-level unobserved

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[3] This assumption does not allow for correlations in profitability across firms for the same location or across locations for the same firm. Such considerations are beyond the scope of this research.

[4] This normalization may be rationalized as a fixed-entry cost that is symmetric across all firms.

effect, $\bar{\xi}^m$, is common for all locations, it does not influence the choice of locations once the firm has decided to enter the market.

The total number of firms from the pool of *F* potential entrants that enter the market is determined by the attractiveness of the locations in the market for all firms and the unobserved market-level term $\bar{\xi}^m$. Because the profitability of not entering the market is normalized to 1 (log transformation equals 0), the probability that a firm enters the market is given by:

$$\Pr(Entry) = \left(\frac{\exp(\bar{\xi}^m) * \sum_{k=1}^{K} \sum_{l=1}^{L^m} \exp(\tilde{\bar{\Pi}}_{kl}^m)}{1 + \exp(\bar{\xi}^m) * \sum_{k=1}^{K} \sum_{l=1}^{L^m} \exp(\tilde{\bar{\Pi}}_{kl}^m)} \right). \tag{15}$$

Hence, the total expected number of entrants in the market, $(N^m + 1)$, is given by:

$$(N^m + 1) = F * \Pr(Entry). \tag{16}$$

By fixing the potential number of entrants *F* and observing the actual number of entrants (N^m+1), $\bar{\xi}^m$ can be estimated as

$$\bar{\xi}^m = \ln(N^m + 1) - \ln(F - N^m - 1) - \ln(\sum_{k=1}^{K} \sum_{l=1}^{L^m} \exp(\tilde{\bar{\Pi}}_{kl}^m)). \tag{17}$$

We assume that $\bar{\xi}^m$ follows a normal distribution, $N(\mu, \sigma)$, whose parameters can be estimated on the basis of the vector of $\bar{\xi}^m$ across the set of markets. Although the pool of potential entrants *F* is not observed, varying the size of this pool should have only a miniscule effect on the location choices, because $\bar{\xi}^m$ adjusts accordingly, relative to the outside option's fixed effect (i.e., choosing not to enter). Hence, we fix the pool size exogenously as twice the actual number of observed entrants. Alternatively, *F* could be fixed as a large number for all markets (e.g., $F = 30$).

Because the probability of entry is a function of the firms' equilibrium conjectures, which in turn is a function of the number of firms that enter the market, a simultaneous solution for this set of equations provides the joint equilibrium predictions for the location choice probabilities and the number of entrants.

Estimation

We identify three store formats in the markets that we analyze and thus tailor our model to three formats ($K = 3$). If we drop the band subscript and denote the competitive effect between format k and format k' as $\beta_{kk'}$, intraformat competition is given by β_{kk}. We estimate the model by maximum likelihood with a nested fixed-point function to estimate the equilibrium location choice probability vectors, P_1^{m*}, P_2^{m*}, and P_3^{m*}, of the firms in each market.

Starting with an initial guess for the parameter vector θ (= [$\alpha, \tau, \beta, \mu, \sigma$]), we first set the probability vectors to 0 in each market. For every market, we can predict consumers' shopping behavior to find the expected potential of each location in the market; then we calculate the elements of the probability vectors as given by Equation 14. We repeat this process for each market until we reach the fixed-points, $P_1^{m*}(\theta), P_2^{m*}(\theta)$, and $P_3^{m*}(\theta)$. Finally, we estimate $\bar{\xi}^m$ as in Equation 17.

The equilibrium probabilities of the observed location choices, stacked across firm types and markets, enters the conditional likelihood function:

$$L(\theta_1 | \mu, \sigma) = \prod_{m=1}^{M} \prod_{k} \prod_{l} \left(p_{lk}^m(\theta_1, X^m, N^m)\right)^{\mathrm{I}(l=l_k^m)}, \qquad (18)$$

where $\theta_1 = [\alpha, \tau, \beta]$), and $I(l = l_k^m) = 1$ if location l is chosen by a firm of type k and is 0 otherwise. The unconditional likelihood function is:

$$L(\theta) = \prod_{m=1}^{M} \prod_{k} \prod_{l} \left(p_{lk}^m(.)\right)^{\mathrm{I}(l=l_k^m)} * \phi(\bar{\xi}^m, \mu, \sigma), \qquad (19)$$

where $\phi(.)$ is the pdf of the normal density.

As we discussed previously, a challenge of this estimation approach is the possibility of multiple equilibria. The system of equations for the conditional location choice probabilities is:

$$\Psi(\text{p, X, N}) = \text{p - F(p, X, N)} = 0\,. \qquad (20)$$

A solution is ensured by Brouwer's fixed-point theorem. The sufficient condition for uniqueness is that the matrix of partial derivatives of Ψ with respect to **p** is a positive dominant diagonal matrix, or that

$$\frac{\partial \Psi_l}{\partial p_l} > 0$$
$$\left|\frac{\partial \Psi_l}{\partial p_l}\right| \geq \sum_{k \neq l} \left|\frac{\partial \Psi_l}{\partial p_k}\right| \qquad (21)$$

We verify ex post that the unique equilibrium criteria are satisfied at the estimated parameter values.

