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A STUDY OF THE SELECTION OF MULTIPLE LOCATIONS
FOR CONSUMER ORIENTED FACILITIES

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
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* * * * *

The Ohio State University
1978

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CHAPTER 1
INTRODUCTION

This research will examine the application of concepts drawn from central place theory to the study of the location of consumer oriented facilities. The facilities which belong to this group are ones whose success is measured in terms of the level of consumer demand generated at the facility. The group includes retail and service outlets, some types of government offices, and public service facilities, among others. While the results will be applicable to the whole range of facilities, the discussion will focus on a single type: the franchised retail outlet.

Location research, especially the study of retail locations, has generally been concerned with the location of a single facility. In recent years, there has been an increasing interest in multiple facility location problems dealing with warehouses, manufacturing plants, and some types of public service facilities and applying the techniques of location-allocation modeling and mathematical programming. However, this interest has not extended to retail location. This research will address itself to the
question of multiple facility location for retail firm in both theoretical and applied contexts.

The retail location problem can be viewed as three distinct decisions: the selection of a city or region, the selection of general areas within the city, and the selection of specific sites within each of the general areas. The multiple facility location problem deals with the second of these decisions. Its goal is to determine the optimum pattern of outlet locations. The determination of this pattern is important because the level of demand generated at the outlets is in part determined by the location of those outlets relative to potential consumers.

Franchising is an excellent example to use in the study of the multiple facility location problem for retailing because it contains within it elements of other forms of retailing. The franchise system is made up of a franchisor, or company which grants the franchise, and franchisees who operate the outlets. Franchisees can either operate a single outlet (referred to as an individual franchisee in the present study, or operate all of the outlets within a defined territory (master franchisee). Within a single market, the individual franchisees have many of the characteristics of independent store owners while the master franchisee resembles the operator of a chain store. Comments on the franchisee location decision
can, therefore, be interpreted as comments on the decision faced by these other types of store owners as well.

Franchising also presents the opportunity to examine the potential for conflict among the members of the franchise system because of differing locational goals. This is a specific case of the more general question of conflict within distribution systems.

The research will concentrate on three general topics. First, the multiple facility location question will be examined using concepts drawn from central place theory. Second, the techniques of mathematical programming will be applied to the study of retail location. Third, normative models of the franchise location decision will be developed which can be applied to practical location questions.

**Research Design**

The multiple facility location decision will be examined with respect to a variety of entrepreneurial objectives. These objectives will be provided by the members of the franchise system. The franchisor represents the entrepreneur interested in demand maximization. Both types of franchisee represent profit maximizing objectives, with the master franchisee interested in maximizing profits from all of the outlets taken together, while the individual franchisee seeks to maximize profits from a single location.
The study will focus on the differences in the location patterns obtained from each of these three perspectives. The differences are the basis for the potential conflict between members of the franchise system, as well as having implications for the location decision for similar facilities under other types of managerial control.

Along with a conceptual discussion of the location question, operational location models will be developed. The basis of the models will be three concepts drawn from central place theory: threshold, range, and the demand cone.

After the models have been developed, they will be tested by applying them to the problem of selecting locations for the outlets of a fast food restaurant franchise system, Wendy's, in the Columbus, Ohio metropolitan area. This will provide an example of how the models might be used by an actual franchise company and provide the basis for a discussion of the effects of the model parameters on the solutions obtained.

The results of the location models will be compared with the actual location pattern of Wendy's outlets, with the theoretical patterns derived from the central place concepts, and with each other. Besides providing evidence of the validity of the models, these comparisons will allow an analysis of the effect of the location selection problem
on the franchise system. This will include the potential for conflict between the franchisor and the franchisees, the best location strategy from each of the three perspectives, and possible compromise location decisions.

**Organization**

The following chapters report on the results of the research described above. The starting point will be a review of the location literature in geography and related fields, emphasizing those studies concerned with the tertiary sector of the economy. This will be followed in Chapter 3 by a discussion of the franchise method of distribution and a description of the characteristics of the franchisor and the franchisees which will be important in the development of the location models.

The location strategies of the franchisor, master franchisee, and individual franchisee will be discussed in relation to central place theory in Chapter 4. The relevant concepts from central place theory will be developed and applied to each of the three types of location problem. Operational models based on this discussion and the earlier reviews will be developed in Chapter 5.

The application of the models to a real world location problem will be discussed in Chapter 6. Extensive discussions on the calibration of the models and comparisons of
the results to real and theoretical patterns will be included. The sensitivity of the results to changes in the model parameters will be the topic of Chapter 7.

A summary of the research and its implications for locational decisions in general and franchising in particular will be presented in Chapter 8.
CHAPTER 2
THE STUDY OF LOCATION

The question of where phenomena are located on the earth's surface has been a dominant concern in geography. Early geographers were primarily interested in accurately describing the locations of items and activities. This interest in where items are located evolved into a concern with why the items are distributed in a particular manner.

Geographers have been concerned with the location of a wide range of items, including cities, culture traits, natural resources, and transportation facilities. One segment of this general concern with location is the study of the location of physical facilities. The feature which has made this interesting to geographers is that the success of the function carried on in the facility depends, at least in part, on the position of the facility relative to other phenomena.

In this chapter, location studies which have examined the spatial pattern of physical facilities will be reviewed. First, the major theoretical bases of these studies will be
discussed. Following this will be a review of studies which have applied these theories to the solution of real world problems. These latter studies will be divided into studies which have addressed the broad question of the distribution of economic activities and the prediction of urban growth through the creation of large scale planning models and studies which have examined the problem of an individual company or agency involved in the selection of individual facility locations.

**Theoretical Bases of Location Models**

Most location studies have drawn on elements from three location theories for their theoretical base. First, studies which have emphasized the importance of consumer demand have drawn on central place theory (Christaller, 1966; Losch, 1954). Primarily a theory of the location of cities or service centers, central place theory contains statements about the spatial behavior of consumers and the relation of this behavior to the level of demand at a particular location which are useful in retail and public facility location studies. Second, those studies which have emphasized the importance of assembly and distribution costs have drawn on the least cost theory presented by Weber (1929). This theory focused on the importance of finding the location which minimizes production
costs and gave primary importance to costs related to the transportation of raw materials and the finished product. Third, some studies have emphasized the importance of land rent, or the relative ability of different kinds of economic activities to pay for land at various locations. These studies draw on the theory of agricultural location proposed by von Thunen (1966). In this section, each of these three basic theories will be examined.

**Central Place Theory**

Central place theory was developed by both Christaller (1966) and Losch (1954) as a theory of the development of a system of cities, focusing on the function of cities, the interrelationships between cities, and the locational pattern of cities. Christaller started with an observed system of cities and created an inductive theoretical structure which could be used to explain that system. Losch used a deductive approach to proceed from basic assumptions about consumer behavior to a system of cities.

Both Christaller and Losch assumed an initial rural population uniformly distributed over a featureless plain. The population was assumed to be distributed in a triangular lattice, the uniform pattern which maximizes the distance between a fixed number of points in a given land area. Each of the points containing a member of the population was a potential central place.
A central place comes into being when one member of the population can produce a good and sell it to his neighbors at a lower cost than the neighbors can produce the good for themselves. Members of the population will travel to this central place to obtain the good up to the point where the cost of the good at the central place plus the cost of transportation to the consumer's residence equals the cost for the consumer to produce the good for himself. The longest distance which a consumer will travel for a particular good is called the range of the good (or the outer range). A circle with its radius equal to the range of a good contains all of the members of the population willing to purchase the good from that central place and, therefore, describes the market area with the maximum demand for the good.

Denike and Parr (1970) observed that the range of a good depends on the price charged at the central place. Starting with an individual's demand curve for the good, they derived a "free spatial demand curve," reflecting the additional effect of transportation costs on the individual's demand for the good and aggregating all of the potential consumers' demand curves. This derivation was based primarily on the treatment of aggregate demand in Losch (1954).

Another useful concept in central place theory is the lower limit of the range of a good, variously referred
to as the threshold, threshold range, or inner range. Christaller (1966) defined this as the radius of the market area containing the minimum amount of demand necessary to support the production of a good at a central place. Parr and Denike (1970) broadened this definition slightly by noting that the number of individuals necessary to support a central place is inversely related to the price charged for the good. As the number of individuals patronizing the central place increases, economies of scale allow the price for the good to be reduced. For this reason, the threshold actually declines as the market area increases.

The fact that the threshold market area contains the minimum number of individuals necessary for the production of the good at the central place implies that the firm producing the good is receiving only normal profits. Parr and Denike (1970) pointed out that when there is free entry of firms and the pattern of central places has reached an equilibrium, each firm will be receiving only normal profits and the market areas will be the same as the threshold market areas. The free market equilibrium pattern with each firm operating at its threshold level is also the pattern which maximizes the number of central places at which a given good is produced.
The concepts of threshold and range and their applicability to location models will be examined in more detail in Chapter 4.

A basic principle of central place theory is that the firms will attempt to locate as far apart as possible so that each firm maximizes the number of potential consumers in its market area. This, along with free entry, leads to an equilibrium pattern with the central places located in a uniform triangular lattice and the spacing determined by the threshold level for the good (Parr and Denike, 1970). In addition, this equilibrium pattern maximizes demand for the good, since individual demand decreases with distance from a central place and the free market equilibrium pattern minimizes the longest distance from any consumer to a central place. Therefore, this pattern will maximize the overall demand for a good.

When a number of different goods are considered, a hierarchy of central places can be identified. The level of a central place in this hierarchy is determined by the size of the largest market area for any good offered at that central place. The nature of this hierarchy is a major difference between the theories of Christaller and Losch. Losch allowed each good to be distributed according to its threshold market size. A central place only offers more than one good if it happens to be the center of
the market areas for more than one good. The level of the central place in the hierarchy is determined by the number of goods offered. Christaller, on the other hand, imposed the restriction that a central place offer all goods with thresholds smaller than that of the good with the largest threshold market offered at that central place. That is, if one good offered at a central place has a threshold market area with a radius of five miles, that central place can also offer other goods which have a threshold market area with a radius of less than five miles. In addition, Christaller assumed a limited number of market area sizes, based on powers of a basic market area. If, for example, the basic market area is three units, the larger market areas will be nine units, 27 units, 81 units, and so forth.

The level of a center in this hierarchy is defined by the largest market area for any good offered at that center. Parr and Denike (1970) observed that excess profits result if any good has a threshold market area which does not exactly correspond to one of the allowable market area sizes in the Christaller system.

Central place theory has generally been applied in inter-urban studies. However, many of the concepts also can be applied in an intra-urban context. Berry (1967) has outlined such an application and provides evidence of an intra-urban central place hierarchy.
Least Cost Location Theory

Weber (1929) proposed a location theory based on the minimization of production costs. These costs were divided into two regional factors, transportation and labor costs, along with costs which do not vary between locations, such as the price of raw materials at their locations and agglomeration economies. Agglomeration economies can be viewed as economies of scale, consisting of all of the differences in production costs between alternative sites exclusive of transportation and labor.

The industries in which Weber was interested had transportation as the dominant spatial factor, with the other factors causing minor distortion to a pattern determined by transportation. To find the location with the lowest transportation costs, it is necessary to

\[ \text{Min } T_i = \sum_{j=1}^{n} w_j \left( (x_j - x_i)^2 + (y_j - y_i)^2 \right)^{1/2} \]

where

- \( T_i \) = total transportation charges at location \( i \)
- \( n \) = number of raw material sites and markets
- \( w_j \) = transportation cost and relative weight of raw material or finished product \( j \)
- \((x_j,y_j)\) = Cartesian coordinates of location \( j \) (raw material or market site)
- \((x_i,y_i)\) = Cartesian coordinates of location \( i \) (potential facility location)
The problem is to select a location $i$ which minimizes the value of $T_i$. Weber limited his discussion of the solution of this problem to the case in which $n$ equals three.

Once the least transportation cost location is found, the modifying effects of labor costs and agglomeration economies can be added. Weber claimed that the firm would move to an alternative site if the savings due to labor costs or agglomeration economies could offset the increase in the cost of transportation.

Much effort has been devoted to developing a mathematical technique to achieve the minimization in the above equation. The non-linear nature of the distance term in the equation makes this minimization difficult. One approach to this problem is to develop a heuristic algorithm which approaches the minimum (Kuhn and Kuenne, 1962). Another is to assume a rectangular distance measure, which eliminates the non-linear term (Wesolowsky, 1977).

As formulated above, the Weber location model is a continuous space model. Every point is a potential location. The mathematical problem is simplified if the model is reformulated as a discrete space model. In this version, only a finite set of points are considered as possible locations. In this case, the Weber equation can be reduced to

$$\text{Min } T_i = \sum_{i=1}^{n} \sum_{j=1}^{n} w_j d_{ij}$$
where \( d_{ij} \) is the distance from potential location \( i \) to raw material or market site \( j \). Since the number of locations is limited, the minimum of this equation can be found relatively easily. This equation is also linear, which allows the use of more powerful mathematical techniques to obtain the solution. This discrete space Weber model is the basis for many of the location-allocation models which will be reviewed below and provides the starting point for the models developed in Chapter 5.

**Land Rent Theory**

Studies which relate the pattern of locations to the distribution of land values draw on the work of von Thunen (1966). The location theory proposed by him bases the location of economic activities on their ability to pay for the use of the land. This ability to pay is based on the profitability of the activity at a given location.

The distribution of agricultural land uses was von Thunen's primary concern. He defined location rent as a function of market price, production cost, crop yield, transportation cost, and distance from the location to a central market. The modern formulation of this function (Dunn, 1954) is

\[
R_i = E_i (p_i - a_i) - E_i f_i k
\]

where
\( R_i \) = location rent per acre for land use \( i \)

\( E_i \) = yield per acre of land use \( i \)

\( P_i \) = price received at the market for the output of land use \( i \) per unit of output

\( a_i \) = production cost, exclusive of land cost, for one unit of the output of land use \( i \)

\( f_i \) = transportation cost per unit of land use \( i \) per unit of distance

\( k \) = distance to the market

For a given type of land use, this equation defines location rent as a linear function of distance from the market. This function is referred to as the bid-rent line for activity \( i \), since it represents the amount that people engaged in that activity would be willing to bid for the use of land at any distance from the market.

A bid-rent line, or surface, can be derived for all of the alternative uses of land in a region. At any point in the region, the activity with the highest value of \( R_i \) for that distance from the market will be the activity which takes place at that site. If there is a single market in the region, the pattern of land uses will be a series of concentric rings centered on the market, with the activities which offer the highest location rent located closest to the center. If more than one market exists in the region, concentric rings will exist around each market and land uses in the areas where the patterns overlap will be determined by the
location rents for the competing activities.

By considering items such as revenue and intensity of land use, von Thunen developed a theory which allocates land based on the efficiency with which it can be used. Instead of locating activities at sites which are best for the individual, this theory yields a pattern of locations which reflects the differential ability of the activities to derive profits from the land.

Summary

Three basic theories of location have been examined in this section: central place theory, the basis for location studies which emphasize the importance of demand; Weberian least cost theory, which underlies production cost based location models; and von Thunen's land rent theory, which supports those location studies which place primary importance on the value of land.

In previous research, central place theory has been used to explain the location of retail and service activities while least cost theory has been employed in industrial and public sector models. In Chapter 5, models are developed which extend the use of least cost theory to the retail sector by applying location-allocation techniques to the retail location problem. In these models, the cost of transporting the product to the consumer is replaced by a demand maximization procedure derived from central place theory.
Therefore, the models provide examples of the link between these two location theories.

In the next two sections of this chapter, examples of the application of the basic location theories will be examined. First, their application to large scale planning problems, focusing on the distribution of land uses, will be reviewed. Second, the application of the theories to the location of individual facilities will be examined.

Application of Location Theory in Large Scale Planning Studies

One type of application of the above theories is concerned with predicting or, in some cases, explaining the equilibrium distribution of land uses in an urban area. The results of these studies are especially useful in the areas of land use and transportation planning.

Most applications of this type have drawn on the land rent and least cost theories. In this section, examples of studies using each of these two theories will be reviewed. Following this will be a review of locational conflict studies, which represent another aspect of the large scale planning process.

Land Rent Based Applications

Alonso (1964) provides an example of the application of land rent theory to the study of the general equilibrium distribution of urban land uses. In his model, each
potential user is assumed to be willing to bid some amount for each parcel of land in the city. For a business enterprise, this amount is claimed to be the difference between the profits at the given site and the profits at the least desirable site. Alonso assumes that profits will be higher at sites closer to the center of the city due to lower transportation costs and a larger potential market, causing the amount bid to decline with distance from the center of the city. The land user which offers the high bid for each parcel of land occupies that site (each user occupying the site which represents his highest bid and for which he bid higher than any other user). The land use pattern which develops is similar to the distribution of agricultural land uses resulting from von Thunen's theory, from which much of Alonso's work is derived. The land uses are found arranged in concentric zones with the most land intensive uses in the outer zones.

