A NORMATIVE EVALUATION OF CORNER STORE POSITIONING - Under Modeling of Traffic Orientation and Consumer Driving Preferences

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ABSTRACT

In this paper, we put forward the following principle: Ceteris paribus, in countries where traffic advances on the right (left) side of the street, a convenience corner store should be positioned clockwise (counterclockwise) with regard to the already established rival stores. The principle is derived within a straightforward framework of corner store competition linking vehicle traffic flow with store potential.

1. INTRODUCTION

Although traffic pattern has been recognized as an important element affecting optimal store positioning, its intrinsic nature has not been formally modeled in either marketing or economic models which analyze spatial competition. This paper demonstrates the importance of such modeling by deriving the following normative micro-principle for corner store positioning:

> In countries where traffic advances on the right (left) side of the street, ceteris paribus, a convenience corner store should be positioned clockwise (counter-clockwise) next to the already established rival stores.

This principle will be qualified within a simple spatial framework. The purpose of our effort is to offer a complementary building block for systems analyzing positioning of convenience stores in marketing.

In marketing, the development of store location models is summarized in a recent review by Craig, Ghosh and McLafferty [1].

Location allocation models (e.g., Ghosh and Craig [8], Goodchild [10]) which attempt to allocate demand and select sites simultaneously, represent the more recent approach to analyzing location strategies. For instance, in their modified dynamic location allocation model, Ghosh and Craig [8] examine different aspects of spatial competition under different scenarios, using a game theoretic framework. To evaluate store potential at different sites, they integrate the Multiplicative Competitive Interaction (MCI) model (Nakanishi and Cooper [32]) into the location allocation systems. In two studies (Jain and Mahajan [23], Hansen and Weinberg [11]), MCI has provided a suitable procedure for evaluating the probability of store site selection when a variety of demographic and non-demographic attributes are considered as independent variables.

However, MCI suffers from the major limitation of Luce's utility model--assuming the independence of irrelevant alternatives. Hence, less restrictive models common in the study of quantal choice, such as Multinomial Logit (McFadden [30], [31]) and Elimination by Aspects (Tversky [38]) are likely to replace MCI in future work. See, for example, Weisbroad, Parcels, and Kerr [39]) for recent application of multinomial logit.

Luce's choice model was also the basis for the pioneering effort of the Gravity Model (Huff [20], [21]) and its continuing generalization (see Gautschi [6], Houston and Stanton [17]).

Since these models are of more restricted functional forms as compared with the MCI's, they often yield lower goodness of fit statistics in empirical studies. However, they retain the clarity of the Huff's model and preserve some congruence with Losch's [28] assumptions on spatial demand, and with Lerner and Singer's [27] generalization of the seminal Hotelling [16] framework.

This bridging with considerations present in spatial economic models is encouraging, since in the past decade we have witnessed a revival in the study of oligopolistic models in general and in spatial economics in particular. The Hotelling framework, in particular, has been extended by considering the ramifications of changing a variety of its assumptions. See Eaton and Lipsey [4]. Other examples are Hay's [12] examination of the positioning of several plants, rather than a single plant, and Prescott and Visscher's [34] study of dynamic sequential competitive positioning of sites under Stackelberg's type of assumptions. Spence ([36]) and Gilbert and Newberry [9], among others, have emphasized the instrumental role of location decisions in deterring the entry of new firms. However, to the best of our knowledge, these models have not taken into account the intrinsic nature of traffic orientation (whether traffic advances on the lefthand or righthand side of the street) and, hence, its effect on store competition.

We will demonstrate that such a deficiency is not warranted by presenting a model which links traffic orientation to optimum store positioning. Due to the space limitations of this paper, the assumptions of the model will be presented in highly condensed form and mathematical derivations of results will be omitted. However, a full specification of assumptions and derivations can be found in Hibshoosh [13].