Identification

To identify our model with agglomeration–differentiation effects, (1) the model must make different predictions for where firms will agglomerate or differentiate as a function of the market characteristics and (2) there should be sufficient variation in the market characteristics that would predict agglomeration in some markets and differentiation in others. According to the model, when concentrations of consumers with high incomes that can sustain stores on their own exist, firms choose to differentiate and avoid competitive effects. But when the concentration of local market potential cannot support a store and consumers and incomes are more dispersed, firms choose to agglomerate through colocation. Colocation also should be greater when business density is disproportionately high in certain areas, which increases that location's market potential because of its ability to attract new customers from outside the location.

We determine whether the data are consistent with this identification argument and report the coefficients of variation (standard deviation/mean) for population, income, and business density in Table 3. Agglomeration is greater in areas where populations and income are more spread out, that is, where the coefficient of variation is greater. Agglomeration also is greater in locations with higher business density (see Table 2) and a lower coefficient of variation in business density. The coefficient of variation varies considerably across locations (in most cases, the standard deviations are comparable to the means). Thus the two characteristics above are satisfied, which enables us to identify the model.

Data

Description of Data

For our analysis, we use a data set obtained from a traditional supermarket chain, which we henceforth call Chain A. The chain operates in several states in the United States, and we possess data from 146 markets in which this chain's stores are located. We use the same definition for a market as that used by Chain A, based on a trade radius that it considers appropriate, given the competitive structure of grocery markets. The trade radius is smaller for urban markets and larger for rural markets (average = 4.44 miles for urban markets and 7.16 miles for rural markets). We also gather data on the coordinates (latitude and longitude) of all major grocery stores in these 146 markets. Each market consists of several hundred census blocks, for which we have data about the coordinates and demographics. To simplify our analysis, we define a location as a collection of some number of census blocks, identified by 12-digit codes: SS-CCC-BBBBBBB. The first two digits represent the state, the next three represent the county, and the last seven digits stand for the specific census block. We group census blocks with the same first nine digits to define a location.[5] This approach divides each market into a reasonable number of locations. We assume the coordinates of each location are the averages of

[5] Some applications (Seim 2006; Watson 2007; Zhu and Singh 2007) that work with census tracts group several tracts (e.g., those within a county with the same first three digits) to define a location.

the coordinates of the census blocks within that location; consistent with existing literature, we assume all consumers and stores within a location appear at these coordinates.

We supplement the demographic data with data pertaining to the number of retail establishments at the zip code level, obtained from the U.S. census. Therefore, we assume that a location belongs to the zip code that is nearest to it (the U.S. census also provides coordinates of the zip codes) and that the retail establishments are distributed uniformly across the locations within a zip code. We take this approach because retail establishment data are available only at the zip code level, not at the census block level, and we do not expect any systematic errors as a result. In Table 4, we present the summary statistics for our data.

Identification of Store Formats

Data on store interaction ratings identify the different formats of grocery stores operating in these markets. Chain A rates its competitors in each market according to the extent of their interaction. These interaction ratings are based on the similarity in store formats and the overlap between their trade areas. In Table 5, column A, we provide the mean interaction ratings of different store chains across all markets. Over all markets, we ran regressions of interaction ratings across different store chains and their distances from the focal Chain A store. In Table 5, Column B, we provide estimates of the individual regressions and interaction ratings for each store chain after we control for distance.

On the basis of the estimates in Table 5, we cluster store chains B and C as closest to Chain A in terms of store format, followed by store chains D and E, and then the remainder. Our knowledge of the grocery market indicates that store chains A, B, and C actually employ a supermarket format (SMF),[6] whereas chain D follows a superstore format (SSF), and store chain

[6] Articles from the popular press suggest that in the markets we analyze, these three store chains were very close competitors for the period that we analyze.

E is similar to a SSF. We group the other store chains, which include food stores, dollar stores, limited assortment grocery stores, warehouse clubs, and others, into a third type, which we call the "Other" store format (OSF).

Results

Homogeneous Firms

We present the results for a benchmark model with only homogeneous firms in Table 6. Here we compare estimates with and without modeling the agglomeration effect. Because of the homogeneity assumption in this benchmark model, we account only for the store agglomeration effect, not the format agglomeration effect.

We consider three distance bands of less than 1 mile (b_0), 1–3 miles (b_1), and 3–5 miles (b_2). The log-likelihoods demonstrate that accounting for agglomeration effects significantly improves the fit ($p < .001$). Both model estimates have the expected signs. Consumers experience disutility from traveling to stores; they value a location with more retail businesses (# Retail Business), consistent with the economies of scope hypothesis. The coefficient for potential is not significantly different from 1, which suggests that stores choose locations under the premise that grocery spending for consumers is proportional to their income. In both cases, competitive effects decrease dramatically with distance. Rivals that are more than 3 miles away have negligible impacts on each other, which is not surprising in grocery markets, because consumers tend to shop at nearby supermarkets[7]. In our subsequent analysis, in which we distinguish formats, we consider only the first two distance bands to reduce the estimation costs.

We find clear evidence for a store agglomeration effect. Not only does the model with store agglomeration effects fit the data better but ignoring it biases estimates of both consumer

[7] As per the International Council of Shopping Centers' classification of shopping centers (DeLisle, 2005), a Neighborhood Center with a supermarket as its anchor store has a primary trade radius of 3 miles.

utility and competitive effects. The estimates that fail to model store agglomeration underestimate both the consumer's disutility from travel for shopping and the competitive effect. This is expected because in the data when consumers and incomes are more dispersed and stores collocate, the simpler models incorrectly predict that consumers must be willing to travel greater distances (i.e., they have a lower disutility from travel), and that the competitive effect must be low, which allows stores to collocate. Specifically, the model without store agglomeration estimates disutility per mile for shopping as –.3139, whereas the corresponding estimate for the model with store agglomeration is –.4637, a 47% difference. Similarly, failing to account for the store agglomeration effect underestimates the competitive effect.