Another example of the application of land rent theory is provided by Lowry (1968) In this model, Lowry considers a city divided into cells, with each type of land use bidding for each cell in a series of time periods. In each time period, the bidding reflects the locations of activities in the preceding time period. The value which is placed on a particular cell for a given land use is assumed to depend on the location of other activities to which that land use requires access.
Least Cost Based Applications

Least cost theory has been operationalized in planning models by using either distance minimization or cost minimization criteria. In this section, the Pittsburgh and EMPIRIC models will be reviewed as examples of distance minimization and the Land Use Plan Design Model will be considered as an example of cost minimization.

The Pittsburgh Model (Lowry, 1964) assigns population and retail functions to one mile square sections of the city on the basis of exogenously determined "basic" employment (manufacturing and other activities which market their products outside of the city). In this model, population is assigned to cells on the basis of access to employment opportunities. Retail functions are then assigned on the basis of access to population. An iterative procedure then assigns population to the cells to satisfy retail employment needs and new retail activities to serve the additional population until an equilibrium state is achieved.

Another model relying primarily on distance minimization is the EMPIRIC model (Traffic Research Corporation, 1967), a system of simultaneous linear equations used to predict growth in population and employment by traffic zone. It was developed for the Eastern Massachusetts Regional Planning Project. The change in retail employment in a zone is related to previous retail employment,
other non-manufacturing employment, population with income less than $15,000, a capacity index for retailing, vehicle accessibility to families, and transit time to families. Similar relationships are defined for other economic activities and population. Solving the simultaneous equations results in a prediction of the level of population and employment in each of the traffic zones.

The Land Use Plan Design Model, developed by the Southeastern Wisconsin Regional Planning Commission (1968), represents the use of cost minimization as a location criterion. In this case, the model is used to locate a pre-defined number of development modules in a specified area in order to minimize linkage and development costs. Each module represents a type of development (low density residential, neighborhood commercial center, library, and so forth) which has unique space, external linkage, and physical site requirements, as well as development costs. The procedure is to partition the land area and place the modules in the partitions to minimize cost. The partitioning technique is based on a linear graph model. The Land Use Plan Design Model is predictive to the degree that the outlined relationships represent real world relationships between the activities included in the modules. In a planning application, the model is normative, since it is used to obtain an optimum land use plan based on the
criteria of minimum development cost.

Locational Conflict

Another type of location study has dealt with the conflicts between entrepreneurs, political units, and the public which arise in the location decision process. In effect, these studies are concerned with the implementation of the results of the planning models discussed earlier in this section.

Locational conflict studies are often concerned with the location of public service facilities (Cox, 1973; Wolpert, 1972; Dear, 1977). The facilities may be ones which people compete to be near, such as parks, or ones which people compete to be far away from, such as power plants, sewage treatment facilities, or transportation facilities. Many of the concepts outlined in these studies are equally applicable to the retail location process. Many retailers have found political barriers and community opposition to their acquisition of specific sites. This is brought to light most often when an entrepreneur attempts to locate in a previously exclusively residential area or attempts to modify some local landmark or community amenity.

Summary

The application of location theory to large scale planning problems was discussed in this section. The models examined were ones which examine the equilibrium distribution
of population and economic activities within an urban area. Alonso (1964) and Lowry (1968) were cited as examples of the application of land rent theory to this type of problem. Examples of the application of least cost theory were provided by examination of the Pittsburgh, EMPIRIC, and Land Use Plan Design models.

The related topic of locational conflict was also discussed in this section. While conflict studies do not generally represent direct applications of location theories, they do consider the difficulties involved in the implementation of location decisions. In this sense, they represent a combination of location theory with social and political theories.

Conflict studies may examine large scale planning decisions, such as urban renewal or the routing of freeways, or they may be concerned with the location of individual facilities. In the next section, the application of location theory to the selection of locations for individual facilities will be discussed.

Application of Location Theory to Individual Facility Location

In this section, methods which have been developed for the analysis of individual facility location will be examined. While the methods will be reviewed in the context of retail facility location, they apply to the location of other types of facilities as well.
As a group, the studies to be reviewed in this section focus on the profitability of individual sites. This includes the determination of costs at the site and the examination of trade areas and potential demand. While not explicit in the studies, concepts from central place theory underlie most of the methods. The methods also draw on least cost theory when analyzing the effects of site related costs.

Kotler (1971) identified three major techniques for the analysis of retail locations: the checklist, analogue, and gravitational methods. Each of these methods will be discussed below. In addition, location-allocation techniques will be reviewed. While these latter techniques have not been used much in retail location studies, they form the basis of the location models to be discussed in Chapter 5.

The Checklist Method

In the checklist method, the entrepreneur compiles a list of characteristics which must be present at an acceptable site and then evaluates the potential site according to this list. It is, therefore, a satisficing technique. The search will end when a site meeting the minimum requirements is found. Of course, if several sites are evaluated, they may be ranked and the most satisfactory site chosen. The optimum site will only be obtained if all possible
sites are evaluated.

One such list of characteristics was presented by Cohen and Applebaum (1960). Accessibility, population characteristics, competition, economic stability, and market penetration were suggested as important factors, although no indication was made of the contribution of each factor to the success or failure of the store. The authors pointed out the importance of considering the expected levels of each of the factors in addition to the current levels. The failure to specify the weight associated with each of the factors makes this technique difficult to quantify. Given the data for each factor, the decision maker must make his own subjective evaluation.

Kane (1966) presented a more detailed guide specifically dealing with supermarket location. He was very specific on ways to calculate the level of each of the location factors, but failed to indicate the relative weight of each factor. The factors included population characteristics, predicted sales volume, competition, market share and saturation, and quality of available sites.

The basic textbook on the checklist method is Nelson (1958). Besides presenting a checklist and discussing the techniques for estimating the components of the list, Nelson examined more general trends in retail location and urban development. Nelson identified eight principles of site selection.
1. Adequacy of present trading area potential
2. Accessibility of site to trading area
3. Growth potential
4. Business interception
5. Cumulative attraction
6. Compatibility
7. Minimizing of competitive hazard
8. Site economics

These eight principles were the basis for Nelson's checklist.

The principles of cumulative attraction and compatibility were Nelson's unique contributions to the checklist method. Nelson's theory of cumulative attraction was that "A given number of stores dealing in the same merchandise will do more business if they are located adjacent or in proximity to each other than if they are widely scattered" (Nelson, 1958, p. 58). His rule of retail compatibility stated that

Two compatible businesses located in close proximity will show an increase in business volume directly proportionate to the incidence of total customer interchange between them, inversely proportionate to the ratio of business volume of the larger store to that of the smaller store, and directly proportionate to the sum of the ratios of purposeful purchasing to total purchasing in each of the two stores (Nelson, 1958, p. 66).

A purposeful purchase was defined as the purchase which was the major reason for the shopping trip.
The Analogue Method

The analogue method involves the use of data on existing stores to predict the performance of a new store. As presented by Applebaum (1966), the technique includes the use of customer spotting at existing stores to determine the geographical extent of the trade area and the use of demographic profiles for predicting the level of sales. The trade area is divided into a primary zone containing sixty to seventy percent of the store's sales, a secondary zone containing fifteen to twenty-five percent, and a tertiary zone containing the remainder of the sales. Census data can be used to determine the characteristics of these zones and to estimate market penetration.

Once a company has built up an inventory of the store profiles developed through customer spotting, it can predict the performance of a new store based on that of a similar existing store. The store which most resembles the proposed store in character and situation is chosen and its data is applied to the population in the predicted trade area for the new store to predict sales and other performance characteristics.

The analogue method is best suited for a company with a large number of outlets. Small chains will be limited by the small number of store profiles available to them. New companies will have no data for developing store profiles.
Like the checklist method, the analogue method is basically a satisficing technique. While it is conceivable that every potential site will be evaluated, this approach would involve a large amount of work. It is more likely that a subjectively selected set of sites will be evaluated and the best of these sites will be chosen if it meets some minimum performance criteria. The search would not continue unless no site in the original set was found to be satisfactory. Used in this way, the method will not result in location at the best site, only in location at a satisfactory site.

The Gravitational Method

The gravitational method derives its name from the "law of retail gravitation" (Reilly, 1931). This method involves the determination of the size and boundaries of the trade area for a store at a given site. Once the size and boundaries are determined, the expected sales of a store at that site can be estimated from the characteristics of the population within the trade area. If this process is repeated for a number of sites, the best site within the group can be determined. This technique may be used on its own or as a component of one of the other methods.

The law of retail gravitation is, in fact, an empirical regularity which can be explained by the tendency for consumers to shop at places which are closer rather than
traveling longer distances than necessary to obtain the same item. The mathematical representation of this hypothesis about consumer behavior is called a gravity model, due to its similarity in form to the equation for gravitational force in physics. In retail terms, the attraction \( A_{ac} \) of a center 'a' to consumers at place 'c' can be described as

\[
A_{ac} = \frac{kS_a S_c}{D_{ac}^2}
\]

where

- \( k \) = a constant scale factor
- \( S_a \) = the size of center 'a'
- \( S_c \) = the size of place 'c'
- \( D_{ac} \) = the distance from center 'a' to place 'c'

The breaking point (trade area boundary) between center 'a' and a competing center 'b,' or the point where \( A_{ac} = A_{bc} \), can be expressed in terms of distance from center 'a' as

\[
D_{ac} = D_{ab}/(1.0 + (S_b/S_a)^{1/2})
\]

This equation and other refinements to Reilly's work were developed by Converse (1949).

Huff (1962) presented a probabilistic model similar in form to the gravity model and based on Luce's choice axiom (Luce, 1959). In Huff's formulation, the probability
(P_{ac}) of a consumer at place 'c' shopping at center 'a' is a function of the size (S_a) of and travel time (T_{ac}) to center 'a' relative to the size of and travel time to all possible alternative centers in a previously defined feasible set. Mathematically,

\[
P_{ac} = \frac{S_a/T_{ac}^\lambda}{\sum_{a=1}^{n} (S_a/T_{ac}^\lambda)}\]

where n is the total number of alternative centers (including the center being evaluated) and \( \lambda \) is a constant describing the effect of travel time.

Huff's model incorporates the possibility that a consumer will not patronize the nearest center. There is some probability of the consumer shopping at any one of the given set of centers. The trade area boundary in this case is the line between two or more centers along which the probabilities of shopping at each of the centers are equal.

Bucklin (1971) used the Huff model to analyze the market areas of shopping centers. The size variable was replaced by several measures of the attractiveness of the centers which were assumed to have a multiplicative effect on the probability of shopping at a given center. These measures included total square footage in the center, number of products offered, available parking, age of center,
and price level. The travel time variable was replaced by the distance to the center in miles. In this case, the model can be generalized as a multiplicative competitive interaction model

\[ P_{ac} = \frac{q}{n} \prod_{i=1}^{q} X_{iac}^{\lambda_i} \]

where

- \( P_{ac} \) = the probability of a consumer at place 'c' shopping at center 'a'
- \( q \) = the number of measures of attractiveness
- \( X_{iac} \) = the value of attractiveness measure 'i' of center 'a' to a consumer at place 'c'
- \( \lambda_i \) = a constant describing the influence of attractiveness measure 'i'
- \( n \) = the number of centers

In this formulation, distance is incorporated as one of the measures of attractiveness.

A major problem in the use of the gravitational method for store location has been the estimation of the weightings, \( \lambda_i \), associated with the attractiveness measures. This problem has recently been solved for the generalized multiplicative competitive interaction model by Nakanishi and Cooper (1974). By assuming that the error associated with each probability is log-normally distributed, Nakanishi and Cooper were able to use a variable transformation to convert
a gravitation-type equation into a linear equation. Generalized least square regression was then used to estimate the parameters ($\lambda_1$).

The gravitational method is limited in its ability to be used to locate more than one store at a time. For two stores, one would have to evaluate all possible combinations of sites for the stores. The number of calculations quickly becomes unmanageable as the number of stores and/or the number of potential locations is increased. Reilly's model assumes that the location of the surrounding competing stores are known, while Huff's assumes that the locations of all competing stores in the region are known. Both assumptions lead to a large amount of work when either more than one store is to be located or the actions of potential competitors are uncertain.

Once the Reilly or Huff equation is used to determine the trade area boundaries, the characteristics of the population can be used to predict the performance of a store at the site under analysis. The area can be divided into cells and the population in each cell multiplied by the probability of shopping at the store under consideration to obtain the number of customers for that store. This number can be multiplied by the average number of shopping trips per person and the average amount spent per trip to obtain the dollar sales expected for that store. If this process is
repeated for all of the alternative locations for a new store. The best location can be selected. The technique may also be applied to individual locations until a satisfactory location is obtained.

The gravitational method, and to some extent the other methods discussed in this section, is based on the assumption that consumer behavior can be predicted by a set of objectively measured store characteristics and travel times. In fact, the consumers' perception of the measures may be more important than the objectively determined values of the measures. Recently, geographers have begun to investigate the effects of perception on spatial behavior.

Downs (1970) studied the effects of store characteristics ("cognitive components") on the spatial behavior of consumers. The characteristics in this particular study included service quality, price, structure and design, traffic conditions, and shopping hours. Once these components were identified, scaling techniques were applied to obtain a measure of their effects on consumer demand. With this measure, it was possible to estimate the level of sales for a proposed center based on the characteristics of the center and of the potential consumers. This is an extension of consumer behavior research in marketing (see, for example, Engel, Kollat, and Blackwell, 1968). Downs added site characteristics to the normal brand and channel
characteristics. This approach allows the entrepreneur to select the particular mix of characteristics which will maximize demand from the target population.

Another approach to the study of consumer behavior is found in the work of Golledge (1974). Rather than studying the response of consumers to specific store characteristics, Golledge has been concerned with the image of the city which each individual develops. This "cognitive configuration" is the basis for much of the individual's travel behavior. Knowledge of the items which distort the individual's image of the city can lead to an explanation of seemingly irrational shopping behavior. Regularities in the pattern of distortion among a group of consumers may help to explain the variation in demand between locations within a city or region.

Location-Allocation Methods

The location-allocation approach involves the simultaneous location of facilities such as warehouses, manufacturing plants, retail outlets, or public service facilities, and the allocation of the market to those facilities in order to optimize some predefined location criteria (such as maximizing demand or profits, or minimizing transportation costs). Location-allocation studies are generally concerned with establishing an optimal pattern of locations
of linkages between locations and, therefore, do not consider the selection of specific sites. This places them at a scale of analysis between the individual outlet location decision (or site selection decision) and the overall development decisions such as market selection. The specific solution technique is often a form of mathematical programming, though heuristic techniques may also be employed. Reviews of the wide variety of location-allocation models which have been developed are provided by Scott (1970), Lea (1973), and Wagner and Falkson (1975).

Location-allocation models have been applied most often to manufacturing and warehouse operations (Kuhn and Kuenne, 1962; Kuehn and Hamburger, 1963; Wesolowsky, 1977; Osleeb and Cromley, 1978). These studies generally attempt to develop a solution for a generalized form of the Weber least cost model (see above) in which the goal is to minimize transportation costs. Models have also been developed for more consumer oriented facilities such as ambulance services (Revelle, Toregas, and Falkson, 1976; Achabal, 1978), day care centers (Holmes, Williams, and Brown, 1972; Brown et al., 1974), and health care centers (Abernathy and Hershey, 1972). In these studies, the goal is to maximize access to the facility for the group for which the service is being provided.
The basis for many of the public facility location models, as well as potential retail applications, is found in Revelle and Swain (1970). The problem for which the Revelle and Swain model was developed involved the location of a set of "central facilities" (warehouses or other such service functions) to serve a finite number of cities, each of which was considered to be a single point in space. The objective was to locate m facilities in the n cities so as to minimize total transportation costs. This can be expressed in the linear objective function

\[
\text{Min } z = \sum_{j=1}^{n} \sum_{i=1}^{n} a_i d_{ij} x_{ij}
\]

where

\[
\begin{align*}
    a_i &= \text{population of city } i \\
    d_{ij} &= \text{distance from city } i \text{ to city } j \\
    x_{ij} &= 1 \text{ if the demand in city } i \text{ is assigned to a facility in city } j \\
    &= 0 \text{ otherwise}
\end{align*}
\]

Three constraints are placed on this objective function

\[
\begin{align*}
    \sum_{j=1}^{n} x_{ij} &= 1 \quad \text{for all } i \\
    x_{jj} &> x_{ij} \quad \text{for all } i \text{ and } j, \ i \neq j \\
    \sum_{j=1}^{n} x_{jj} &= m
\end{align*}
\]
The first constraint requires that the demand in city $i$ be completely assigned. The second allows facilities to be located only in cities for which the local demand is assigned to that same city ($x_{jj} = 1$). The third requires that $m$ facilities be located and is necessary because the objective function is minimized when no facilities are located.