2.0 ASSUMPTIONS OF THE MODEL

2.1 Consumer Driving Preferences

In a variety of contexts, human beings treat entities such as physical effort, negative emotions, time, and cognitive attention as expenditures which, without reasons to do otherwise, they seek to minimize (e.g., Homans [15], Norman [33], Kellerman [24]). We believe that traveling in an auto constitutes one of these contexts, and that travelers drive so as to save time, avoid stress, and minimize cognitive attention and physical effort.
Given these criteria, a strict preference order for traffic movements results. Specifically, a driver entering an intersection is most likely to continue forward, less likely to turn right, still less likely to turn left, and least likely to execute a U turn.

Estimating the probabilities of turning increments with a set of similar micro-situations has been a prevalent approach to modeling traffic flows and designing roadways (Huber [19], Homburger [37]).

Some of the physical restrictions traffic engineers build into roadways to facilitate traffic flow increase the likelihood of this preference order (Hulbert [22]). For example, stop lights are generally programmed so that the time allotted for turning left is much shorter than the time allotted for autos moving straight through the intersection (Homburger et al. [37]).

2.2 A "Nearest Store" Hypothesis

We assume that potential customers prefer to shop at the nearest store, where by "nearest store" we mean specifically:

- The first store along a driver's travel path.

o A store within minimal walking distance. Drivers do not, for instance, park their cars and walk to a store across the street.

Selection of nearest store is a strict assumption which may not be valid because of asymmetric traffic conditions, special store or site attributes, or low threshold distances. See the review of Hubbard [18] as well as that of Craig, Ghosh, and McLafferty [1]. In general, there is wide empirical evidence (mostly through generalized gravity models) as well as recent experimental evidence (Eagle [3]) supporting at least a probabilistic version of the nearest store hypothesis. We follow Hotelling's [16] framework, both in assuming a deterministic version of the nearest store hypothesis and in ruling out complementarity across stores.

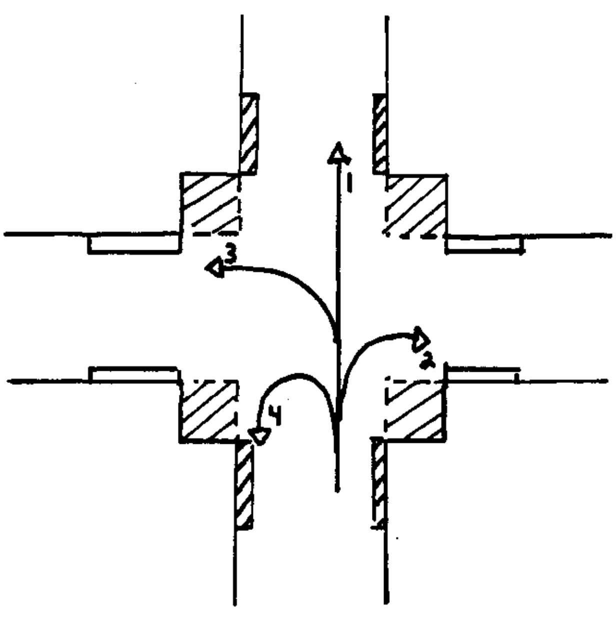
We will assume that, of the travelers who pass a particular store, a uniform proportion of them will become actual buyers and that a contant monetary profit is obtained from each buyer.

2.3 Extraneous Variables

Under the previous assumptions, the intrinsic nature of traffic orientation has surprisingly clear implications for corner store competition. To explore these implications we control extraneous variables by restrictive assumptions. Specifically, our framework considers a single interaction with four potential sites denoted as NW, NE, SE, and SW (see Figure 1). The stores that will occupy these sites are convenience stores such as minimarkets, fast food restaurants, or self service gas stations.

We postulate there is no price differential or brand name advantage to any potential or actual store. Likewise, all store and site attributes such as size, image, service, variety, visibility, parking, and ease of access are assumed to be equivalent. The only variable relevant to sales that distinguished the stores is location.