To understand how the competitive effect affects profits, we compute how profits of Chain A stores change with the addition of a new competitor in the different distance bands. New entry affects both customer choice and competitive effects. If a competitor agglomerates with an existing store at a distance of 0–1 miles, the change in profits results from the increased potential of the location because of the agglomeration and also from the increased competition because of colocation.

If the store agglomeration effect is not modeled (Table 7, column a), when a new competitor decides to enter within 1 mile of Chain A stores in all markets, the store's profits are estimated to decrease by an average of 65.6% (maximum = 75%; minimum = 36.7%). However, the competitive effect decreases dramatically with distance, such that for a new competitor entering within 1–3 miles of Chain A stores, the profits are estimated to decrease by only 8.35% on average (maximum = 13.3%; minimum = 1.8%). When we also model the store agglomeration effect, as in Table 7, column b, we find that when a new competitor enters within 1 mile of Chain A stores, the potential of the location increases by approximately 20%

(maximum = 23.6%; minimum = 17.1%). Overall, the profits of Chain A are estimated to decrease by an average of 60.4% (maximum = 73%; minimum = 23.4%). Thus, omitting the agglomeration effect gives biased results.

Previous research often assumes an additive profit function in terms of the number of competitors, so that the incremental effect of each additional competitor is the same. Our multiplicative functional form for profits realistically allows for proportional effects of competition on profits as a function of the potential of the location and the location of already existing competitors in the market.

Three Different Store Formats

We present the results for the complete model, which allows for format-specific effects, in Table 8. Because we distinguish among stores of three formats—SMF, SSF, and OSF—we allow for a format agglomeration effect. That is, the consumer may gain additional utility from a cluster if it consists of multiple formats. Competition between two firms with the same format A in distance band b equals $(A - A)b$, whereas competition between firms of different formats A and B in a distance band b is denoted $(A - B)b$.

The estimates again display the expected signs. Consumers benefit if the location has more retail businesses, and they receive a disutility from travel. We again find evidence of both store and format agglomeration benefits; that is, consumers benefit from the colocation of stores and the colocation of formats. This finding is in line with previous theoretical research, which suggests that in a cluster of heterogeneous firms (different formats), consumers anticipate better chance of finding a product–price match. The grocery spending of consumers (potential) is roughly proportional to their income. Finally, the negative intercepts for SSF and OSF suggest that these formats tend to have a higher threshold for profit than does the SMF. This result matches our observation in the data that these formats do not enter in some markets.

When we compare the different kinds of competition faced by firms, we find that, not surprisingly, intraformat competition affects profitability roughly twice as much as does interformat competition, which is critical because for the homogeneous case, we assumed that the competitive effect of a rival is the same, irrespective of its format. The competitive effects of SSF and OSF on the SMF not only support our assumption of three different formats in the market but also fall in line with our analysis of store interaction ratings, in which we showed that on the store format dimension, SSF are closer to SMF than are OSF. The within-type competition at greater distances (1–3 miles) is greatest for SSF. In addition, the high uncertainty surrounding the estimate of (SSF – SSF)0 reflects that very few markets in our data contain two SSF within a radius of 1 mile.

The differences in intraformat versus interformat competition can be illustrated by a simulation in which we imagine a new entrant that locates within 1 mile of Chain A stores but belongs to any of the three formats. When the new entrant is either a SSF or OSF, in addition to the store agglomeration effect, the SMF Chain A experiences a format agglomeration effect that affects its profits positively. Also, because the interformat competitive effect is smaller than that of intraformat competition, the net effect on profits should be lower than if the entrant uses SMF. As we suggest in Table 9, a new SMF entrant in the 0–1 mile range decreases Chain A's profits by an average of 77.2% (maximum = 82.6%; minimum = 44.1%). However, if the entrant were a SSF, profits decrease by only 54.1% on average (maximum = 64.5%; minimum = 16.5%). Finally, an OSF entrant means the positive externalities dominate, and net profits could increase (average increase = 17%). Similar detailed type-specific results emerge for firms with the other two formats as well. These asymmetric effects would not occur if we assumed that all firms have similar competitive effects, as previous research has done. We next illustrate the implications of our results for firms' entry and location choice strategies through counterfactual simulations.

Counterfactual Simulations

To illustrate our results using counterfactual simulations, we generate a hypothetical 8 × 8 square market with 64 locations, with a randomly generated distribution of population, per capita income, and retail business in these locations. In Figure 1, we depict the distribution of these variables in the market. We use our estimation results to determine the location choice probabilities of different store formats for the case in which four firms can enter the market. In Figure 2, we portray how firms' optimal strategies transform the distribution of total income of consumers (Pop × PCI) into the potential across locations, and in Figure 3, we depict these strategies (i.e., probability distributions of location choices for different formats). The four firms that enter the market include one SMF, one SSF, and two OSF. The firms choose their locations according to the predictions of the static entry model. In Figure 4, we show the characteristics of the market locations and the locations chosen by these stores.