While linear programming solutions do not routinely yield zero-one solution sets as required in this problem, Revelle and Swain argue that such solutions will be generated in most cases with the formulation shown above. They present a proof of the theorem that if all of the $x_{ii}$ are either zero or one, then all of the $x_{ij}$ will be zero or one in the optimal solution. They also present a branch and bound technique to be used in the cases in which zero-one solutions do not occur.

The major advantage of location-allocation methods over the other methods described in this section is the relative ease with which multiple facility location problems can be solved. The other methods generally assume that only one facility is being located by the company (or other decision maker) at any particular time. In some location problems, such as the location of a chain of retail outlets or fire stations, for example, this is an unrealistic assumption.
Studies of location, including the location-allocation studies, have assumed that a single company controls the entire decision when considering the location of private sector facilities. As discussed by Stern and El-Ansary (1977), there are forms of channel organization with varying degrees of control exercised by companies at different levels in the channel. In these cases the location chosen may have different consequences for the different companies and can lead to conflict within the marketing channel. This is a somewhat different type of conflict than that examined in the studies cited above, which are primarily concerned with conflict between the entrepreneur and forces outside of the marketing channel. The subject of within channel conflict will be examined in more detail in later chapters.

Summary

Three commonly used methods of retail location analysis, the checklist, analogue, and gravitational methods, have been reviewed in this section as examples of the application of location theory, particularly central place theory, to the individual facility location problem. In addition, location-allocation methods were examined. While the latter technique has not been used much in retail location research, it appears to have an advantage over the other methods when more than one facility is being located. In
Chapter 5, this will be further demonstrated by the development of multi-facility retail location models based on the location-allocation approach.

Summary

In this chapter, the major theoretical bases for locational analysis have been reviewed, along with examples of their application to problems of planning and individual location selection. The theories examined were central place theory, least cost location theory, and land rent theory.

Land rent theory and least cost location theory were illustrated by large scale planning models. The Alonso and Lowry models provided examples of the application of land rent theory to the problem of determining the equilibrium spatial distribution of land uses. The Pittsburgh, EMPIRIC, and Land Use Plan Design models were used to demonstrate the application of least cost theory to urban planning problems.

The application of central place theory was demonstrated by a discussion of three commonly used methods of retail store location analysis. These were the checklist, analogue, and gravitational methods. While these methods do not explicitly include central place theory, they draw on it for concepts such as trade area and the spatial variation in consumer demand.
Several related topics were also reviewed in this chapter. Locational conflict was cited as a problem of implementing the results of the location models. The conflict examined in the studies cited in this chapter involves differences between the goals of the location decision maker and outside parties. In the next chapter, a situation will be described in which a similar conflict can arise between the interests of different parties involved in making the location decision itself. Also examined were the problems associated with predicting consumer behavior, particularly the distinction between objective measures and the consumers' perception of those same measures of store attractiveness.

The chapter ended with a discussion of location-allocation techniques. It was noted that these techniques have not been applied extensively in retail location research, though they are well established in research dealing with the location of other types of facilities. In the remaining chapters, location-allocation techniques will be combined with some concepts from central place theory to develop a location model for a chain of retail outlets. The form of retailing to be examined is franchising, which will allow an examination of locational conflict within the marketing channel as well as the problem of multiple facility location. Before the model is developed, however,
it is necessary to examine the nature of the franchise method of retailing. This will be the subject of the next chapter.
CHAPTER 3
FRANCHISE SYSTEMS

The franchise relationship is a unique blend of corporate control and individual enterprise in the marketing system. As such, it presents some unique problems and advantages to both the franchisor and the franchisee. In this chapter, the nature of the franchise method of distribution will be examined along with the characteristics of the franchise agreement, sources of revenue and costs for the franchisor and the franchisee, and location practices commonly found in franchise systems.

The Nature of Franchising

The term franchise has been applied to a wide range of business activities, from the licensing of a production process to permission to operate a professional sports team. The present concern, however, is limited to franchising in the retail distribution field. Hackett (1977) defines franchising as

... a continuing relationship between two independent parties based on contractual arrangements whereby a franchisor (producer) grants and provides tangible and non-tangible assets as well as managerial guidance, training and expertise to the franchisee for a fee.
This is a broad definition which emphasizes the contractual nature of the franchise system. A more specific definition was provided by Rosenberg (1969):

Franchising is a system for the selective distribution of goods and/or services under a brand name through outlets owned by independent businessmen, called 'franchisees.' Although the franchisor supplies the franchisee with know-how and brand identification on a continuing basis, the franchisee enjoys the right to profit and runs the risk of loss. The franchisor controls the distribution of his goods and/or services through a contract which regulates the activities of (the) franchisee, in order to achieve standardization.

This definition points out three important aspects of the franchise arrangement: the independence of the contracting parties, the channel control exerted by the franchisor, and the standardization of the system.

Ideally, a franchise contract is made between two equal and independent business entities. In fact, this is seldom the case. We will see that in some cases the franchisee is controlled by the franchisor to the point where he is no longer independent. The equality of the contracting parties has also been questioned (Brown, 1973). Often the franchisee is an inexperienced person who can be coerced easily into signing an unfair contract. However, this is not always the case. Some large corporations operate as franchisees of smaller companies, as in the case of Standard Oil (Ohio) operating as Dutch Pantry franchisee.
One of the major incentives for a company to go into franchising is the opportunity to control the marketing channel without heavy capital expenditures. Franchising allows a company to build a chain of outlets while investing only a small amount of its own capital. This point will be examined in more detail later.

This standardization of the system is an advantage to both the franchisor and the franchisee. By building a readily identifiable image, both parties can take advantage of common advertising and goodwill built up throughout the system.

The Franchise Marketing System

Stern and El-Ansary (1977) separate marketing channels into conventional channels and vertical marketing systems. They further divide the latter category into administered systems, contractual systems, and corporate systems. The franchise method of distribution is classified as a contractual vertical marketing system.

Conventional marketing channels consist of totally independent manufacturers, wholesalers, and retailers. Firms at each level in the channel purchase and sell goods based solely on their individual business objectives. The manufacturer has no control over the way in which his product is presented to the ultimate consumer.
An administered vertical marketing system is characterized by greater control by one of the parties in the marketing channel. This control is informal and may take the form of suggested retail prices, special display or advertising assistance, or assistance in developing sales plans in a more systematic manner. While the control frequently comes from the manufacturer, it can originate anywhere in the marketing channel.

Contractual vertical marketing systems are differentiated from administered systems on the basis of the formal agreement between channel members on rights and responsibilities. This class of marketing channel includes voluntary and cooperative groups, such as the Independent Grocers Alliance (IGA) and Sentry Hardware, as well as franchise systems. The formal contract spells out the way in which each member of the group or franchise system will operate his outlet and what benefits he will receive. In exchange for giving up the right of independent choice in the matters covered by the contract, the member can benefit from the expertise of the sponsor and share in any scale economies derived from having an integrated system.

Corporate vertical marketing systems exist where operations at more than one level of the marketing channel are owned by a single company. In the extreme case, this would be a company which manufactures a product and then
distributes it to company owned retail outlets. The vertical integration may be initiated by a manufacturer (such as Sherwin-Williams; Hart, Schöffner, and Marx; and Goodyear) buying or establishing its own retail outlets, or by a retailer (such as Sears or Safeway) acquiring a financial interest in its suppliers.

As a contractual vertical marketing system, franchising exhibits some characteristics of both the administered and the corporate vertical marketing systems. The franchisee retains some of the characteristics of an independent businessman, such as the right to participate in the profits of his outlet and the responsibility for its losses, while the standardization of the outlets makes the entire system appear as a company owned chain to the consumer.

Franchise Agreements

The franchise contract spells out the rights and responsibilities of the parties in the franchise system. In exchange for training, site selection assistance, marketing support, and use of the company trade name and image, the franchisee agrees to pay an initial franchise fee, a percentage of gross sales as a royalty, and other fees and charges for services rendered by the franchisor in addition to promising to operate the outlet according to a set of rules established by the franchisor (McGuire, 1971; Brown, 1973).
The franchise agreement is for a fixed number of years (usually fifteen to twenty) and after this time the rights to the franchise revert to the franchisor. Franchise contracts can also be terminated by the franchisor if the franchisee fails to follow any of the operating rules. Brown (1973) points out the problems which these termination clauses can create. In effect, the franchisee does not benefit from the "sweat equity" in his franchise. That is, the goodwill and community image built up by the work of the franchisee are appropriated by the franchisor. In many cases, the franchisor repurchases the franchise for the original capital investment rather than the market value of the outlet. In addition, the franchisor reserves the right to approve the transfer of the franchise, so that the franchisee cannot sell out unless he sells to the franchisor or can find a buyer who can gain the franchisor's approval. This approval clause can even prevent the franchisee from leaving the franchise to his heirs.

Advantage of Franchising

Franchisors choose the franchise method of distribution for a number of reasons. Lillis, Narayana, and Gilman (1976) suggest that market penetration, risk sharing, entry capital, and franchisee motivation are important factors during the early development of a franchise system. In
these early years, it is difficult for a company to raise capital. It is useful, therefore, to have the franchisees provide capital and take on some of the risk of losses. This allows the system to expand much more rapidly. McGuire (1971) lists a similar set of advantages. Hackett (1977) adds two additional reasons: less susceptibility to labor organization and creation of certain scale economies for the franchisees. To these, we can add the avoidance of certain state taxes by the franchisor.

Franchisee motivation as a reason for franchising is interesting because it implies that the franchisor views the franchisee as a type of employee. The argument is that an owner-manager will work harder and be more productive because he has a direct interest in the financial performance of his outlet. The manager of a company owned outlet, on the other hand, is merely an employee putting in an eight hour day. Brown (1969) claimed that, to a large extent, this extra productivity comes from the franchisee using his family and not paying himself an adequate salary in order to show a profit on his operation. In the extreme, Brown claimed, franchisees actually work harder to make less than they would as company employed managers.

One trend which brings franchisee motivation as a reason for franchising into question is the increase in company owned outlets. Oxenfeldt and Kelly (1969), McGuire (1971),
Hunt (1973), and Hackett (1977) have all pointed out that franchising companies are increasingly found operating their own outlets. John W. Brown, former president of Kentucky Fried Chicken, was quoted in Hackett (1977) as saying: "We'll make more profit from 300 company owned stores than we will from 2,100 franchise outlets." If franchisees outperform company employees, why should companies be interested in operating outlets themselves?

While many forces affect this decision, it seems that franchisees are better as managers of marginal outlets where the profits are not great enough to offset the cost of using company hired managers.

The lowering of susceptibility to labor organization and avoidance of certain state taxes are achieved in franchising because of the legal independence of the franchisees. Labor organizations have a more difficult time penetrating a large number of small outlets than a unified chain. The cost of organizing hundreds of independent companies may exceed the potential benefits.

State corporate taxes are usually based on a three factor formula including employment, sales, and capital investment in the state. In a franchise system, a company can have outlets throughout a state without having any employees or capital investment in the state. This transfers the burden of taxation to the franchisees, often at a much lower tax rate.
Hackett (1977) listed the disadvantages to the franchisor of franchising as less control over the distribution channel, less participation in profits, and greater chance for conflict. All of these items stem from the independence of the franchisee. Conflict in the channel is a common problem which has resulted in numerous lawsuits and has been examined in detail by Brown (1973) and Thompson (1969, 1971). Oxenfeldt and Kelly (1969) and Lillis, Narayana, and Gilman (1976) suggested that these factors become more dominant the longer the franchisor is in business and that the result of this trend is the effort by the franchisor to repurchase franchises.

The major benefits of franchising accruing to the franchisee are the training, financial support, and expert guidance offered by the franchisor (Bernstein, 1969). By giving up a few freedoms in the operation of his business, the franchisee can avail himself of this franchisor support and be more likely to succeed. Hunt (1972) reviewed the evidence that franchising has allowed more small businesses to be created and has made it more likely that these businesses will succeed. To many, the genius of the franchising concept is that it allows a person who is totally ignorant about a certain type of business to become established in that business in a short amount of time. Largely for this reason, the U.S. Office of Minority Business Enterprise,
along with other federal agencies, has attempted to expand the opportunities for minorities in franchising as a means to bring them into the mainstream of American business. Hunt (1972) listed several reasons why this effort has not been as successful as it might be.

In another article, Hunt (1973) cited increasing frustration with the franchise arrangement through time as a reason for the increasing number of company owned outlets. According to this argument, the franchisee is initially satisfied with the arrangement because of the training and other benefits. However, as time goes on and the franchisee becomes more experienced in the business, resentment begins to build up over the continuing royalty payments and the control exerted by the franchisor. The result is that, after a period of time, the franchisee resells the franchise (usually to the franchisor) and sets out on his own. The freedom of the franchisee to establish his own firm is sometimes limited by a clause in the franchise contract prohibiting the franchisee from establishing a firm in competition with the franchisor for a certain time period and/or certain specified territories.

**Characteristics of Franchise Companies**

The companies which make up a franchise system, the franchisor and the franchisees, differ in certain ways from companies in other types of distribution systems. Most of
these differences are reflected in the sources of revenue and costs for these companies. In this respect, a unique relationship can be identified which is common to most franchise systems and differentiates companies in these systems from those in other types of distribution systems.

**Sources of Revenue for the Franchisor**

The franchisor obtains revenue from an initial franchise fee, which can vary from less than one thousand dollars to several hundred thousand dollars depending on the type of business, and three basic sources of continuing income. The most important source of continuing revenue is a royalty fee based on the franchisee's sales. This payment is usually three or four percent and is based on gross sales (Thompson, 1971). The franchisor collects this fee whether or not the franchisee is making a profit. It is in the interest of the franchisor, therefore, to encourage the franchisee to emphasize sales rather than profits. While the ability of the franchisees to make a profit affects the ability of the franchisor to sell new franchises, the franchisor is more interested in increasing sales than with having franchisees earning the largest possible profits.

Advertising is a responsibility of both the franchisor and the franchisees in most franchise systems. To gain a national image as a chain, the franchisor usually does a certain amount of regional or national advertising. To
help cover the cost of this effort, a fee of about three percent, again based on gross sales, is often charged to the franchisees (Thompson, 1971). Another approach to advertising is for the franchise agreement to specify that the franchisee spend a fixed percentage of gross sales, usually three or four percent, on local advertising (Thompson, 1971; Boas and Chain, 1976).

The third major source of franchisor revenue is the sales or lease of buildings, equipment, and materials to the franchisees. The revenue derived from this source, and the method of collection, varies widely between different types of franchise systems. The payments may take the form of specific fixed payments or of a percentage of gross sales. If the franchisor is a manufacturer of a product, significant income may be derived from the sale of that product to the franchisees. Likewise, the lease of buildings and equipment (or, in some cases, the sale of equipment) may be a significant source of revenue in some franchise systems. Boas and Chain (1976) credit the leasing of real estate to franchisees for a major part of the success of McDonald's.

Costs of the Franchisor

The costs of the franchisor are for the most part derived from the effort to recruit and establish franchisees.
They include the maintenance of a corporate office; product development and improvement; screening prospective franchisees and outlet locations; establishing and updating building, sign, and equipment designs; and training new franchisees and their staffs.

In addition, advertising campaigns are often coordinated by the franchisor. Nationwide or regional advertisements are supplied by the franchisor and may be paid for either out of franchisor revenues or from a special assessment against the sales of the franchisees. Local advertising is usually the responsibility of the franchisee. However, films and materials are often supplied by the franchisor to maintain a uniform image (Thompson, 1971).

The franchisor is responsible for all aspects of developing and maintaining the image of the company. This includes the products to be sold, the design of the buildings, the uniforms for the employees, and even the prices of the products. The purpose of this standardization is to make the franchise system appear to the public as a chain of company owned stores. The consumer can, therefore, be confident that he will receive the same treatment and product in any outlet. Besides emphasizing the company identification, this standardization takes advantage of the consumers' fear of experimentation. A traveler can walk into a franchised outlet hundreds of miles from home
and know exactly what to expect, based on his past experience with his home town outlet in the same franchise system.

Most franchisors maintain some kind of system to supervise the operations of the franchisees. This both allows the franchisor to guarantee standardization and helps guarantee that he receives the proper royalty payments. Supervision can include both personal visits by inspectors and auditing of the sales reports at the home office (Boas and Chain, 1976).

Product development is an important function of the franchisor. In order to remain competitive, it is vital that the chain continually update its product line, incorporating innovations developed by other chains and introducing new items to attract additional customers. Since the franchisees are usually forbidden to experiment with the product line and company image, it is the franchisor's sole responsibility to provide this service.

The recruiting of franchisees is a major item in the functions of a franchisor. This is the bread and butter of the franchise system. For an established franchise system, this recruiting may only involve talking with people who seek out the franchisor. However, when the franchising process is just beginning and the firm has not established a reputation, it is usually necessary for the franchisor to search for prospective franchisees. This process can include
the use of trade journal advertising, notices in existing outlets, and approaches through suppliers or other personal contact channels. Some franchise systems have even used general newspaper and television advertisements.