Figure 1. Setting of Intersection Spatial Competition



To neutralize any advantage of a given site due to differential traffic flows, we assume symmetric flows from all directions. We also premise that the probability of making a given turning movement within the intersection is independent of one's direction of origin. At some cost to the simplicity of our results, this assumption can be replaced by weaker, more robust ones.

Our assumptions concerning traffic flows, traffic movements, and store profits can be more precisely stated in terms of a probability space. Upon arrival at the intersection a driver performs one of the following traffic movements:

Movement		
1	-	Continuous forward
2	-	Turns left
3	-	Turns right
4	-	Makes a U turn

Let P^i_j be the (elementary probability that an automobile approaches the intersection from direction i and executes traffic movement j. Let P^i be the probability of approaching the interseciton from direction i, and P_j be the probability of performing traffic movement j upon entering the intersection. Under the assumption of symmetric traffic flow:

$$P^N = P^S = P^E = P^W = 1/4$$

In its weakest form, our preference assumption states that, within a traffic flow originating from direction i, a driver is most likely to drive straight forward, least likely to make a U turn, etc.

$$\forall i, j, k \quad P^i_j > P^i_k \text{ if } j < k$$

We imposed a second condition on traffic movements, and assumed that the particular movement executed is statistically independent of direction of origin. From this and the symmetric flow assumption it follows that the probability of executing a given movement is the same for traffic originating in each direction:

$$\forall j \quad P^N_j = P^S_j = P^E_j = P^W_j$$

Assume that, of the travelers who pass a particular store, a uniform proportion of them, c, will become actual buyers and that a constant monetary profit, K, is obtained from each buyer. Assuming that N autos enter the intersection during some (relatively large) unit of time, the profit from trafic which originates from geographical direction i and performs traffic movement j, is:

$$S^i_j = (N/4)P^i_j cK$$

For ease of exposition we can express K in $(Nc/4)^{-1}$ monetary units so that $S^i_j = P^i_j$.

3.0 GAME ANALYSIS UNDER 0 CONJECTURAL VARIATION

Our analysis is presented in two parts. We first assume 0 conjectural variation, so that each store is positioned without taking into account the future positioning of its competitors. Next, we remove this assumption and consider the competitive positioning strategies which result.

3.1 Local Monopoly

We begin by considering the positioning of a single store A in the market. Since our setting and assumptions are symmetric, the sales potential of any of the corners is identical. Hence, we can assume without loss of generality that A is positioned NW. Customers to A would come along the following paths:

* All traffic from N
* Traffic from E executing move 1
* Traffic from S executing move 3
* Traffic from W executing move 4

Hence, the expected profit at NW with only store A positioned in the intersection is:

Store A profit: $P^N + P^E_1 + P^S_3 + P^W_4$

Similar observations are conducted below.

3.2 Local Duopoly

Suppose A is positioned at NW. A second competitor, store B, may be positioned in the NE, SE, or SW corners. Which one of these locations is the profit maximizing one? An inspection of Figure 1 reveals two advantages to positioning in a clockwise direction next to A (i.e., in the NE corner). First, A cannot block any of B's primary or secondary traffic paths. The only loss to B comes from losing customers through U turn movements executed by traffic coming from the north. However, U turn movements are not likely to constitute a high percentage of B's customer base. Second, B is able to block one of A's major traffic paths (that of traffic originating in the east and traveling west directly through the intersection). This leads to a higher market share for the second competitor.

Further, there is a strict preference order for these locations, running from the best to worst in a clockwise direction. There are three cases to consider:

A in NW, B in NE

Store A profit:

$P^N + P^S_3 + P^W_4$ A loses P^E_1 to B

Store B profit:

$P^E + P^W_3 + P^S_1$ B loses P^N_4 to A

Since $P^S_1 > P^W_4$, store B's profit exceeds that of store A.