The model estimates enable us to predict the location choice strategy of a new entrant that can observe the chosen locations of the existing firms. In our hypothetical market, after the four stores have entered, we assume a previously unexpected increase in the unobserved exogenous demand (ξ^m), so that a fifth firm can enter the market. If that fifth firm is a SMF entrant, we can compare the predicted location choice when the agglomeration effects are modeled versus when the model ignores them and find that the entrant chooses to colocate with the SSF so it can reap the benefits of format agglomeration at that location while still maintaining a comfortable distance from the SMF incumbent (Figure 5, Panel a). Ignoring the benefits of agglomeration would cause an erroneous prediction for the entrant's location choice (Figure 5, Panel b). Thus, modeling the differentiation–agglomeration trade-off is critical for firms to arrive at accurate predictions about their location choice strategies for given market conditions.

Conclusion

Retail store chains looking for growth opportunities must make crucial entry and location decisions. We estimate a structural model of entry and location choice to investigate the nature of competition among different grocery store formats as a function of their locations. As we show, previous research in this area, which focuses only on the differentiation benefit of locating far apart, fails to capture the agglomeration benefits of colocation and therefore cannot explain observed colocations. By decomposing firm profits, typically modeled in a reduced form in structural entry and location literature, into the constituent elements of customer location choice and competitive effects, we disentangle the differentiation–agglomeration trade-off.

In particular, we find support for agglomeration benefits from both format and store agglomeration, in support of both the economies of scope and hold-up avoidance arguments behind agglomeration. Furthermore, consumers suffer high travel costs, and the extant of competition decreases dramatically with distance. Ignoring agglomeration effects significantly biases estimates of travel costs and the extent of competition. Intraformat competition reduces profits at twice the rate of interformat competition, and our policy simulations show that disentangling the agglomeration–differentiation trade-off is critical if firms want to arrive at the correct entry and location decisions.

We conclude with a discussion of some of the limitations of our research and some suggestions for further work. Although our focus is on the choice of a geographic location, researchers could apply a similar approach to choice of location in product spaces. Therefore, our approach can be extended to the development of new products or new services.

We use Seim's (2006) approach, which requires a unique equilibrium and shows parametric conditions where the uniqueness condition is satisfied. Research using two-step approaches (Bajari et al. 2006; Ellickson and Misra 2007) sidesteps the multiple equilibria issue, but they are not efficient. Recently, Su and Judd (2007) developed mathematical programming with equilibrium constraints approaches that are both efficient and avoid the multiple equilibria problem; it therefore would be worthwhile to try this alternative approach to the problem discussed herein.

Finally, we treat entry and location decisions within a static equilibrium framework, even though these decisions are made over time and therefore might be better modeled in a dynamic framework. This modeling approach would require richer data (i.e., timing of entry), as well as richer modeling frameworks to solve the dynamic game. These interesting issues await additional research.

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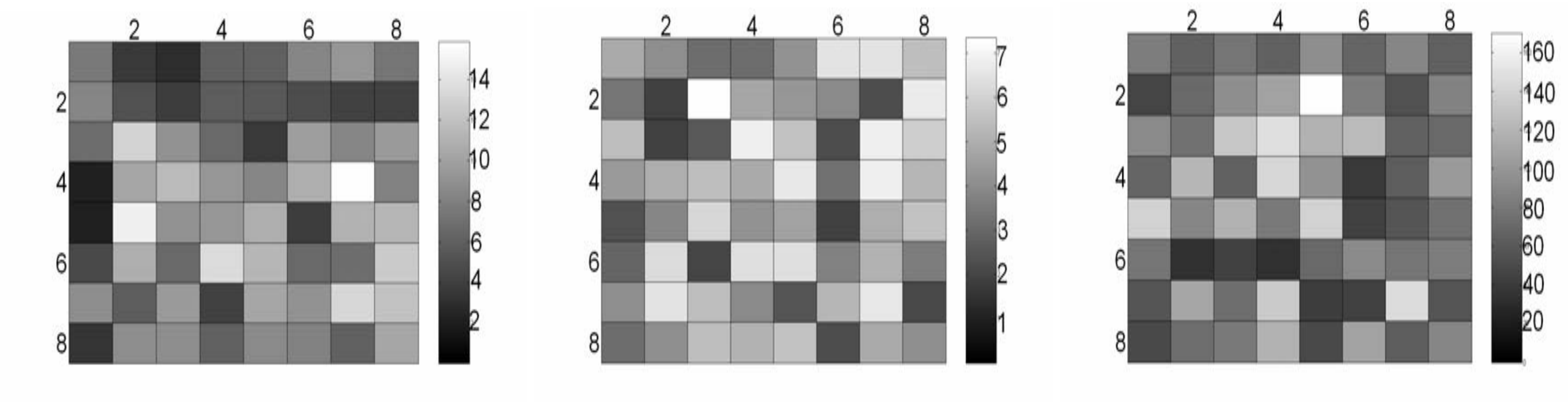
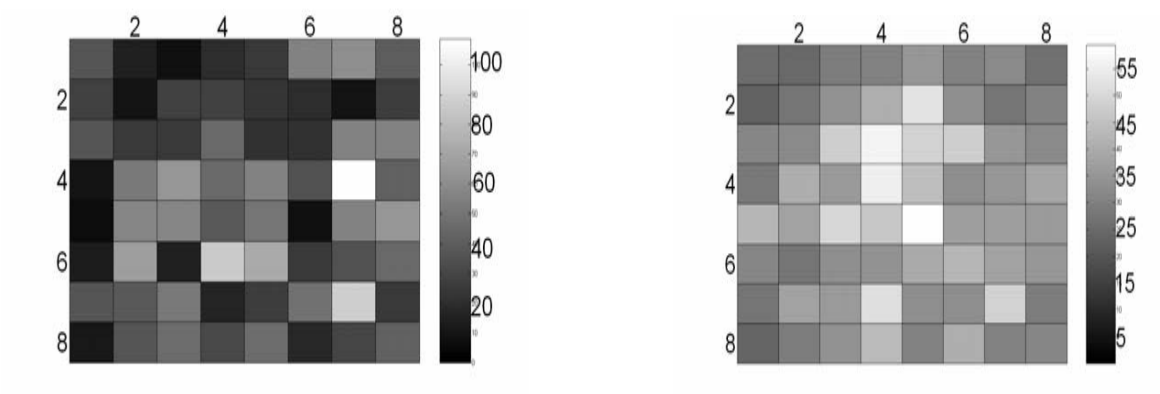
Counterfactual Simulation (8X8 square market)