The amount of effort needed to sell a franchise is likely to depend on the franchisee's perception of the risk involved. For a new franchise system, this perceived risk is high, since there is little in the way of performance data on which the prospective franchisee can base his decision. As the system grows older, the prospective franchisee can observe the performance of existing outlets and, therefore, will have fewer doubts about his chances for success. In the latter case, the franchisor can spend less money and effort on selling each franchise.

The above comments on risk also have implications for the amount of power the franchisor has over the channel. In a new franchise system, or one that is failing, the franchisor will probably have to give up some power in order to sell franchises. In a well established and successful system, the franchisor should be able to gain additional power since people will most likely be competing to obtain franchises.

In most franchise systems, the franchisor is not directly involved in production. It is illegal for the franchisor to require that franchisees buy any product from him if it is available from other sources. For this reason, most
franchise systems have recommended suppliers or national buying contracts. These schemes allow the franchisees to take advantage of large scale buying without forcing them to buy from the suggested supplier if they do not want to. Recommended suppliers are companies which the franchisor suggests as the best able to supply the products needed in order to comply with the specifications in the franchise contract. These suppliers can offer a special price, since they sell large quantities of the same product to different franchisees. In a national buying contract, the franchisor contracts with a company for a discount which the supplier passes on the franchisees directly or through regional distributors. Again, the large volume allows a lower price.

In one case, the franchisor can become directly involved in supplying the franchisees without violating anti-trust laws. This occurs when there is some patented process or item involved. This is the reason for the large number of secret recipes and sauces found in fast food restaurants, for example. It also covers the case in which the franchisor must provide the process in order to maintain uniform service, as in photographic film developing services.

In some franchise systems, including gasoline service stations, the franchise actually conveys the right to sell the franchisor's product (gasoline, bicycles, television,
and so forth). In this case, the franchisor incurs all of the normal production costs and receives the wholesale price of the product from the franchisees. The antitrust laws do not apply in this case, since a consumer has the right, for example, to expect that Exxon products will be sold at an outlet displaying an Exxon sign.

Sources of Revenue for the Franchisee

The only source of revenue available to the franchisee is the receipts from the sale of the product or service. This, of course, ignores the illegal "pyramid sales" franchise in which the franchisee is given the right to sell other franchises, or distributorships, and few people, if any, ever actually end up selling the product.

There are actually two types of franchisees. The individual franchisee is given a franchise for a single outlet which he operates. The master or area franchisee is given a franchise covering a large area such as a county or state. The master franchisee may operate all of the outlets in the area himself or as joint ventures, or he may have the right to sub-franchise the outlets to individual franchisees. In the latter case, the master franchisee takes on some of the characteristics of a franchisor, such as collecting franchise fees and royalties.

The most unusual feature of the franchise method of distribution with respect to franchisee revenues is that the
franchisee is not usually free to set the price of the product. In order to maintain the image of uniformity in the outlets, the franchisor usually dictates the price level which all of the franchisees in a given area are required to use. This does not allow the franchisee to adjust prices to allow for the cost level at his particular location or set of locations. This practice varies depending on the type of products and the strength of the franchisor.

Price fixing on the part of the franchisor is actually illegal, but informal price fixing still occurs through a variety of practices. Many franchisors provide franchisees with pre-printed menus or advertising material which contain prices. Others place a suggested price on their products or make the suggestion of prices part of their management assistance. As a practical matter, it is difficult for one franchisee to charge higher prices than the other franchisees in the same city, since the consumer views all of the outlets as belonging to the same chain.

Costs of the Franchisee

In a production-distribution franchise, such as a fast food restaurant, the franchisee has a cost structure similar to that of an independent businessman. He must purchase materials (often under a special buying contract arranged by the franchisor, see above), hire labor, provide a store
and equipment, and pay overhead and other normal operating costs.

The unique costs to the franchisee relate to his position with respect to the franchisor. These costs include the franchise fee, a one time payment to the franchisor; the royalty payment on gross sales; and any advertising assessments. In addition, there may be charges for training, supervision, and management consulting provided by the franchisor. In general, these latter costs are in the form of fees for services rendered.

In order to break even, the benefits in terms of additional revenue derived from holding a franchise must at least cover the franchise fee (mortized over some suitable period of time) and royalty payments. Otherwise, the franchisee would be better off as an independent businessman.

Location Selection Practices of Franchise Systems

The location decision process for a franchise firm is actually a multi-stage process. Kotler (1971) identified four stages in the retail location process: the market selection, number of outlets, site selection, and store size and characteristics decisions. The market selection decision involves the choice of a region or city in which to locate. The next step is to determine the number of outlets to be located in that region. Next, specific sites must be found for each of the outlets. Finally, the size
and characteristics which will best serve the target population of each outlet must be determined. Each step requires different information and involves different criteria for making the decision.

Actual location practices vary widely between franchise systems. One of the biggest differences between systems is the amount of control exercised by the franchisor. McGuire (1971) suggested that franchisors are reluctant to give the franchisee any part in the location decision and almost never relinquish the final decision. However, in a study of pancake restaurants, Lamb (1965) found a range of procedures, varying from no franchisor assistance to a strict set of locational criteria imposed by the franchisor. Generally, Lamb found that the franchisor looks for a set of minimum requirements in a site proposed by the franchisee.

McDonald's is an extreme example of franchisor control of the location process (Boas and Chain, 1976). The company selects the location, constructs the building, and then leases the package to the franchisee. The franchisee has no input into the location decision. In fact, the location is often selected before a franchisee is found. If he wants the franchise, the prospective franchisee must trust the company's judgment.

The market selection decision is generally made by the first franchisor, though the franchisee may select the
market in which he as an individual wishes to operate from among those offered by the franchisor. The decision is based on long term expansion plans, supervision or distribution problems, or the availability of franchisees.

The number of outlets decision is also generally made by the franchisor. The number chosen is based on the potential demand in the market area and the capacity of each outlet. If the franchisee is given a franchise for more than one outlet, the number to be developed is often specified in the franchise contract.

The site selection decision is often a cooperative decision between the franchisor and the franchisee, though either one might control the decision in any particular franchise system. As noted above, McDonald's makes this decision with no franchisee input. A more common practice is for the franchisee to propose a site which is then subject to the approval of the franchisor. This is the approach followed, for example, by Arthur Treacher's Fish and Chips and Wendy's.

The evaluation of sites is usually based on the market area for the individual outlet. The only concern given to other outlets in the same area is that no two outlets are closer than some predetermined distance and that the target number of outlets in the area is not exceeded. The evaluation is usually carried out using a checklist of
site and area characteristics, such as population, growth patterns, traffic patterns, zoning, highway access, location of competitors, and the cost of the site. These factors are drawn from the retail location guides such as Nelson (1958), discussed in the previous chapter.

The selection of store size and characteristics is usually the privilege of the franchisor, since the franchisor determines store designs. However, the decision often depends on the specific site selected and the franchisee may be given a choice between a number of outlet sizes and designs.

Franchisors generally include a guarantee of an exclusive territory in the franchise contract. This can either be based on some predetermined geographical boundary, such as a county, on a minimum distance between outlets, or on the population of the market area. Hackett (1977) pointed out that population provides the most flexible basis for allocating territories, since new franchisees can be added easily as the market grows. When fixed physical boundaries are used, once all of the territory is allocated, no new outlets can be added without renegotiating contracts. Recognizing this problem, Lovell (1970, 1971) developed a location model based on the spatial duopoly model (Hotelling, 1929) which derives a set of contracts which force
franchisees into locations which maximize sales and the collection of franchise fees (that is, maximize franchisor profits). However, Lovell's model requires that the franchise contracts can be renegotiated at any time, as well as assuming that customers are evenly distributed along a single line.

The above discussion has not distinguished between the individual franchisee and the master franchisee. The two types of franchisees have somewhat different locational goals. While the individual franchisee is concerned only with selecting the location for his one outlet which will yield the maximum profit, the master franchisee is concerned with locating many outlets. To maximize his profits, the master franchisee must concern himself with the optimal number of outlets for the market, the distribution of the outlets so as to maximize aggregate profit, and the trade off between the cost of additional outlets and the additional profit they might generate.

**Summary**

Franchising is a method of creating a vertically integrated marketing channel by establishing a formal contractual arrangement between parties at different levels of the channel. Each of the parties maintains a degree of independence and this independence creates both benefits and problems for all involved.
Franchisors are attracted to this form of marketing by the low capital requirements, the lower level of risk involved, and the chance for faster market penetration. Franchisees are attracted by the technical and financial assistance provided by the franchisor and the absence of any need for previous experience or training in the field.

Franchisors incur extra costs in establishing and supervising the system and are compensated by a franchise fee and royalties paid by the franchisees. Outside of these extra payments and certain operating controls imposed by the franchisor, the franchisee's situation is similar to that of an independent businessman.

Since the contractual vertical marketing system is midway between the administered and the corporate vertical marketing systems, it is not surprising that the location decision process is a combination of elements from the location processes of firms in the latter two systems. The franchisor will tend to behave as if it was a corporate marketing system and the franchisee as if it was an administered marketing system.

The existence of independent businessmen at the different levels of the contractual vertical marketing system can easily lead to conflict within the channel if goals do not coincide. Brown (1973) lists numerous examples of litigation resulting from this type of conflict within franchise
systems. The following chapters will examine the potential for conflict because of differences in the locational goals of the franchisor and the franchisees.

Now that the characteristics of franchise systems have been established, the application of central place theory to the problem of selecting locations for retail outlets, specifically franchise outlets, can be examined. This will be the subject of the next chapter.
CHAPTER 4

THEORETICAL IMPLICATIONS OF CENTRAL PLACE CONCEPTS
FOR OUTLET LOCATION DECISIONS

Central place theory was developed in the context of central market places or cities. However, certain concepts developed as a part of central place theory also apply to the location of individual facilities. In this chapter, the concepts of threshold, range, and the demand cone will be examined in relation to the problem of locating consumer oriented facilities. Franchised retail outlets will be used as a specific example of this type of facility. After a discussion of the development of these concepts in a classical central place context, their implications for the retail outlet location decision will be examined from the perspective of the franchisor, the master franchisee, and the individual franchisee.

The goal of this chapter is to provide a theoretical basis for the location models which will be developed in Chapter 5. Therefore, the comments on the behavior of businessmen should not be taken as statements about the variables actually considered by them when making decisions.
They should be viewed as statements about the theory under-
lying those decisions.

Central Place Concepts

Threshold and Range

The concept of range was introduced by Christaller (1966) to describe the distance which members of the popu-
lation will travel to obtain a given good from a central
place. Three types of range have been identified: the inner
range, or threshold distance; the ideal range, and the real
range.

The inner range is the distance from a central place
which contains the level of demand which Berry and Garrison
(1958) referred to as the threshold of a good. This is the
minimum level of demand necessary for a particular good to
be offered at a central place and is dependent on the size
and distribution of the population, the income of the popu-
lation, the nature of individual demand for the good in the
region, and the price of the good at the market. The way
in which members of the population value the time spent
travelling to obtain the good also affects this distance.

The ideal or outer range is defined by the maximum
distance which a consumer is willing to travel to obtain a
good at a given price. Its existence is based on the
assumptions that there is some maximum price for a good
above which demand will be zero and that the consumer considers the transportation expense necessary to obtain the good as part of the price of the good. Therefore, at the distance where the price of the good plus the transportation cost equals the maximum price a consumer will pay for the good, the ideal range has been reached. This distance depends on the value which the consumer places on travel time and the character of the good as well as on the price at the central place.

The inner and ideal ranges have been defined solely in terms of the characteristics of a single central place. However, the actual trade area around any market is also affected by the existence of competing markets. Consumers will purchase from these competing centers if they are closer than the original market under consideration. Therefore, the extent of the trade area will be limited by competition to some distance between the inner and the ideal range. This is referred to as the real range of the good.

The real range can vary from a minimum corresponding to the inner range to a maximum corresponding to the ideal range. In the former case, the trade areas are at their minimum size, since each firm is operating at its threshold level. The small trade areas imply that the number of central places is maximized and this, in turn, implies that the distance to a central place for any given consumer is
at its minimum. This pattern maximizes overall demand in the system, since each consumer obtains the good at the lowest possible delivered price (transportation costs are minimized).

If the real range corresponds to the ideal range, trade areas are at their largest size and the number of central places is minimized. This pattern maximizes demand at the individual central places, since there is no competition between central places for potential consumers (no overlapping trade areas). Overall demand, however, is lower since consumers located toward the outer edges of the trade areas must travel farther to obtain the good than they would if the real range was closer to the inner range.

The owner of a chain of outlets, or a franchisor, would prefer to have the real range correspond to the inner range, since overall demand for the good in the region is maximized. The individual store owner, on the other hand, would prefer to have the real range correspond to the ideal range, since demand at the individual store would then be maximized.

The determinants of market area size and shape will be discussed in more detail later. First, however, it is necessary to examine the demand cone concept.
The Demand Cone

Christaller (1966) did not specify a method of calculating the inner and ideal ranges. This was accomplished by Losch (1954) through the derivation of the demand cone. The demand cone is simply the spatial variation in the level of individual demand. Called a cone because its decline from a single center resembles that geometric shape, the demand cone reflects the change in the delivered price of the product (price at the central place plus transportation cost) with distance from the central place. As this delivered price increases, the individual's level of demand decreases, ceteris paribus.

The basis of the derivation of the demand cone is the individual demand curve, relating the quantity demanded to a price which is a combination of the market price and the transportation cost incurred by the individual in obtaining the good from the market. This curve was assumed by Losch to be concave to the origin and to intersect both the price and quantity axes (Figure 1). The price at the central place can be represented by $P$ and the corresponding quantity demanded by $Q$ in Figure 1. Point A represents the price at which demand reaches zero and so, by implication, indicates the ideal range of the good. By rotating the segment of the demand curve between points $Q$ and $A$ around a central place using the line $\overline{FQ}$ as an axis, the spatial
Price

Individual Demand Curve

Figure 1

The Demand Cone

Figure 2

Price

Losch's Aggregate Demand and Long Run Average Cost Curves

Figure 3
variation in demand, or the demand cone, is illustrated (Figure 2). Since P and A represent prices, distance in this case is measured in terms of price. It can easily be converted to miles by dividing the difference between P and A by the transportation rate. Notice that the choice of the price level, P, is arbitrary. There is a unique demand cone for every value of P between zero and A. The actual price depends on supply and demand conditions at the central place and requires a consideration of the aggregate demand curve.

The aggregate demand curve is easily derived from the individual demand curve shown in Figure 1. Losch defined the individual demand curve as a function of market price (p) and transportation cost (t), which includes both the transportation rate and the distance to the central place. This can be expressed as \( f(p + t) \). Total demand is then defined as

\[
D = 2b \pi \int_0^R f(p + t) \ t \ dt
\]

where b is the population density (assumed to be uniform throughout the region) and R is the maximum transportation charge (PA in Figure 1). This formula for aggregate demand is simply the volume of the demand cone multiplied by the population density. Losch assumed that the aggregate
demand curve would be convex to the origin and represented by a curve similar to that shown as AC in Figure 3.

Determining the market price also requires an examination of the costs faced by the entrepreneur. These costs are represented in Figure 3 by the long run average cost curve, labeled LAC. The entrepreneur chooses the price, \( P \), and the associated quantity, \( Q \), at which the marginal cost equals marginal revenue. Once this price has been determined, the ideal range can be calculated from the individual demand curve as described earlier.

Though Losch did not explicitly derive the threshold for a good, this value can be easily determined from the information in Figure 3. The threshold is the smallest demand which will support production or sale of the good at the central place. Also, this production or sale cannot occur if the long run average cost curve is above the aggregate demand curve (which is also the average revenue curve) since if average cost exceeds average revenue in the long run, the firm will be bankrupt. Therefore, the threshold level of demand is at the point where the long run average cost curve first crosses the aggregate demand curve from above (at a price of \( P \) and a quantity \( Q' \) in Figure 3). If the aggregate demand curve is tangent to the long run average cost curve, the threshold corresponds to the entrepreneur's optimal output level and the system is at the
equilibrium implied by Christaller and Losch. Market areas are at their minimum size, the number of producers is maximized, and no excess profits are earned. If, as is illustrated in Figure 3, some part of the long run average cost curve is below the aggregate demand curve, the entrepreneur's optimal output is above the threshold level and excess profits can be earned. This situation corresponds to one in which the real range lies somewhere between the inner range and the ideal range (possibly at the ideal range).

It is also possible for the long run average cost curve to be at all points above the aggregate demand curve. In this situation, threshold demand cannot be achieved within the ideal range and the good cannot be offered at the central place.