A in NW, B in SE

Store A profit:

$P^N + P^E_1 + P^W_4$ A loses P^S_3 to B
& by symmetry

Store B profit:

$P^S + P^W_1 + P^E_4$ B loses P^N_3 to A

Store B's profit is therefore the same as that of Store A.

A in NW, B in SW

By symmetry with the first case:

Store A profit:

$P^N + P^E_1 + P^S_3$ A loses P^W_4 to B

Store B profit:

$P^W + P^S_4 + P^E_3$ B loses P^N_1 to A

Since $P^S_4 < P^E_1$, store B's profit is less than that of Store A. Comparing B's profits in each position directly, it is clear that location NE dominates locations SE and SW, and that position SE dominates location SW. The order of preference is thus clockwise.

It is easy to verify that, if traffic advances on the lefthand side of the street, the preference order is reversed and becomes a counterclockwise one. For example, consider the following case:

A in NW, B in NE

(Traffic advances on the lefthand side of the street)

Store A profit:

$P^W + P^S_1 + P^E_2$ A loses P^N_4 to B

Store B profit:

$P^N + P^E_4 + P^S_2$ B loses P^W_1 to A

$P^S_1 > P^E_4$ and Store A's profits exceed that of Store B.

Other cases are similarly obtained by recalling that P_2 and P_3 exchange roles when traffic orientation is changed. Next, we consider corner competition among three competitors.

3.3 Oligopoly with Three Competitors

Three competitors will always position themselves in a chain of three adjacent stores. It therefore suffices to analyze one such chain to see which store maximizes its profits:

A in NW, B in NE, C in SE

Store A profit:

$P^N + P^W_4$ A losing $P^E_1 + P^S_3$

Store B profit:

$P^E + P^W_3$ B losing $P^S_1 + P^N_4$

Store C profit:

$P^S + P^W_1$ C losing $P^N_3 + P^E_4$

Because $P^W_1 > P^W_3 > P^W_4$, A gains the least and loses the most, C gains the most and loses the least, and B is in an intermediate position. Thus, the counterclockwise position (SE) is again the profit maximizing one.

The case of four competitors is trivial.

4.0 GAME ANALYSIS UNDER COMPETITIVE FORESIGHT

In this case, the optimal strategy is given by our positioning rule, with one exception. For three competitors, B's optimal strategy depends on utility considerations, specifically on his attitude towards risk. Because of space limitations, the foresight analysis cannot be given here (see, however, Hibshoosh [13]).

5.0 DIRECTIONS FOR FUTURE RESEARCH

The model we have presented can be extended in a number of directions. For example, we could segment the population of drivers in terms of a variety of criteria: (a) ability to handle risk; (b) pre-planned versus incidental purchasing; (c) attitude toward saving time and effort, etc. Secondly, differences in traffic conditions could be considered such as (a) differential traffic flow by time of day and direction of approach; (b) signalized versus unsignalized intersections; or (c) legal restrictions on traffic flow. Thirdly, we could consider the effects of different store attributes such as (a) store name; (b) pricing; (c) parking and accessibility, and so on. Finally, future research may focus on the dynamics of store potential, as entrance takes place. In forming its site strategy, the retailer (existing or potential) ought to take a look at the possibility that existing stores may actually attract traffic into the intersection. While the principle of clockwise positioning remains valid, the market potential for each store may rise as entrance occurs, affecting the temporal retailer strategy.

Our approach has been to demonstrate the importance of modeling the substantive relationships that exist in spatial competition in a restricted micro-context. We believe that modeling the micro-aspects of spatial competition holds some advantages over some of the current synthetic methods for site selection. In the latter, emphasis is put on aggregating the effects of relevant variables without much regard for modeling their substantive interrelationships. We share Ghosh and Craig's perspective [8] that such a style of analysis should be incorporated to these more comprehensive systems capable of analyzing and simulating global marketing location strategies.

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