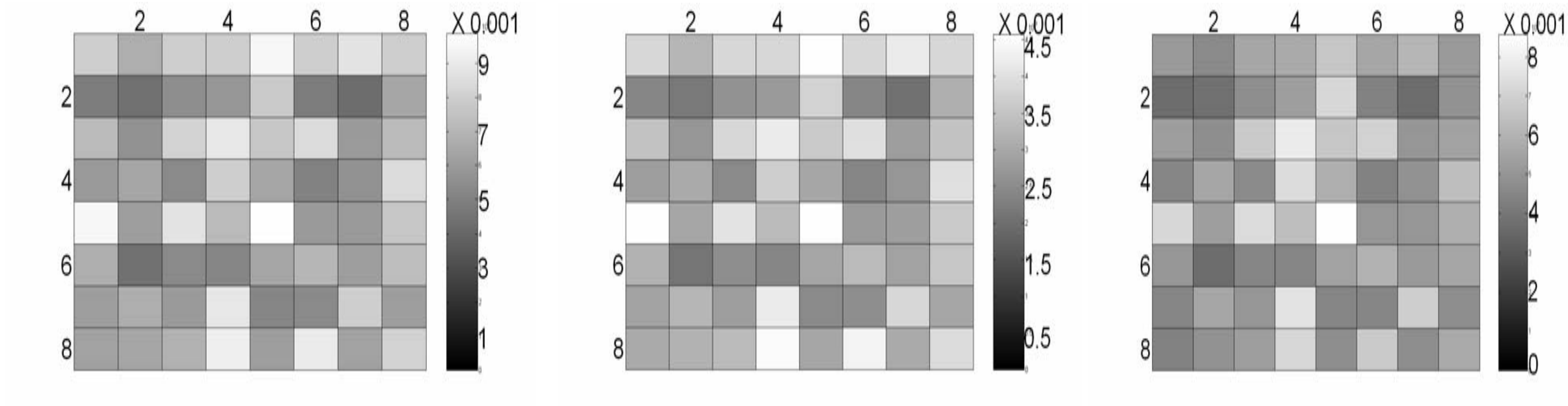
Population (in 100s) **Per Capita Income (in $10,000s)** **# Retail Businesses**

Figure 1: Distribution of Population, Per Capita Income, Business Density, and Estimated Potential in Simulated Market



Total Income (in $M) **Estimated Potential (in $M)**

Figure 2: Distribution of Total Income and Estimated Potential in Simulated Market



Supermarket Format **Superstore Format** **Other Store Format**

Figure 3: Distribution of Location Choice Probabilities in Simulated Market for Different Store Formats

Location 1 P = 756, R = 84, I = $49,000	Location 2 P = 350, R = 64, I = $,40,800	Location 3 P = 274, R = 77, I = $31,000	Location 4 P = 620, R = 65, I = $31,000	SSF P = 599, R = 95, I = $42,300	Location 6 P = 841, R = 68 I = $64,800	Location 7 P = 920, R = 89 I = $64,800	Location 8 P = 723, R = 66 I = $54,400
Location 9 P = 838, R = 45, I = $34,000	P = 499, R = 70, I = $18,600	P = 383, R = 93, I = $73,400	P = 590, R = 108, I = $48,000	P = 547, R = 170, I = $42,900	P = 490, R = 83, I = $39,400	P = 419, R = 55 I = $22,700	P = 399, R = 87 I = $66,600
Location 17 P = 689, R = 91, I = $54,000	P = 1,305, R = 76 I = $18,700	P = 916, R = 131 I = $26,200	OSF P = 667, R = 148, I = $68,000	P = 367, R = 119 I = $55,700	P = 988, R = 124 I = $21,900	P = 825, R = 66 I = $67,700	P = 944, R = 69 I = $58,500
Location 25 P = 206, R = 69, I = $44,000	P = 1,030, R=121 I = $50,000	P = 1,165, R= 64, I = $54,900	P = 920, R = 141, I = $48,800	P = 839, R = 98, I = $66,000	P= 1,083, R = 38 I = $32,800	P = 1,589, R = 63 I = $68,500	P = 799, R = 103, I = $52,000
Location 33 P = 221, R = 138, I = $23,700	P = 1,478, R = 88 I = $38,100	P = 914, R = 119 I = $61,800	P = 927, R = 82, I = $41,300	SMF OSF P = 1,079, R=140 I = $46,000	P = 388, R = 43, I = $19,100	P = 1,103, R = 58 I = $49,800	P = 1,128, R = 75 I = $56,000
Location 41 P = 450, R = 78 I = $29,800	P = 1,087, R = 33 I = $62,500	P = 661, R = 44, I = $20,600	P = 1,349, R = 33 I = $63,100	P = 1,120, R = 71 I = $64,200	P = 662, R = 92 PCI = $37,300	P = 675, R = 78 I = $51,000	P = 1,250, R = 83 I = $36,000
Location 49 P = 879, R = 58 I = $41,000	P = 579, R = 109, I = $65,000	P = 953, R = 73 I = $54,100	P = 420, R = 134, I = $39,200	P = 1,037, R = 40 I = $25,200	P = 915, R = 43 I = $52,300	P = 1,330, R=144 I = $66,300	P = 1,194, R = 58 I = $21,200
Location 57 P = 340, R = 48 I = $31,000	P = 890, R = 74 I = $41,000	P = 870, R = 81 I = $54,500	P = 604, R = 118, I = $51,500	P = 845, R = 48, I = $55,900	P = 810, R = 109 I = $22,100	P = 620, R = 63 I = $48,600	P = 1,030, R = 90 I = $41,000