The relationship between the long run average cost curve and the aggregate demand curve is important to the franchisor-franchisee relationship to be discussed below. If the long run average cost curve is tangent to the aggregate demand curve, the goals of the franchisor and the franchisee must coincide, since there is only one possible level of operation for the outlets. However, when the long run average cost curve exceeds the aggregate demand curve over some interval and the possibility of excess profits at the outlet exists, the goals of the franchisor and franchisee diverge. As a sales maximizer, the franchisor would
still prefer to have all of the outlets operate at the threshold level so that the number of outlets is maximized along with total demand in the region. The franchisee, on the other hand, is attempting to maximize profits from the outlet(s) and will, therefore, attempt to operate at a level greater than the threshold to take advantage of the excess profits available at that level. In the extreme case, the franchisee would prefer to operate at the ideal range. This point will be examined in more detail after a discussion of the determinants of market area size and shape.

**Market Areas under Free Entry**

In the above discussion of the concepts of threshold and range, the size and shape of market areas were not explicitly included. Both Christaller and Losch argued that an equilibrium pattern would include hexagonal market areas containing the threshold level of demand, given their initial assumptions about the spatial distribution of population. Denike and Parr (1970) derived market areas from the aggregate demand and long run average cost curves and showed that an assortment of market area shapes are possible.

Denike and Parr started their analysis by deriving the aggregate demand curve. Their method was essentially the same as that employed by Losch. However, by examining the derivatives of the demand function they were able to
show that it is concave to the origin instead of convex as was suggested by Losch. This results in an aggregate demand curve such as the one labeled D in Figure 4.

Faced with a long run average cost curve, LAC, and an aggregate demand curve, D, as illustrated in Figure 4, the entrepreneur will choose a price, P, and corresponding demand level, Q, which maximizes the amount of excess profit for the firm. This point is found where marginal cost equals marginal revenue for the firm. The existence of excess profits encourages other firms to enter the market at nearby central places. Eventually, these firms will have to locate so close together that their ideal ranges will overlap. This has the effect of reducing demand for each firm, since some customers will be lost from the outer portion of the market area. To reach equilibrium, excess profits must be eliminated. This occurs when the aggregate demand curve for each firm is reduced to the level where it is tangent to the long run average cost curve (D' in Figure 4). At this point, no new entrepreneurs will desire to enter the market.

Denike and Parr claimed that the shape of the market areas at equilibrium could be one of three shapes: hexagons, rounded hexagons, and circles. Which of the three actually occurs depends on the price at the central place. A high price implies that the ideal and inner ranges are the
Aggregate Demand and
Long Run Average Cost Curves

Figure 4
same and the firm is operating at the threshold level. If it is necessary for the market area to extend to the ideal range in order to attain the threshold level of demand, the market area must be a circle, since the radius must be the same in all direction (and equal to both the inner and ideal ranges). This situation would occur if a price of B was arbitrarily imposed in the situation depicted in Figure 4 or if the free spatial demand curve (the aggregate demand curve when there is no competition present) was D' in Figure 4.

As the price at the central place falls, or the demand curve moves toward the one labeled D in Figure 4, the potential market areas as determined by the ideal range begin to overlap. As this occurs, the equilibrium market areas will first take on the form of hexagons with rounded corners and, eventually, true hexagons. This is possible because the consumers lost to competition along the line directly between central places can be compensated for by extending the market area beyond the inner range in other directions. The result is a hexagon with a short radius less than the inner range, a long radius greater than the inner range, and an area approximately equal to a circle with a radius equal to the inner range.

In the next section, the implication of these central place concepts for location decisions will be examined.
The Franchisor

A franchisor obtains revenue based on the level of sales at the outlets in his system in the form of royalty payments. The common procedure is to take a fixed percentage of the outlet's gross sales. Most of the franchisor's costs, on the other hand are fixed, since the franchisee absorbs the normal variable costs of doing business such as labor, supplies, rent, utilities, and so forth. The franchisor may have certain variable costs, advertising and supervision costs, for example, but these are likely to be a relatively small part of total costs. For this reason, the goal of the franchisor is to maximize the total sales of all of the outlets taken as a group. Within reason, the franchisor is not concerned with the level of sales at any particular outlet or with the profits of the franchisees. Of course, the franchisor will become concerned if the franchisees are losing money, since this will make it difficult to sell additional franchises.

In order to maximize sales, the franchisor would prefer that each outlet operate at its threshold level (quantity Q' in Figure 4) and that enough outlets exist so that the entire market will be served. This is accomplished by locating enough outlets in the market so that each one can
only obtain a threshold level of sales due to competition with other outlets. Assume that the free spatial demand curve (aggregate demand when there is no competition) is depicted by the curve labeled D in Figure 4. The outlet would then operate at a level of demand Q and charge price P in order to maximize excess profits. However, the franchisor can increase sales in the market by introducing additional outlets which drive the aggregate demand curve down to the level depicted by D'. Each outlet will now operate at a lower demand level, Q', and charge a higher price, P'. However, there are now more outlets in the market.

To see that this strategy does, in fact, increase demand in the market, refer to the individual demand curve in Figure 1. Because the outlets are now closer together, consumers which were toward the outer edge of one of the former market areas and paying a delivered price of, for example, P, are now located closer to an outlet and paying lower transportation charges to obtain the same product. The new delivered price might be P', raising the demand level of this individual from Q to Q'. Since no individual in the market is located farther away from an outlet than he was originally, total demand has been increased. However, it was noted above that the outlets would charge a higher price when operating at their threshold level. This will
tend to offset some of the increase in demand. The franchisor will only add outlets, then, up to the point where the next new outlet will add less to demand due to lower transportation costs than it will subtract due to the higher price which must be charged because of the lower average demand per outlet.

In general, the franchisor is interested in having enough outlets in the market so that each outlet will operate at the threshold level. For this reason, the franchisor can be expected to oppose any limitations on the number of outlets or the minimum distance between outlets which might result in less than this optimal number of outlets being located in the market.

The Master Franchisee

The situation of the master franchisee is considerably different from that of the franchisor. Assume that the master franchisee has at least a partial financial interest in the operation of each of the outlets in his assigned territory. Then, the master franchisee must be concerned with maximizing the profit derived from those outlets. Like the franchisor, however, he will be interested in the performance of all of the outlets taken as a group, not with the performance of any single outlet.
Denike and Parr (1970) suggest that the market area size which maximizes excess profits for the individual outlet is not the same as the size which would be selected by the multi-plant monopolist (which is the same as a master franchisee). They claim that the multi-plant monopolist will select the market area size which maximizes the aggregate level of excess profits. There is a trade-off between the level of excess profits at each outlet and the number of outlets in the region which must be considered.

When there is only one outlet in the market, it faces an aggregate demand curve such as $D$ in Figure 4 and will operate at a quantity $Q$ and price $P$ which maximizes excess profits. When a second outlet is opened in the market, each of the outlets face a somewhat lower aggregate demand curve, say $D''$. Each of the outlets will serve a smaller demand, $Q''$, charge a slightly higher price, $P'$, and earn a slightly smaller level of excess profit. However, there are now two outlets contributing excess profits to the master franchisee. Outlets can continue to be added until the aggregate demand curve faced by each outlet is $D'$ and there are no excess profits. Over some range, each additional outlet will add to the total excess profit. However, as the level of operation of each outlet approaches the threshold level, the excess profits begin to disappear. The master franchisee will continue to add outlets up to the point where the
marginal contribution of the next new outlet to excess profits is zero. The result will be that the outlets will have market areas which exceed the threshold size, but will most likely not reach the ideal range. The optimum size will depend on the exact relationship between demand and long run average costs.

The Individual Franchisee

The equilibrium pattern for the individual franchisees taken together, if free adjustment of locations is allowed, will be the same as the pattern preferred by the franchisor. However, this is not the pattern that would be preferred by each individual franchisee.

If one franchisee could control the location of all of the other franchisees, he would select the locations so as to maximize his own excess profits. To do this, the individual franchisee would seek to eliminate competition, so that the effective demand curve would be the free spatial demand curve (D in Figure 4). The individual franchisee would then select the price and associated demand level which would maximize excess profits (P and Q). If the individual franchisees were allowed to conspire to restrict entry into the market, the result would be a pattern which eliminates competition between outlets for consumers, contains the fewest number of outlets of the
three patterns discussed here, offers the product at the lowest market price, and has the largest trade area for each outlet. Figure 5 shows the demand cones for two centers in this location pattern. Each individual franchisee in this system operates with a trade area equal to the ideal range and receives the maximum possible level of excess profits.

If free entry of new individual franchisees is allowed and the locations of outlets can be freely adjusted, a much different pattern will develop. Each franchisee will be trying to maximize his own excess profit. However, as long as excess profits exist in the system, there will be an incentive for a new franchisee to locate in the region. New franchisees will continue to enter until each franchisee faces an aggregate demand curve which is exactly tangent to his long run average cost curve (D' in Figure 4), each outlet is operating at its threshold level, and no excess profits are being earned. Figure 6 illustrates the demand cones corresponding to this location pattern. This is exactly the pattern which is preferred by the franchisor. Demand per outlet is lower than in the pattern shown in Figure 5, but the overall level of demand is higher due to the increased number of outlets.

The behavior of the individual franchisee under free entry conditions is similar to the behavior predicted by
Demand Cones for Two Outlets
Operating at Ideal Range

Figure 5

Demand Cones for Five Outlets
Operating at Inner Range

Figure 6
Hotelling (1929). Each individual franchisee will seek to locate so as to capture as much of the potential market as possible from his competitors. If two franchisees are competing for the same potential market, they will tend to locate next to each other, each taking half of the market. Each additional franchisee will attempt to locate at a place which will allow him to capture as large a part of the market as possible from the original franchisees. The resulting pattern is highly dependent on the location of the first outlet and will tend to be more concentrated in the center of the market than the patterns preferred by the franchisor and master franchisee. In addition, if free adjustment of locations is not allowed, many of the locations chosen in early time periods may have large parts of their market areas captured by later entrants and become unprofitable locations.

It is obviously to the individual franchisee's advantage to restrict the entry of new franchisees as much as possible. In practice, this is accomplished by requesting the franchisor to grant exclusive territories. This grant generally takes the form of a promise to not allow another outlet within a specified distance of the franchisee's outlet. The individual franchisee would prefer that this distance be at least as large as the ideal range for his good. This would effectively eliminate all competition for
consumers and maximize the excess profits of the franchisee. The franchisor, on the other hand, would prefer that the distance be less than or equal to the inner range. Any greater distance will reduce total demand and thereby reduce franchisor revenues.

Compromise Patterns

From the above, it can be seen that the control of a franchise system by the individual franchisees will result in a location pattern different from that of a system controlled by the franchisor. While the individual franchisees would select a few widely spaced outlets, the franchisor would prefer to pack as many outlets as possible into the market, with each outlet operating just at the threshold level. A master franchisee would prefer still a third pattern, with more outlets than the individual franchisee pattern, but still maintaining some level of excess profit at each outlet. Since the franchisor and at least one type of franchisee must be present in an actual franchise system, the location pattern must represent a compromise between the parties involved. If the bargaining position of one party is vastly superior to that of the others, the compromise may be the imposition of that party's preference. If bargaining power is more evenly distributed, the location pattern should be a true compromise between the parties.
The best strategy for the franchisor is to deal only with individual franchisees and allow free entry, since this would lead to his preferred pattern through the process of competition between the franchisees. The individual franchisees, however, will seek some guarantee of an exclusive territory. The size of this exclusive territory can be the basis of the compromise between the franchisor and the individual franchisees. The franchisor is likely to make the exclusive territory as small as possible while still attracting franchisees.

If the master franchise method is used, the compromise is more likely to be based on the number of outlets to be opened in the market. The specification of the number of outlets to be established by the master franchisee is a common element of franchise contracts. The master franchisee would prefer that the number specified be the number which will maximize excess profits from all of the outlets. The franchisor is likely to prefer more, since his preferred pattern is one in which excess profits are eliminated.

If the master franchisee resells franchises to individual franchisees, a conflict similar to the franchisor-individual franchisee conflict develops. The master franchisee desires more outlets and smaller trade areas than does the individual franchisee. However, the difference between the master franchisee and individual franchisees
positions is not as great as the one between the franchisor and the individual franchisee positions. The master franchisee, like the individual franchisee, desires to maintain some level of excess profits at each outlet. The compromise between the master franchisee and the individual franchisees involves the trade-off between excess profits at the individual outlets and excess profits in the overall system, with the individual franchisees preferring the former and the master franchisee preferring the latter.

**Summary**

In this chapter, three concepts from central place theory, threshold, range, and the demand cone, were examined and their implications for the location of consumer oriented facilities were discussed. First, the development of the three concepts by Christaller (1966) and Losch (1954) and their refinement by Berry and Garrison (1958) and Denike and Parr (1970) was outlined. Then the applicability of the concepts to the location decision in a franchise system was discussed as a specific example of the use of the concepts to analyze the location of this type of facility.

It was seen that the major point of disagreement between the franchisor, the master franchisee, and the individual franchisee involves the restriction of the number
of franchisees entering a given market. While the franchisor was shown to prefer free entry of franchisees, both the master and individual franchisees were seen to prefer some restriction. The individual franchisee prefers to eliminate all overlap of potential market areas in order to maximize the excess profit at each outlet, while the master franchisee seeks to restrict the number of outlets to that which will maximize the excess profits from all of the outlets taken together.

Of course, the participants in an actual franchise system are not likely to think in the terms used in this chapter. Their attitudes are more likely to be expressed as business experience and common sense, though the ultimate goals of the parties are likely to be the same as those suggested here.

In the next chapter, the central place concepts developed here will be combined with the earlier discussions of franchising and retail location processes to develop mathematical models for the location of franchise outlets.
CHAPTER 5
LOCATION-ALLOCATION MODELS OF A FRANCHISE SYSTEM

In this chapter, normative location-allocation models will be developed for the franchisor, the master franchisee, and the individual franchisee. These models are a combination of the location-allocation technique based on Weber's least cost theory and the central place concepts discussed in Chapter 4.

As noted in Chapter 3, the selection of a retail location was viewed by Kotler (1971) as a series of four decisions: the market selection, number of outlets, site selection, and store size and characteristics decisions. In this chapter, the selection of a retail location will be considered as three separate location questions. The first question is the choice of a market or region and corresponds to Kotler's market selection decision. The second question involves the choice of trade areas within the market. This question includes the selection of the optimal number of outlets and the selection of an optimal pattern of trade areas to cover the market. The third question is the choice of specific sites and the characteristics of the stores to be located at the sites. This
last question includes part of Kotler's site selection decision and the store size and characteristics decision. The models to be developed in this chapter deal with the second location question. Their purpose is to determine the optimal number and distribution of outlets within a single market.

This chapter will proceed by first examining the procedure for estimating demand which is common to all of the location models. Following this discussion, separate location models will be presented for the franchisor, the master franchisee, and the individual franchisee. The sections containing the franchisor and master franchisee models will include separate discussions of the derivation of the objective function, the dynamic application of the model, and a mathematical solution technique. The final topic in this chapter will be a combined model, describing the entire franchise system.

**Estimating Demand in the Franchise Models**

All of the models developed in this chapter will contain a term

\[ D_{jk} e^{-\alpha d_{ij}} \]

where
\( D_{jk} \) = potential demand in area \( j \) in time \( k \)

\( e \) = base of the natural logarithms

\( \alpha \) = constant describing the effect of distance on demand

\( d_{ij} \) = distance from area \( j \) to an outlet in area \( i \)

This term describes the spatial distribution of demand in the market and represents the method by which the demand cone concept discussed in Chapter 4 is operationalized in the location models.

The level of potential demand \( (D_{jk}) \) is estimated by relating demand for the product to census variables such as population, income, age, family size, housing type, or other appropriate measures. The level of these variables within the area can then be used to obtain an estimate of potential demand. However, potential demand may also be affected by factors such as the growth of demand through time, increasing market penetration through time, and competition. These factors can be accommodated by modifying the estimate of potential demand obtained from census variables.

One way in which the growth of demand over time and increasing market penetration can be incorporated into the models is by using a logistics function to modify the demand estimates. For example, a multiplier of the form
could be applied to the demand estimate. In this function, e is the base of the natural logarithms and t is the length of time since the first outlet was opened in the market. The effect of this particular multiplier would be for demand to increase following an S-shaped curve asymptotic to the estimated level of potential demand. This might represent increasing acceptance of the company's product over time, the effect of exposure to the product, or simply the growth in the population's purchasing power. The parameters control the initial demand level and the rate of increase. Their values would depend on the decision maker's expectations of market growth.

The multiplier representing growth in demand over time can take on several more complex forms, depending on their applicability to a particular application of the models. One possibility would be to expand the function shown above to include the number of outlets previously opened in the market. If this number if represented by N, the function might take on the form

\[
\frac{1.0}{1.0 + e^{-\gamma - \delta t - \epsilon N}}
\]

Another approach would be to make the growth in demand a function of the amount of sales in previous time periods.
One example of this type of multiplier is

\[
\frac{1.0}{t=1} \frac{1.0+e^{-\gamma-\delta \sum S_k}}{t=1}
\]

where \( t \) is the current time period and \( S_k \) represents sales in time period \( k \) (Craig and Brown, 1975).