Notes: P, population; R, # retail businesses, I, per capita income, SMF, supermarket, SSF, superstore, OSF, other store format.

Figure 4: Equilibrium Store Locations in the Simulated Market

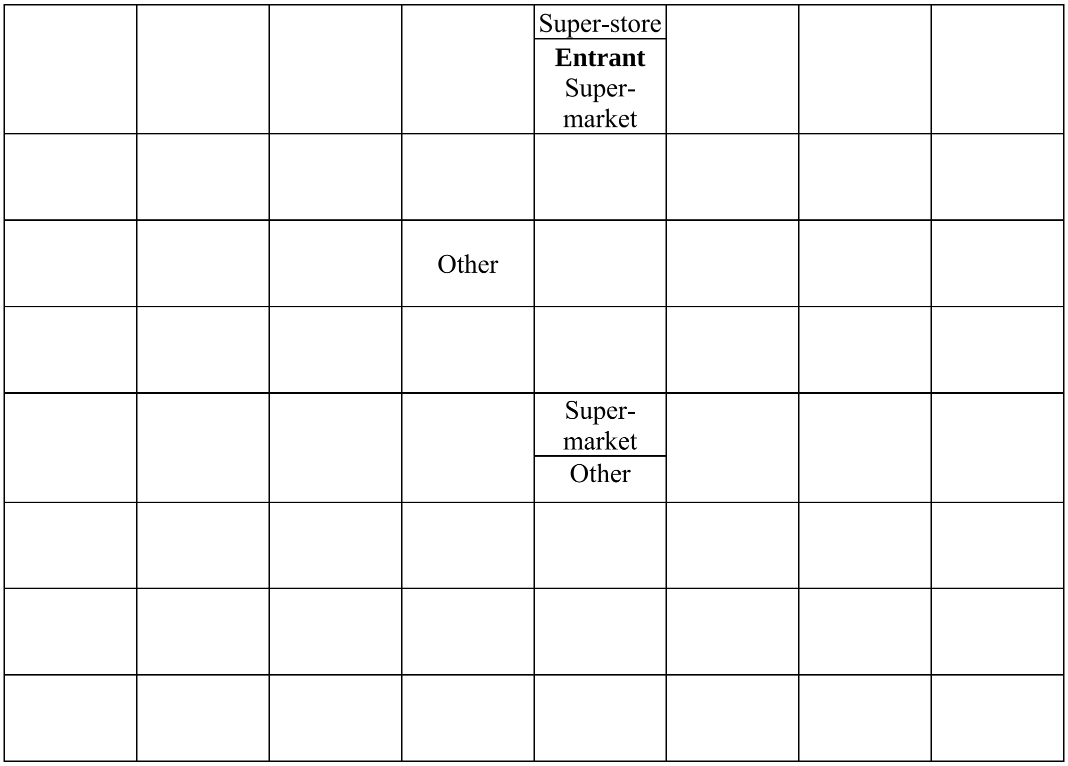


Figure 5(a): Entrant's Location when Model Includes Agglomeration Effects

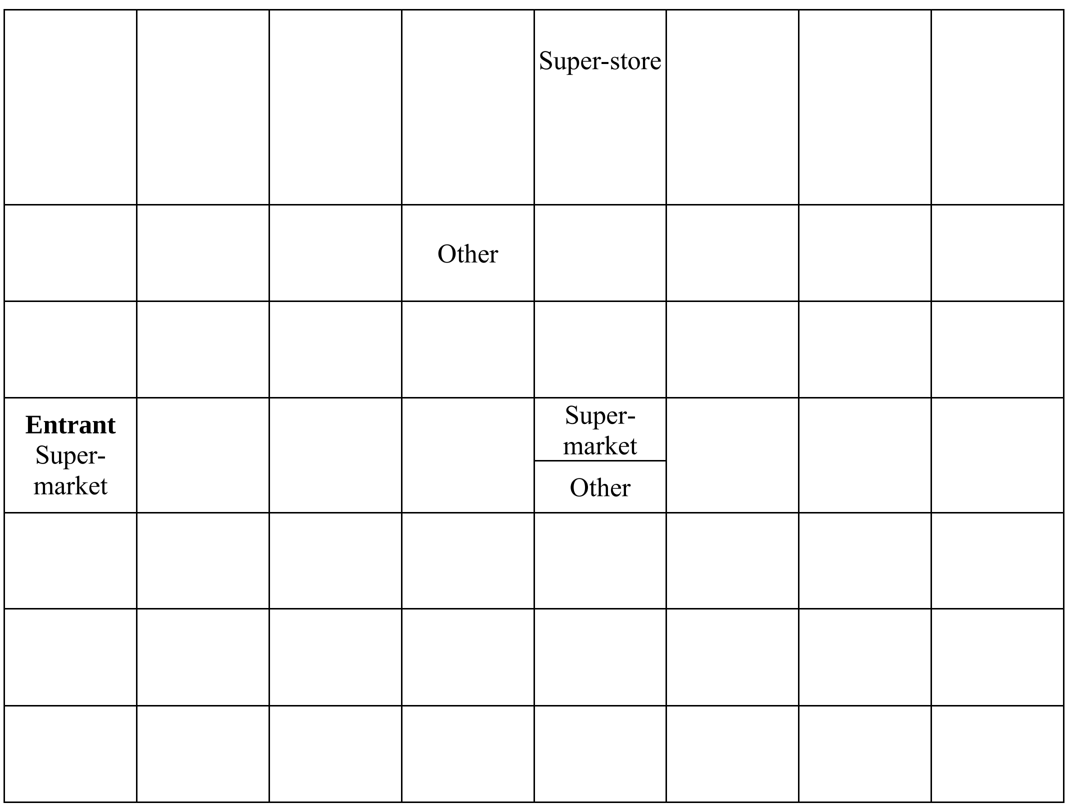


Figure 5(b): Entrant's Location when Model Does Not Include Agglomeration Effects

Table 1: New Store Openings for Retailers

SPECIALITY	2001	2002	2003	2004	2005	2006	2007 (proj.)
Abercrombie	137	106	103	88	63	104	95
American Eagle	62	28	52	41	23	56	40
Ann Taylor	60	46	64	90	86	76	70
Bombay Company	11	3	49	31	-4	-46	-42
Buckle	21	9	12	11	11	16	16
Claire's Stores	-144	48	28	31	66	90	85
Coach	19	23	20	18	25	29	40
GAP	249	20	-95	-28	59	-3	0
Pacific Sunwear	129	73	86	113	115	100	95
Sharper Image	12	18	22	26	15	0	0
Talbot's	78	86	91	72	34	67	50
Total	**634**	**460**	**432**	**493**	**493**	**489**	**449**
ANCHOR							
Dillard's	1	-5	-5	1	1	5	5
Federated	18	-3	4	0	486	-80	5
JCPenney	-36	-14	17	1	-60	21	40
May's	18	4	1	57	-501	0	0
Nordstrom	15	11	13	2	7	2	5
Total	**16**	**-7**	**30**	**61**	**-67**	**-52**	**55**
COMMUNITY							
Cost Plus	48	0	29	33	33	17	23
Dollar General	540	573	587	620	609	525	-175
Dress Barn	31	34	18	4	-65	67	44