The effect of competition on the level of demand can be included in the demand estimate in a number of ways. One way is to simply assume that the effect of competition does not vary with location and reduce the estimated potential demand by a factor representing the market share of the company being studied.

An alternative method of treating competition would be to assume that competing outlets are perfect substitutes for the outlets being located. In this case, the strategy would be to avoid any existing competing outlets. This could be accomplished by fixing the locations of competing outlets in the location models as if they were previously opened stores in the chain being studied. New stores would then be forced away from these locations.

Another approach would be to consider demand as a function of the distance to the nearest existing outlet. In this case, the total potential demand in each area would be reduced according to the distance between it and the nearest previously established outlet, including competitor's
outlets. The strategy implied by this technique is to locate near competition only when there is enough excess demand available to support another outlet.

Other treatments of competition are also possible. The one used will depend on the characteristics of the industry and the company being studied. The only limitation inherent in the models is that no technique may be used which requires that the location of the new outlets be assumed before demand can be estimated.

The demand cone concept is operationalized through the exponential distance function \( e^{-\alpha_{ij}} \). This form was chosen for the distance function because it has a defined value (one) at a distance of zero and recognizes that an outlet might obtain some level of demand, however small, from every area within the region. Another possible form would be a linear function of distance such as \( 1.0 - \alpha_{ij} \).

An important consideration when estimating the value of \( D_{jk} \) is the difference between residential population and work force or daytime population. Demand estimates which are obtained using the distribution of the residential population are likely to be in error if most people travel to the outlet from their place of work. For some types of retail establishments a third type of population, the transient population, might also be important. This population consists of shoppers and commuters who might stop
at an outlet as they pass it in the course of carrying out some other function.

The different population distributions could be incorporated in the location models by separately estimating demand for the residential, working, and transient populations, applying the individual demand function to the population in each category, and adding the results to obtain an estimate of total demand.

As used in the equations in the following sections, the demand term is general. It is not tied to any assumptions about the product, competition, or the distribution of the population. The next chapter will include an example of the way in which this general demand term can be adapted for a specific application.

The Franchisor Model

The location model for the franchisor can be described by the following mathematical program

\[
\begin{align*} 
\text{Max } P_t &= \sum_{i=1}^{m} \sum_{k=1}^{a} (1.0 + r)^{-k} (-S_k + R_k D_{ik}) Y_{ii}^t \\
&+ \sum_{i=1}^{m} \sum_{j=1}^{m} (1.0 + r)^{-k} (R_k D_{jk} e^{-\alpha_d ij}) Y_{ij}^t \\
&\quad + \sum_{j \neq 1}^{m} (1.0 + r)^{-k} (R_k D_{jk} e^{-\alpha_d ij}) Y_{ij}^t 
\end{align*}
\]
\[ + \sum_{i=1}^{m} F (1.0 - Y_{ii}^{t-1}) Y_{ii}^{t} \]

- \[ \sum_{i=1}^{m} C (1.0 - Y_{ii}^{t-1}) Y_{ii}^{t-1} \]

subject to

\[ \sum_{i=1}^{m} Y_{ij}^{t} \leq 1.0 \quad \text{for all } j \quad (1) \]

\[ Y_{ii}^{t} \geq Y_{ij}^{t} \quad \text{for all } i \text{ and } j, i \neq j \quad (2) \]

\[ \sum_{j=1}^{m} (D_{jk} e^{-\alpha_{ij}}) Y_{ij}^{t} \leq K_{it} \quad \text{for all } i \quad (3) \]

\[ \sum_{i=1}^{m} Y_{ii}^{t} \leq L_{t} \]

\[ Y_{ii}^{t} + Y_{jj}^{t} \geq 1.0 \quad \text{for all } i \text{ and } j \text{ for which } d_{ij} < U \quad (5) \]

\[ \sum_{k=1}^{a} ((1.0 + r)^{-k}(1.0 - V_{k}) D_{ik} - M_{k}) Y_{ii}^{t} \]

+ \[ \sum_{k=1}^{a} (1.0 + r)^{-k}(1.0 - V_{k}) \sum_{j=1}^{m} (D_{jk} e^{-\alpha_{ij}}) Y_{ij}^{t-1} \]

- \[ F (1.0 - Y_{ii}^{t-1}) Y_{ii}^{t} \geq G Y_{ii}^{t} \]

for all i \quad (6)
where

\[ P_t = \text{expected profit over a planning period starting in time } t \]

\[ t = \text{first year in the planning period} \]

\[ m = \text{number of areas into which the region is divided (number of potential outlets locations)} \]

\[ a = \text{number of years in the planning period} \]

\[ r = \text{discount rate on future earnings} \]

\[ S_k = \text{franchisor's fixed cost per outlet in time } k \]

\[ R_k = \text{franchisor's revenue per dollar of sales in time } k \]

\[ D_{ik} = \text{potential demand in dollars in area } i \text{ in time } k \]

\[ \gamma_{ij}^t = \begin{cases} 1 & \text{if an outlet is located in area } i \text{ in time } t \\ 0 & \text{otherwise} \end{cases} \]

\[ e = \text{base of the natural logarithms} \]

\[ \alpha = \text{a constant describing the rate at which demand decreases with distance from an outlet} \]

\[ d_{ij} = \text{distance from area } i \text{ to area } j \]

\[ y_{ij}^t = \text{proportion of the demand in area } j \text{ allocated to an outlet in area } i \text{ in time } t \]

\[ (0.0 \leq y_{ij}^t \leq 1.0) \]

\[ F = \text{franchisee fee per outlet} \]

\[ C = \text{cost of closing an outlet} \]

\[ K_{it} = \text{capacity of outlets in area } i \text{ in time } t \]

\[ L_t = \text{maximum number of outlets open in time } t \]

\[ U = \text{minimum distance required between outlets} \]

\[ V_k = \text{franchisee's variable cost per dollar of sales in time } k \]

\[ M_k = \text{franchisee's fixed cost in time } k \]
\[ G = \text{minimum level of profit over the planning period for any open outlet} \]

This model is an extension of the central facilities location model (Revelle and Swain, 1970) discussed in Chapter 2.

The first constraint in the model requires that no more demand be assigned than exists in each area \( j \). The second constraint requires that if the demand in area \( j \) is assigned to an outlet in area \( i \), then an outlet must be located in area \( i \). The third constraint is a capacity constraint which limits the amount of demand allocated to an outlet in area \( i \) to the maximum capacity of outlet(s) in that area.\(^1\)

The fourth constraint is a budget constraint. It limits the total number of outlets allowed to be open in time \( t \) to some predefined maximum \( (L_t) \). This maximum represents the capital available to the franchisor and includes the number of outlets previously opened. For example, if

\[ \text{It is conceivable that the demand in area } i \text{ might at some time exceed the capacity of outlets in that area. In this case, it is necessary to increase the capacity and r-run the models to obtain an optimum solution. Otherwise, the capacity constraint will force area } i \text{ to be served from some other area with excess capacity. The best approach, however, is to choose a size for the areas into which the market is divided which will always be smaller than the capacity of a single outlet. This may be difficult in large markets where the number of areas would exceed the capacity of the mathematical programming computer algorithms.} \]
five outlets were already open in a market and the franchisor could afford to open three more in the current time period, the value of $L_t$ in the constraint would be eight. A smaller number of outlets might actually be contained in the solution if this smaller number optimizes the profit equation or if other constraints limit the number to a level below $L_t$.

The fifth constraint set specifies the minimum distance required between outlets. If the distance between two areas is less than the minimum, an outlet is only permitted to be open in one of the areas.

The final constraint requires that the profit for the franchisee at each outlet be at least some minimum amount ($G$) over the planning period. This may represent a normal rate of return for the franchisee or some greater amount of profit. This constraint is included because the profitability of the franchisees will affect the ability of the franchisor to attract new franchisees. If the profit level is too low, new franchisees will not be attracted to the system. If there are no profits, the franchisees will not be able to keep the outlets open and the franchisor will lose his profits also. The constraint is derived from the objective function of the master franchisee model which will be explained in detail in the next section.
Objective Function

The objective function of the franchisor model describes the expected franchisor profit from a single market over the planning period. It can be considered in three parts: the profit derived from areas in which outlets are located, the profit derived from the remaining area, and the revenue from franchise fees and costs associated with closing outlets.

The expected profits derived from the areas in which the outlets are located are defined by the term

\[ \sum_{i=1}^{m} \sum_{k=1}^{a} (1.0 + r)^{-k} (-S_k + R_k D_{ik}) Y_t \]

The first part of this term, \( (1.0 + r)^{-k} \), defines the rate at which future earnings are discounted (obtains the present value of future earnings). \( S_k \) represents the franchisor's fixed cost per outlet and includes items such as supervision costs and management assistance provided to the franchisee. \( R_k \) represents the revenue to the franchisor per dollar of sales at the outlet. This value can include the royalty payment, advertising assessment, and/or lease payments on the building and equipment. It may also be adjusted for any variable costs the franchisor may incur in the course of supervising the outlet or carrying out his other functions. \( D_{ik} \) represents the potential demand
in dollars in area \( i \) in time \( k \).

The contribution of the remaining areas to expected profit is described by the term

\[
\sum_{i=1}^{m} \sum_{j=1}^{m} \sum_{k=1}^{a} (1.0 + r)^{-k}(R_{jk}e^{-ad_{ij}}) Y_{ij}^t \quad j \neq i
\]

There are only two differences between this term and the first term in the objective function. First, fixed costs are not considered in this case, since they only need to be entered into the objective function once for each outlet. Second, the level of demand is reduced by an exponential function of distance describing the decline in demand with distance from the outlet.

The remainder of the objective function deals with the collection of the franchise fee and the payment of the cost of closing an outlet. These events occur only once for any given outlet.

The franchisor receives a franchise fee, \( F \), for each outlet which is opened, but only in the first time period in which the outlet is open. This can be described by the term

\[
\sum_{i=1}^{m} F(1.0 - Y_{ii}^t) Y_{ii}^t
\]
The value of this term is \( F \) for each area \( i \) if an outlet was not open in time \( t-1 \) \( (Y_{ii}^{t-1} = 0.0) \) but an outlet is opened in time \( t \) \( (Y_{ii}^{t} = 1.0) \). The value is zero if an outlet was open in area \( i \) in time \( t-1 \) or if no outlet is open in time \( t \). In other words, the amount \( F \) is added to the objective function for each outlet which is open in time \( t \) for the first time.

Similarly, the franchisor may incur some cost, \( C \), if an outlet which was previously open is closed in time period \( t \). This is described by the term

\[
\sum_{i=1}^{m} C(1.0 - Y_{ii}^{t}) Y_{ii}^{t-1}
\]

The value of this term is \( C \) for each area \( i \) in which an outlet is not open in time \( t \) \( (Y_{ii}^{t} = 0.0) \) but an outlet was open in time \( t-1 \) \( (Y_{ii}^{t-1} = 0.0) \). The value is zero if an outlet was not open in time \( t-1 \) or an outlet is open in time \( t \) in area \( i \).

**Dynamic Application of the Franchisor Model**

The franchisor model can be solved for a single year, \( t \), to obtain an optimal pattern if all of the outlets are opened in that year. It is also possible to solve the model in an iterative fashion with the number of outlets in the solution allowed to change over time.
The level of demand, \( D_{ik} \), is already a function of time. It is likely that the level of demand at individual locations will increase over time as the company's market penetration increases. It is also possible that demand will increase over time due to population increases or increases in income. Specific demand estimates may be entered into the objective function for each area and time period. Alternatively, the variable \( D_{ik} \) may be replaced by a function describing the growth in demand over time.

It also is highly probable that the franchisor will not be able to open all of his outlets in a single market in a given year. In this case, the budget constraint (constraint (4)) can be used to budget the opening of outlets through time. For any time period \( t \), the value of \( L_t \) in the constraint is the upper limit on the number of outlets in the solution for the planning period beginning in \( t \). The actual solution may contain fewer outlets because of the limit imposed by constraint set (5).

With these modifications, the franchisor model can be solved for a number of planning periods, allowing the value of \( t \) to increase between each solution. Using the model in this fashion will allow the pattern of outlets to evolve over time.
Solution Technique

The objective function and constraint sets (1) through (6) form a mixed integer programming problem in $m^2$ variables and $2m^2 + 2m + 1$ constraints. Following the approach of Revelle and Swain (1970), this problem can be solved using the revised simplex method. While there is no guarantee that the simplex algorithm will yield all zero or one values for the $y_{ii}$ as required by the model, this will in fact occur in many cases (see Revelle and Swain (1970) for a discussion of this point).

For the cases in which zero-one solutions are not obtained, a simple branch and bound algorithm can be employed to force such a solution. First, take each area which partially assigns to itself and create a new problem by adding a constraint of the form

$$y_{ii}^t = \neq 0$$

After the problem has been resolved for each of the partially self-assigning areas, select the solution with the highest value of the objective function. If this is a zero-one solution, the process is ended. Otherwise, it will be necessary to follow this branch by setting a second $y_{ii}$ value to one. The lower bound is always the highest value of the objective function on another branch. Experience has shown that no more than one area will need to be forced into the solution in most cases.
Constraint set (6) may cause a problem with some computer algorithms because of the relatively large numbers in it. If this is the case, the problem can be solved without this constraint set. The solution is then evaluated and if this constraint is violated, the problem is solved again with the value of $L_t$ in constraint (4) set at one fewer than the number of outlets in the previous solution. This process is repeated until a solution is obtained which does not violate constraint set (6).

The Master Franchisee Model

A master franchise can take a number of forms. It will be assumed in this case that the master franchisee operates all of the outlets in his assigned territory either by himself or in partnership with others. Therefore, the master franchisee will not obtain any income from selling sub-franchises.

The programming formulation of the master franchisee location model is as follows

$$\text{Max } P_t = \sum_{i=1}^{m} (-G + \sum_{k=1}^{a} (1.0 + r)^{-k}((1.0 - V_k)D_{ik} - M_k))Y_{ii}$$

$$+ \sum_{i=1}^{m} \sum_{j=1}^{m} \sum_{k=1}^{a} (1.0 + r)^{-k}((1.0 - V_k)D_{jk}e^{-\alpha d_{ij}})Y_{ij}$$

$$+ \sum_{i=1}^{m} F(1.0 - Y_{ii})Y_{ii} - \sum_{i=1}^{m} C*(1.0 - Y_{ii})Y_{ii}$$
subject to

\[ \sum_{i=1}^{m} Y_{ij}^t \leq 1.0 \quad \text{for all } j \quad (1) \]

\[ Y_{ii}^t \geq Y_{ij}^t \quad \text{for all } i \text{ and } j, i \neq j \quad (2) \]

\[ \sum_{j=1}^{m} (D_{ik}e^{-ad_{ij}}) Y_{ij}^t \leq K_{it} \quad \text{for all } i \quad (3) \]

\[ \sum_{i=1}^{m} Y_{ii}^t \leq L_t \quad (4) \]

\[ Y_{ii}^t - Y_{ij}^t \leq 1.0 \quad \text{for all } i \text{ and } j \text{ for which } d_{ij} < U \quad (5) \]

where

\[ P_t = \text{expected excess profit over the planning period starting in time period } t \]

\[ t = \text{first year in the planning period} \]

\[ m = \text{number of areas into which the region is divided} \]

\[ \text{number of potential outlet locations} \]

\[ G = \text{normal profit over the planning period for a single outlet} \]

\[ a = \text{number of years in the planning period} \]

\[ r = \text{discount rate on future earnings} \]

\[ V_k = \text{variable cost per dollar of sales in time } k \]

\[ D_{ik} = \text{potential demand in dollars in area } i \text{ in time } k \]

\[ M_k = \text{fixed cost per outlet in time } k \]

\[ Y_{ii}^t = \begin{cases} 1 & \text{if an outlet is located in area } i \text{ in time } t \\ 0 & \text{otherwise} \end{cases} \]

\[ e = \text{base of the natural logarithms} \]

\[ a = \text{a constant describing the decline in demand with distance from the outlet} \]
\[ d_{ij} = \text{distance from area } i \text{ to area } j \]

\[ Y_{ij}^t = \text{proportion of the demand in area } j \text{ allocated to an outlet in area } i \text{ in time } t \]

\[ 0.0 \leq Y_{ij}^t \leq 1.0 \]

\[ F = \text{franchise fee per outlet} \]

\[ C^* = \text{cost of closing an outlet} \]

\[ K_{it} = \text{capacity of outlets in area } i \text{ in time } t \]

\[ L_t = \text{upper limit on the number of outlets open in time } t \]

\[ U = \text{minimum distance required between outlets} \]

The master franchisee model is similar in form to the franchisor model. The constraint sets are identical to constraint sets (1) through (5) in the franchisor model. Constraint set (6) in the franchisor model is contained in the objective function of the master franchisee model. The objective function describes excess profits. To maximize this value, no outlet can be opened which will not yield at least a normal profit (\( G \)). Otherwise, the value of the objective function would be reduced.