Family Dollar	452	475	411	439	432	275	335
Men's Wearhouse	29	9	41	4	18	25	5
Office Depot	-29	8	33	69	78	108	125
Pier 1	75	100	105	79	42	-25	-10
Ross Stores	43	55	61	81	71	75	90
TJX	172	178	219	162	161	101	104
Total	**1,361**	**1,432**	**1,467**	**1,501**	**1,379**	**1,168**	**541**
COMMUNITY/POWER ANCHORS							
Target	74	94	78	-245	89	98	115
Wal-Mart	315	364	372	349	352	349	260
Total	**389**	**458**	**450**	**104**	**441**	**447**	**375**
POWER ANCHORS							
BJ's	12	10	10	7	8	10	13
Bed Bath & Beyond	80	130	103	92	88	81	90
Circuit City	-5	2	-22	13	18	20	0
Costco	52	9	23	20	16	22	30
Home Depot	203	195	175	183	152	118	90
Lowe's	94	110	98	135	147	155	151
Total	436	456	387	450	429	406	374

Source: Company Reports, Merrill Lynch

Table 2: Average Demographics by Location With and Without Agglomeration

		Store Locations Where Nearest Rival Is More than 2 Miles Away	Store Locations Where Nearest Rival Is Within Half Mile
Population ($\times 10^3$)	0–1 mile	31.47	22.52
	1–3 miles	158.87	95.39
	> 3 miles	209.8	259.69
Per capita income ($\times 10^3$)	0–1 mile	19.4	20.8
	1–3 miles	18.9	20.0
	> 3 miles	20.5	19.8
Cumulative income ($\times 10^6$)	0–1 mile	57.39	45.00
	1–3 miles	280.12	185.73
	> 3 miles	430.80	513.83
# Retail businesses	0–1 mile	97.4	121.15
	1–3 miles	90.88	111.58
	> 3 miles	87.57	74.44

Table 3: Coefficients of Variation by Markets

With and Without Agglomeration

		Store Locations Where Nearest Rival Is More than 2 Miles Away ***Average (Std. Dev.)***	Store Locations Where Nearest Rival Is Within Half Mile ***Average (Std. Dev.)***
Population ($\times 10^3$)	0–1 mile	0.1067 (0.1841)	0.2011 (0.1972)
	1–3 miles	0.3756 (0.1999)	0.4189 (0.1688)
	> 3 miles	0.4977 (0.1941)	0.5133 (0.2620)
Per capita income ($\times 10^3$)	0–1 mile	0.0673 (0.1239)	0.1516 (0.1860)
	1–3 miles	0.2686 (0.1391)	0.3137 (0.1733)
	> 3 miles	0.3423 (0.1669)	0.3851 (0.1938)
Cumulative income ($\times 10^7$)	0–1 mile	0.1163 (0.1989)	0.2498 (0.2587)
	1–3 miles	0.5013 (0.2544)	0.5604 (0.2091)
	> 3 miles	0.7168 (0.2946)	0.7338 (0.3583)
# Retail businesses	0–1 mile	0.1537 (0.2899)	0.0780 (0.2200)
	1–3 miles	0.5664 (0.4478)	0.6027 (0.4207)
	> 3 miles	0.6684 (0.4042)	0.7690 (0.3684)

Table 4: Summary Statistics of Data

Total Number of Markets	146	
	Mean	Std. Dev.
Number of stores in a market	4.6	2.5
Market radius (miles)	5.85	1.89
Number of locations in a market	29.74	27.66
Population in a location	951.3	618.4
Per capita income in a location	17,859	9,537
Retail establishments in a zip code	81.23	69.98

Table 5: Store Interaction Ratings for Different Store Chains

Store chain	A. Average Rating	B. Rating after Controlling for Distance
B	7.75	15.23
C	7.31	9.78
D	5.60	8.23
E	5.16	8.12
F	3.68	5.71
G	4.82	5.20
H	4.24	4.94
I	3.49	4.60
J	3.41	4.34
K	2.48	3.46
L	1.94	2.12

Table 6: Results with the Assumption of Homogeneous Firms

	A. Without Agglomeration Effect		B. With Agglomeration Effect	
Consumers' Shopping Behavior				
# Retail businesses (100)	**0.4483**	(0.0664)	**0.4241**	(0.0867)
Distance (in miles)	**-0.3139**	(0.0589)	**-0.4637**	(0.0577)
Store agglomeration effect	-	-	**0.2660**	(0.0525)
Store Profitability				
ln(Potential)	**1.1375**	(0.1608)	**1.1623**	(0.1696)
ln(# Rivals in 1mi.)	**-3.3468**	(0.1637)	**-3.8907**	(0.1337)
ln(# Rivals in 1-3mi.)	**-0.2056**	(0.0412)	**-0.3341**	(0.0547)
ln(# Rivals in 3-5mi.)	-0.0369	(0.0381)	-0.0281	(0.0558)
Mean Exgns unobv, μ	**-6.2772**	(0.3719)	**-5.9701**	(0.3826)
Std Exgns unobv, σ	**0.6864**	(0.0529)	**0.6983**	(0.0552)
Negative log-likelihood	2166.61		2161.34	

Table 7: Reduction in Chain A's Profits Because of a New Entrant Within 1 Mile

Estimated Reduction in Profits	When Agglomeration Effect is Not Modeled (a)	When Agglomeration Effect is Modeled (b)
Average	65.6%	60.4%
Maximum	75.0%	73.0%
Minimum	36.7%	23.4%

Table 8: Asymmetric Competition Among Three Store Formats

Consumers' shopping behavior								
# Retail Businesses (100)	**0.4410**	(0.0623)						
Distance in miles	**-0.4181**	(0.0715)						
Store agglomeration effect	**0.2151**	(0.0743)						
Format agglomeration effect	**0.0765**	(0.0218)						
Store profitability								
Ln(Potential)	**1.1325**	(0.0741)						
Intra-format competition								
(SMF-SMF)0	**-5.1874**	(0.2480)	(SSF-SSF)0	**-4.6672**	(1.4621)	(OSF-OSF)0	**-3.4253**	(0.3891)
(SMF-SMF)1	**-0.3579**	(0.0937)	(SSF-SSF)1	**-0.5191**	(0.1932)	(OSF-OSF)1	**-0.2845**	(0.0923)
Inter-format competition								
(SMF-SSF)0	**-2.3126**	(0.2841)	(SMF-OSF)0	**-0.7733**	(0.1482)	(SSF-OSF)0	**-2.3966**	(0.2891)
(SMF-SSF)1	0.0060	(0.0475)	(SMF-OSF)1	0.1057	(0.1215)	(SSF-OSF)1	**-0.2743**	(0.0389)
SSF intercept*	**-0.7033**	(0.0681)	μ	**-3.5248**	(0.2984)			
OSF intercept	**-0.5689**	(0.0314)	σ	**0.6810**	(0..0571)			
Negative log-likelihood	2769.70							

SMF –

Notes: Supermarket format; SSF – Superstore format; NSF – Niche store format; (SMF-SMF)0 – Competition between two supermarket stores that are within 1 mile of each other; (SMF-SMF)1 - Competition between two supermarket stores that are 1-3 miles from each other; Similarly others.

*For SMF, we normalize the intercept to 0 for identification.

Table 9: Reduction in Chain A's Profits Because of a New Entrant Within 1 Mile

Reduction in Profits	SMF Entrant	SSF Entrant	OSF Entrant
Average	77.2%	54.1%	-17.0%
Maximum	82.6%	64.5%	1.8%
Minimum	44.1%	16.5%	-41.2%