**Objective Function**

The objective function of the master franchisee model describes the expected level of profit over the planning period for the master franchisee. It can be considered in three parts: the expected profit from the areas in which outlets are located, the expected profit derived
from the remaining areas, and the franchise fee and closing costs paid by the master franchisee.

The expected profit derived from the areas in which outlets are located is represented in the objective function by the term

$$\sum_{i=1}^{m} (-G + \sum_{k=1}^{a} (1.0 + r)^{-k}((1.0 - V_k)D_{ik} - M_k))Y_{ii}$$

This term is the present value of the franchisee's revenues minus costs in each year summed over the planning period less normal profits. $G$ is the normal profit level for the planning period for a single outlet and represents the minimum expected profit required before an outlet can be opened. The term $(1.0 + r)^{-k}$ is the discount placed on future earnings. Revenue minus variable cost is described by the term $(1.0 - V_k)D_{ik}$. Fixed cost, $M_k$, is subtracted from the remaining revenue.

The second term in the objective function,

$$\sum_{i=1}^{m} \sum_{j=1}^{m} \sum_{k=1}^{a} (1.0 + r)^{-k}((1.0 - V_k)D_{ik}e^{-ad_{ij}})Y_{ij}$$

represents the expected profits derived from areas in which outlets are not located. These profits are calculated in the same manner as those in the first term except that fixed costs and normal profits are not included (they only need to be subtracted once for each outlet) and the
potential demand is diminished by an exponential distance function based on the distance between area \( j \) and the area to which its demand is assigned.

The master franchisee pays a franchise fee, \( F \), to the franchisor for each outlet which is opened. He may also incur costs, \( C^* \), for any outlet which is closed, covering such items as penalty payments for broken leases and lost goodwill. These costs are only incurred in the time period during which the outlet is opened or closed.

The franchise fee is incorporated in the objective function through the term

\[
- F \cdot (1.0 - Y_{ii}^{t-1}) \cdot Y_{ii}^t
\]

The negative sign indicates that the franchise fee is a cost for the franchisee. The value of this term is \(-F\) if an outlet was not open in time \( t-1 \) (\( Y_{ii}^{t-1} = 0.0 \)) but an outlet is open in area \( i \) in time \( t \) (\( Y_{ii}^t = 1.0 \)). The value of the term is zero if either there is not an outlet open in area \( i \) in time \( t \) or there was an outlet open in area \( i \) in time \( t-1 \).

Similarly, the cost of closing an outlet can be described as

\[
- C^* \cdot (1.0 - Y_{ii}^t) \cdot Y_{ii}^{t-1}
\]

The value of this term is \(-C^*\) when there was an outlet in area \( i \) in time \( t-1 \) (\( Y_{ii}^{t-1} = 1.0 \)) but there is not an outlet
open in area $i$ in time $t$ ($Y_{it}^c = 0.0$). The value of the term is zero if either there was not an outlet open in area $i$ in time $t-1$ or there is an outlet open in area $i$ in time $t$.

Dynamic Application of the Master Franchisee Model

As is the case with the franchisor model, the master franchisee model can be applied in either a static or a dynamic context. The same iterative procedure described for the franchisor model can be used for this model, including the scheduling of outlet openings using the budget constraint.

The major difference between the franchisor and the master franchisee models in a dynamic context involves the closing of outlets. For the franchisor, the franchise fee is income and the cost of closing an outlet is an outlay. The two tend to offset each other when an outlet is closed and a new one opened in another area. For the master franchisee, both the franchise fee and the cost of closing an outlet represent expenditures. When a master franchisee closes an outlet and opens a new one in another area, he incurs both costs. For this reason, the master franchisee can be expected to be less willing to move outlets than the franchisor will be.

Solution Technique

The objective function and five constraint sets yields a mixed integer programming problem with $m^2$ variables and
a maximum of \(2m^2 + 1\) constraints. The problem can be treated as a linear program and solved using the revised simplex method. This approach yields the required integer solution in most cases. When values other than zero or one are obtained for the \(Y_{ii}\) variables, the branch and bound technique described for the franchisor model can be applied to force a zero-one solution.

**The Individual Franchisee Model**

If each franchised outlet is operated by an independent owner (independent of other owners, not the franchisor), a much different location process can be expected to occur. The individual franchisees will not be interested in obtaining an optimal pattern of outlets. Maximizing the profit of the individual outlet will be the goal of each individual franchisee. Each new outlet will be placed so as to take advantage of the highest potential demand, given the locations of existing outlets. The franchisees can be viewed as selecting their locations in a sequential manner, with the first entrant in the market taking the location with the highest potential demand, the second entrant taking the location with the highest potential demand after considering the demand absorbed by the first outlet, and so forth until no new firms can enter the market and obtain normal profits.
The previous two models have yielded system wide solutions which maximize profits for a single entrepreneur. The individual franchisee model, however, is a series of individual location problems with each location decision made by an independent entrepreneur. While the following discussion will focus on the overall location pattern, it should be remembered that each of the location decisions is made independently of the others. Mathematically, this location process can be described in two steps. The first is to select an area in which to locate an outlet in order to maximize

\[ D_i^* = \sum_{j \in I} \sum_{k=t}^{t+a} (1.0 + r)^{-k}(D_{jk}e^{-\alpha d_{ij}}) \]

subject to

\[ d_{ih} \leq U \quad \text{for all } i \text{ and } h \text{ containing outlets} \]

\[ D_i^* \geq T \]

where

- \( D_i^* \) = potential demand for an outlet in area \( i \)
- \( I = \) set of all areas closer to \( i \) than to any other area containing an outlet
- \( t = \) first year in the planning period
- \( a = \) number of years in the planning period
- \( r = \) discount rate on future earnings
- \( D_{jk} = \) potential demand in area \( j \) in time \( k \)
\( e \) = base of the natural logarithms

\( \alpha \) = constant describing the decline in demand with distance from an outlet

\( d_{ij} \) = distance from area \( j \) to an outlet in area \( i \)

\( U \) = minimum distance required between outlets

\( T \) = threshold level of demand for an outlet

Demand from area \( j \) is only allocated to a new outlet in area \( i \) if area \( i \) is closer to the new outlet than to any previously opened outlet. If an area is equidistant from two or more outlets \( (d_{ij} = d_{hj}) \), its demand is divided equally between the outlets.

The first constraint establishes a minimum distance between outlets (which may be zero). This is a common feature of franchise contracts and is used by the individual franchisee to obtain a guaranteed minimum trade area. The second constraint requires that a new outlet have some threshold level of demand available to it before it can open.

Once a new outlet is located, the second step is to evaluate all of the current locations to see if they are still profitable. This is done by recalculating the value of \( D_i^* \) for each area containing an outlet. All outlets for which the value of \( D_i^* \) has fallen below the threshold level, \( T \), are now unprofitable and will go out of business.

Following the closing of unprofitable outlets, the first step is repeated. The process is continued until no
new outlets can be located with at least the threshold level of demand.

The following heuristic algorithm can be used to obtain a solution for the individual franchisee model.

1. For each potential outlet location, calculate total demand by summing the demand from each area which is closer to that location than to any existing outlet. If the distance is equal, divide the demand equally.

2. Rank the potential locations by demand.

3. Locate an outlet at the potential location with the highest demand unless it is either closer than the minimum distance to an existing outlet or the demand level is below the threshold level.

4. If the location was rejected because of the threshold constraint, stop.

5. If the location was rejected because of the distance constraint, remove it from the ranking and return to step 3.

6. Calculate total demand at each outlet using the same procedure as in step 1.

7. Eliminate any outlet for which the demand level has fallen below the threshold level.

8. Go to step 1.

Note that in this procedure potential locations are areas in which outlets might be located, not individual sites within those areas.

The individual franchisee model is inherently dynamic, since outlets are located sequentially. However, there is no time frame explicitly stated in the model. The time between successive outlet locations might be measured in
days or years. Also, the elapsed time between outlet
openings is not necessarily constant. Two outlets might
be opened within days of each other while a third is not
opened for a year. One possible way to impose a time frame
on this model is to take the franchisor's budget for
expansion in the market (the value of $L_t$ in the franchisor
model) as an indicator of the number of outlets to be
opened in each year. Following this approach, the second
year would begin after the first $L_1$ outlets are opened, the
third year would begin after $L_2$ outlets are opened, and so
forth.

Even though the results of the individual franchisee
model may not be related to a specific time scale, the
results do show how the franchise outlet pattern will
evolve. The order of outlet openings through time is
generated by the model.

The demand term in the individual franchisee model can
be expanded to incorporate growth in demand through time in
the same manner as in the other two models.

A Combined Location Model for a Franchise System

The location practices of actual franchise systems may
vary from complete franchisor control to complete control
by a master franchisee or the individual franchisees. The
models described above are designed for these three cases.
In the middle ground between these extremes, the location
decision will be a compromise between the franchisor and the franchisees. A combined model can be created which will represent this situation.

The individual franchisee model is inappropriate as a component of a combined model of a franchise system. While this model maximizes the profits of some of the individual franchisees, the overall level of profits is likely to be lower than if the outlets are located according to the outcome of the master franchisee model (see Chapter 4 for a discussion of this point). This is because the least favorably located franchisees in the individual franchisee model will be forced to locate so that they are operating at their threshold level and can just earn normal profits.

Using the master franchisee model for both the master and the individual franchisees, it is possible to construct a combined franchisor-franchisee model by simply adding together the objective functions of the franchisor and the master franchisee models and using the constraints from the franchisor model. This new model will maximize the sum of franchisor and franchisee profits, while guaranteeing that each outlet located will at least earn normal profits.

However, to be realistic, it would be necessary to weight the two objective functions in the combined model to reflect the difference in investment levels and bargaining power between the two levels of the franchise system. In a
well established system, it is likely that the franchisor
equation would be given the larger weight. In a new system,
or one that is in financial trouble, the franchisee
equation might be given more weight.

If the weight assigned to the franchisor's objective
function is $W$, the combined location model is the following
mixed integer program

$$
\text{Max } P_t = W \left( \sum_{i=1}^{m} \sum_{k=1}^{a} (1.0 + r)^{-k} (-S_k + R_k D_{1k}) Y^t_{ii} \right) \\
+ \sum_{i=1}^{m} \sum_{j=1}^{m} \sum_{k=1}^{a} (1.0 + r)^{-k} (R_k D_{jk} e^{-a_{ij}}) Y^t_{ij} \\
+ \sum_{i=1}^{m} F (1.0 - Y^t_{ii}) Y^t_{ii} \\
- \sum_{i=1}^{m} C (1.0 - Y^t_{ii}) Y^t_{ii} \\
+ (1.0 - W) \left( \sum_{i=1}^{m} \sum_{k=1}^{a} (1.0 + r)^{-k} \right) \\
\left( (1.0 - V_k) D_{ik} - M_k \right) Y^t_{ii} \\
+ \sum_{i=1}^{m} \sum_{j=1}^{m} \sum_{k=1}^{a} (1.0 + r)^{-k} (1.0 - V_k) D_{jk} e^{-a_{ij}} Y^t_{ij}
$$
subject to

\[ m \prod_{i=1}^{m} y_{ij}^{t} \leq 1.0 \quad \text{for all } j \tag{1} \]

\[ y_{ii}^{t} \geq y_{ij}^{t} \quad \text{for all } i \text{ and } j, i \neq j \tag{2} \]

\[ m \prod_{j=1}^{m} (D_{jk}e^{-\alpha_d ij}) y_{ij}^{t} \leq K_{it} \quad \text{for all } i \tag{3} \]

\[ \prod_{i=1}^{m} y_{ii}^{t} \leq L_{t} \tag{4} \]

\[ Y_{ii}^{t} + Y_{jj}^{t} \leq 1.0 \quad \text{for all } i \text{ and } j \text{ for which } d_{ij} < U \tag{5} \]

\[ \sum_{k=1}^{a} ((1.0 + r)^{-k}(1.0 - V_{k})D_{ik} - M_{ik}) Y_{ij}^{t} \]

\[ + \sum_{k=1}^{a} (1.0 + r)^{-k}(1.0 - V_{k}) \sum_{j=1}^{m} (D_{jk}e^{-\alpha_d ij}) y_{ij}^{t} \quad \text{j \neq i} \]

\[ - F(1.0 - Y_{ii}^{t-1}) Y_{ii}^{t} \geq G Y_{ii}^{t} \]

\[ \text{for all } i \tag{6} \]
The variables in the above equations are as defined for the franchisor model, except for the weight assigned to franchisor profits ($W$) and the franchisee's cost for closing an outlet ($C'$). The constraints have the same interpretation as those in the franchisor model. The solution technique described for the franchisor and master franchisee models can also be used to obtain a solution for the combined model.

The combined model can be used to study actual franchise systems. The weight assigned to the franchisor section of the objective function ($W$) provides a parameter which represents the degree to which the franchisor controls the location decision process. In addition, the value of this parameter can be established through bargaining between the franchisor and the franchisees and the resulting model used to locate the outlets in a pattern representing a compromise between their respective preferences. This type of application of the location model might serve to reduce the potential for conflict in the marketing channel.

**Summary**

Four models of the franchise location problem have been outlined in this chapter. Three deal with the separate perspectives of the franchisor, the master franchisee, and the individual franchisees. The fourth is a combined model for the franchise system.
The estimation of demand was treated separately from the models. Some variations of the procedure for treating demand were discussed. Since most of the demand estimation procedure is outside of the location models, the procedure may be changed without affecting the structure of the models.

The models for the franchisor and the master franchisee, as well as the combined model, are mixed integer programming models based on the central facilities location model of Revelle and Swain (1970). The individual franchisee model is a heuristic model in which each outlet is located at the area of highest potential demand given the existing competition.

Each model was first presented as a static model. The adaptation of the model for a dynamic application was then discussed. Finally, a solution technique was described for each of the models.

The last section of the chapter dealt with the development of the combined model of the franchise system. It was shown that such a model can be obtained by combining elements of the franchisor and the master franchisee models. Also, it was noted that a parameter can be added to the objective function of the combined model which will indicate the degree of franchisor control over the location decision.
In the next chapter, the franchisor, master franchisee, and individual franchisee models will be applied to a real franchise location problem as an example of the way in which they might be used in the planning or study of a franchise system.
CHAPTER 6
APPLYING THE LOCATION MODELS

This chapter contains an example of the application of the models developed in the last chapter to a real world location problem. The models will be adapted for a specific franchise system, Wendy's International, Inc., and applied to the problem of locating Wendy's restaurants in Columbus, Ohio. To avoid revealing confidential corporate data, the model parameters will be estimated using the data for sample outlets provided in Wendy's pro forma statement (Wendy's International, Inc., 1975).

The models developed in the last chapter for the franchisor, the master franchisee, and the individual franchisee will each be applied to the problem of selecting outlet locations. The results will then be compared to the actual locations of Wendy's restaurants, the location patterns expected from the theoretical discussion Chapter 4, and each other. Comparing the results of the three models with each other will allow an evaluation of the potential for conflict within the franchise system over location decisions.
The first section of this chapter contains a description of the study region. This will be followed by sections describing the development of estimates of the model parameters and the spatial distribution of demand. Each of the model solutions will then be presented, followed by comparisons of the solutions to the actual location pattern, theoretical patterns, and each other.

The Study Region

The study region for the sample application of the location models is comprised of Columbus, Ohio and its contiguous suburbs. This region is divided into twenty-seven areas, based on an aggregation of the 1970 census tracts (Figure 7). Table 1 displays the census tracts which make up each area and the populations of the areas. Each of the twenty-seven areas is a potential location for a Wendy's outlet.

The number of areas used for this application of the location models represents a compromise between the desire to use as small an area as possible and the difficulty of obtaining solutions for large scale integer programming problems. Ideally, the areas would be small so that the model solutions would specify relatively precise locations for the outlets. However, the number of variables in the location-allocation models increases with the square of the
The Study Region

Figure 7
TABLE 1

POPULATION OF AREAS IN STUDY REGION
AND CENSUS TRACTS WHICH COMPRISE AREAS

<table>
<thead>
<tr>
<th>Area</th>
<th>Population</th>
<th>Census Tracts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25,976</td>
<td>1,2,4</td>
</tr>
<tr>
<td>2</td>
<td>39,796</td>
<td>3,8,77</td>
</tr>
<tr>
<td>3</td>
<td>23,798</td>
<td>7,9</td>
</tr>
<tr>
<td>4</td>
<td>19,310</td>
<td>5,6,10,11,10</td>
</tr>
<tr>
<td>5</td>
<td>23,258</td>
<td>11,20,12,13</td>
</tr>
<tr>
<td>6</td>
<td>25,405</td>
<td>18,20,21,17,22,16</td>
</tr>
<tr>
<td>7</td>
<td>30,710</td>
<td>14,15,23,24,76,30,29,28,25</td>
</tr>
<tr>
<td>8</td>
<td>23,405</td>
<td>26,75</td>
</tr>
<tr>
<td>9</td>
<td>30,942</td>
<td>69 excluding 69.10 and 69.50</td>
</tr>
<tr>
<td>10</td>
<td>23,515</td>
<td>68.20,68.10,67,69.10</td>
</tr>
<tr>
<td>11</td>
<td>31,918</td>
<td>63</td>
</tr>
<tr>
<td>12</td>
<td>35,789</td>
<td>19,64,65,66,78,30,84,85</td>
</tr>
<tr>
<td>13</td>
<td>16,400</td>
<td>69.50,78 excluding 78.30</td>
</tr>
<tr>
<td>14</td>
<td>25,742</td>
<td>41,42,43,44,50,51</td>
</tr>
<tr>
<td>15</td>
<td>34,431</td>
<td>45,46,47,48,49</td>
</tr>
<tr>
<td>16</td>
<td>31,592</td>
<td>83</td>
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<td>21,995</td>
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<td>19,211</td>
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<td>56,58,59,60,61</td>
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<td>27,462</td>
<td>54,55,87</td>
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<td>22</td>
<td>24,013</td>
<td>88</td>
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<td>23</td>
<td>14,888</td>
<td>89,90,91</td>
</tr>
<tr>
<td>24</td>
<td>19,877</td>
<td>92</td>
</tr>
<tr>
<td>25</td>
<td>29,262</td>
<td>93.2,93.3</td>
</tr>
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<td>26</td>
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<td>93.1,93.40,93.50,93.6,93.70</td>
</tr>
<tr>
<td>27</td>
<td>14,013</td>
<td>93.8,93.90</td>
</tr>
</tbody>
</table>

number of areas and the number of iterations in the computer algorithm necessary to obtain a solution increases in proportion to the number of variables. Therefore, increasing the number of areas drastically increases the computer resources required to obtain solutions. In actual applications, the number of areas may be increased according to the computer and financial resources available. For meaningful results, it is necessary to have more areas than the number of outlets expected in the solution. Otherwise the solution is trivial; one outlet is located in each area.

To simplify the analysis, physical barriers to travel in the study region, such as rivers and the existing highway system, are ignored. This allows the straight line distance between the centroids of the areas to be used as a measure of travel costs. It also eliminates distortion due to these physical barriers from the model solutions. In applications where such barriers may have an impact on the solutions, they can be incorporated by substituting the travel time or cost between areas for the distance terms in the models.

Model Parameters

The values of the model parameters used in this application, along with their symbols in the equations in Chapter 5, are listed in Table 2. Five of these values, royalty,
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Franchisor's fixed cost per outlet per year</td>
<td>$S_k$</td>
<td>$1,000.00</td>
</tr>
<tr>
<td>Franchisor's revenue per dollar of sales (royalty)</td>
<td>$R_k$</td>
<td>$0.04^*$</td>
</tr>
<tr>
<td>Discount rate</td>
<td>$r$</td>
<td>0.08</td>
</tr>
<tr>
<td>Planning period (years)</td>
<td>$a$</td>
<td>20.00</td>
</tr>
<tr>
<td>Franchise fee per outlet</td>
<td>$F$</td>
<td>$10,000.00^*$</td>
</tr>
<tr>
<td>Cost of closing an outlet</td>
<td>$C$</td>
<td>$10,000.00</td>
</tr>
<tr>
<td>Minimum level of profit for the franchisee per outlet over the planning period</td>
<td>$G$</td>
<td>$98,181.00</td>
</tr>
<tr>
<td>Franchisee's variable cost per dollar of sales</td>
<td>$V_k$</td>
<td>$0.61^*$</td>
</tr>
<tr>
<td>Franchisee's fixed cost per year</td>
<td>$M_k$</td>
<td>$78,600.00^*$</td>
</tr>
<tr>
<td>Individual franchisee's threshold demand level per year</td>
<td>$T$</td>
<td>$229,791.00</td>
</tr>
<tr>
<td>Minimum distance between outlets (miles)</td>
<td>$U$</td>
<td>3.00</td>
</tr>
</tbody>
</table>

franchise fee, franchisee's fixed and variable costs, and threshold demand level, were calculated from information contained in Wendy's pro forms statement. A sixth, the minimum distance between outlets, was obtained from Wendy's location evaluation form. The remaining parameter values are estimates based on discussions with Wendy's personnel and observation of the operation of the franchise system. The sensitivity of the solutions to changes in these latter parameters will be evaluated in Chapter 7.

There is no capacity constraint in this application of the models. Fast food restaurants are primarily take-out or drive-through operations. As such, they are normally not limited by available seating to a particular level of operation. Within reason, capacity can be expanded by purchasing more supplies and adding more employees. Heavy usage of part time employees allows the amount of labor to be adjusted easily to the level of demand.

The budget constraint in the franchisor and master franchisee models will be set to duplicate the expansion of Wendy's in the study region from 1970 to 1975. Accordingly, the total number of outlets open will be limited to two in the first year, four in the second, six in the third, eight in the fourth, ten in the fifth, and fourteen in the sixth. In order to evaluate the optimal pattern of outlets, the models will be solved for a seventh year with the number
of outlets left unconstrained. This expansion pattern is identical to that actually followed by Wendy's, except that the first outlet was in fact opened in late 1969.

Four of the parameters were obtained from Wendy's pro forma statement. Two, the franchise fee ($10,000) and the royalty payment (four percent), are specified in the franchise contract. The other two were calculated from information in the pro forma statement. The franchisee's variable cost per dollar of sales ($0.61) includes the cost of food products ($0.37), labor ($0.0925), royalty payment ($0.04), advertising and promotion ($0.04), paper products ($0.04), laundry ($0.0035), other supplies ($0.0125), and payroll taxes ($0.0115). The franchisee's fixed cost per outlet per year ($78,600) includes rent ($25,800), salaries of the manager and co-manager ($23,500), utilities ($10,250), depreciation of equipment ($6,000), insurance ($2,100), taxes ($3,000), repair and maintenance ($4,500), telephone ($500), trash removal ($1,500), office expenses ($1,200), and miscellaneous expenses ($250). All amounts are estimated for 1975.

The discount rate has been set at a conservative eight percent. This rate is somewhat higher than the return from savings accounts, but less than would be expected for investments. The effect of higher discount rates is to
increase the importance of earnings in the later years of the planning period.

The profits of the outlets are considered over a twenty year planning period. This length of time was chosen because Wendy's grants its franchises for twenty year periods. Since the franchisee fee is, in effect, amortized over this time period, the twenty year interval seems to be an appropriate planning period.

The level of profit in the outlet profitability constraint ($98,181) is the present value of a $10,000 annual profit over a twenty year planning period with a discount rate of eight percent. This represents a rate of return of about ten percent on the original investment if thirty percent of the outlet start-up cost is paid in cash by the franchisee. The individual franchisee's threshold level of demand ($229,791) is the annual demand required to yield the minimum profit in the master franchisee model and corresponds closely to the "break even" level of demand of $225,000 suggested in Wendy's pro forma statement.

While most of the franchisor's costs, such as advertising for new franchisees, designing new products, making changes in uniforms or store designs, and so forth, do not vary with the level of sales or the number of outlets in operation, it is possible that some costs will vary. These might include the cost of supervising the outlets and
collecting the royalty payment, expenses for local advertising, and the cost of management assistance provided to the franchisees. These costs are incorporated in the models as the franchisor's fixed cost per outlet ($S_k$). This cost represents any costs to the franchisor that vary with the number of outlets in operation. The value assigned to this parameter ($1,000$) was chosen to represent the cost of assigning one person to each outlet for a period of one month per year (or assigning one person to supervise every twelve outlets). It is assumed that the franchisor has no costs which vary with the level of sales. If there were such costs, they could be incorporated by subtracting the appropriate amount from the royalty payment.

The cost of closing an outlet is intended to represent the loss of goodwill built up at the old location and any costs associated with breaking a lease or selling the property and equipment. The value used in this application of the models ($10,000$) was chosen to eliminate any advantage to the franchisor gained by moving outlets to obtain additional franchise fees. The franchise fee for the new outlet will be completely consumed by the closing cost for the old one. The closing cost for the master franchisee is the same amount as for the franchisor, though this may not always be the case.
Demand

Four elements are considered in the estimation of demand. The basis of the demand estimate is an estimate of the total potential demand in each area. This is obtained by determining per capita demand for the product and the population of each area. This base figure for each area is then modified to account for competition, the effect of distance to the outlet, and the growth of demand through time.

In this application of the location models, the basis for the estimation of total potential demand for fast food by area is a consumer attitude survey done for the National Restaurant Association (Market Facts, Inc., 1974). From the information displayed in Table 3 and the average number of meals eaten away from home per person per week (2.08), it can be calculated that the average person spent $39.52 per year in fast food restaurants in 1974. This is derived as follows:

1. Multiply the average cost per person for each meal by the average number of meals eaten away from home per week and the percentage that meal comprises of all meals eaten away from home to obtain the average amount spent on each meal per person.

2. Multiply the average amount spent per person on each meal by the percentage of times that meal is eaten at a fast food restaurant to obtain fast food demand per week per person by meal.
# TABLE 3

**SELECTED DATA ON FAST FOOD DEMAND BY MEAL***

<table>
<thead>
<tr>
<th></th>
<th>Breakfast</th>
<th>Lunch</th>
<th>Dinner</th>
<th>Snack</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average cost per person</strong></td>
<td>$1.29</td>
<td>$1.44</td>
<td>$1.68</td>
<td>$1.07</td>
</tr>
<tr>
<td><strong>Percent of total meals eaten away from home</strong></td>
<td>9%</td>
<td>37%</td>
<td>40%</td>
<td>14%</td>
</tr>
<tr>
<td><strong>Average amount spent on meals eaten away from home per person</strong></td>
<td>$0.24</td>
<td>$1.11</td>
<td>$1.40</td>
<td>$0.31</td>
</tr>
<tr>
<td><strong>Percent of time this meal purchased at a fast food restaurant</strong></td>
<td>7%</td>
<td>32%</td>
<td>20%</td>
<td>34%</td>
</tr>
<tr>
<td><strong>Fast food demand per week per person</strong></td>
<td>$0.02</td>
<td>$0.35</td>
<td>$0.28</td>
<td>$0.11</td>
</tr>
</tbody>
</table>

3. Add the demand per week for the four meals and multiply by 52 to obtain annual fast food demand per person.

The average expenditure on fast food is multiplied by the population of each area to obtain the total potential demand for fast food by area. The population figure used in this application is obtained by adding the 1970 populations of the census tracts which comprise the areas (Table 1). The total population is used, since the figures obtained from the consumer attitude survey are not divided into population classes. If more detailed demand figures were available, it would be possible to segment the population for a more accurate demand estimate.

The residential population has been used in this application of the location models. For some applications, however, it might be more appropriate to use the daytime or work force population. This would be true, for example, for a business which caters to working people on their lunch break. If this demand factor is considered important for a particular application, it can be added to the estimation procedure. However, obtaining an estimate of the daytime population distribution is much more difficult, since census figures are not available.

Competition is incorporated in the demand estimate for this application by assuming that its effect is constant throughout the study region and simply reducing the total
potential demand in each area by a factor representing Wendy's market share. It is further assumed that the demand for fast food is evenly divided between the four hamburger franchises which have similar operations in Columbus: Wendy's, Burger Chef, Burger King, and McDonald's. Conversations with Wendy's personnel have indicated that the location of competing outlets is not considered of major importance; the company's goal is to obtain the best locations possible and then compete on the quality of product and service.

Estimating the value of $\alpha$ in the exponential expression which operationalizes the demand cone concept is a particularly difficult, but a key element in estimating the demand for a product. It is difficult because in any survey the spatial pattern of customers for a given store will include the effect of intervening opportunities as well as the effect of distance. The observed effect of distance may be as much a reflection of the existing pattern of outlets as of the decrease in demand with distance from the outlet.

In this application of the models, the estimation of $\alpha$ is based on the claim of Claus and Hardwick (1972) that the range of the market for a fast food type of operation is two to three miles. Using the three mile figure and defining this range as containing the primary market area,
or sixty to seventy percent of the store's sales (Applebaum, 1966), implies a value for $\alpha$ of approximately 0.8. If the range is defined as containing both the primary and secondary market areas (85% of the store's sales), the implied value of $\alpha$ is increased to approximately 1.1. The 1.1 value will be used for the application reported in this chapter. The effect of using other values will be examined in Chapter 7.

The growth in demand and market penetration through time is described in this application by a logistic function which acts as a multiplier to reduce the total potential demand to a level determined by the time period. The parameter values chosen for this multiplier reflect the decision maker's belief about the rate of growth in demand through time and the rate at which market penetration can be accomplished. In this example, the values used are 0.0 for $\gamma$ and 0.44 for $\delta$. With these parameters, demand starts out at about sixty percent of the total potential demand and reaches ninety percent after five time periods. This implies an expectation that total market penetration will have been achieved after about five years of operation in the market.

Combining the elements of demand discussed above and including the specific parameters used in this application, the complete demand term in the model equations becomes
where

\[ D P_j(0.25)(e^{-1.1d_{ij}})(\frac{1.0}{1.0+e^{-0.0-0.44(t+k)}}) \]

\[ \text{where} \]

\[ D = \text{estimated annual demand per capita in dollars} \]
\[ P_j = \text{population of area } j \]
\[ 0.25 = \text{competition multiplier} \]
\[ e = \text{base of the natural logarithms} \]
\[ d_{ij} = \text{distance from area } j \text{ to a potential outlet in area } i \]
\[ t = \text{first year in the planning period} \]
\[ k = \text{current year in the planning period} \]

The value of \( t \) is measured from the year in which the first outlet was opened in the market. The exponential distance term was shown in the model equations in Chapter 5. The remainder of this function replaces \( D_{jk} \) in those equations.

With the demand estimate and model parameters developed above, the location models can now be applied to the problem of locating Wendy's outlets in Columbus.

Results

This section contains the results of a sample application of the franchisor, master franchisee, and individual franchisee location models based on the parameter estimates developed in the last two sections. Each model is used to simulate the development of the location pattern for Wendy's
for the period 1970 to 1976. This period covers the time between the first outlet located in Columbus and the most recent year for which comparable data were available. These years are referred to as time periods one through six. In addition, each model is run for a seventh time period to test if additional outlets beyond those actually opened by Wendy's appear in the solutions. To simplify the discussion, results will be reported for four of the time periods: two, four, six, and seven.

Franchisor Model

The pattern of outlet locations and the areas served by each outlet as generated by the franchisor model for the four sample time periods are shown in Figure 8. In time period two, outlets are located in areas 2, 7, 12, and 15 (see Figure 7 for area numbers). The assignment of demand from area 27 to an outlet in area 2 is a result of the solution being constrained to four outlets. Considering the distance to outlets in either area two or seven, the demand from area 27 will be negligible. By time period four, outlets are added in areas 9, 11, 21, and 25. In time period six, outlets are added in areas 1, 6, 14, 16, 20, and 26.

When the number of outlets in the solution is left unconstrained in the seventh time period, three additional outlets are located in areas 3, 17, and 22, making a total
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Franchisor Model Results

Figure 8
seventeen outlets in the optimal pattern.

The effect of the franchisee profitability constraint is important in determining the outcome of the franchisor model. In each time period, the franchisor model would have yielded a pattern containing the largest number of outlets allowed by the budget constraint if the profitability constraint had been left out. In the case of time period seven, when there is no budget constraint, this would have resulted in an outlet being located in every area. However, several of these outlets would not show a profit for the franchisee. The level of profit used in the franchisee profitability constraint will be the determining factor for the number of outlets included in the optimal pattern in cases where the budget constraint is not binding.

Master Franchisee Model

Figure 9 displays the outlet locations and areas served generated by the master franchisee model for the sample time periods. Except for the final time period, the patterns are almost identical to those generated by the franchisor model. This is to be expected, since the number of outlets in the solutions for the earlier time periods are fixed by the budget constraint and both the franchisor and the master franchisee face the same demand surface. The only difference in the first three patterns is the assignment of area 27 to
Master Franchisee Model Results

Figure 9
an outlet in area 7 instead of area 2 in time period two. As mentioned earlier, this represents an extremely small amount of demand, so the different assignment in the master franchisee solution is not significant.

In the seventh time period, the master franchisee model generates a pattern containing only one additional outlet, in area 17. The optimal pattern for this model contains fifteen outlets.

**Individual Franchisee Model**

The sequential nature of the individual franchisee location model causes the location pattern to develop somewhat differently from the other two models. An optimal pattern of outlets is not guaranteed.

If the number of outlets opened in each time period are budgeted in the same way as in the other models, the growth of the individual franchisee location pattern over time can be followed. The results for four sample time periods are shown in Figure 10. In time period two, areas 2, 7, 12, and 15 contain outlets. This is the same pattern of outlets and demand assignments that was developed by the master franchisee model. By the fourth time period, outlets have been added in area 9, 11, 16, and 20. The difference in this time period between this pattern and those developed for
Individual Franchisee Model Results

Figure 10
the franchisor and master franchisee is the location of an outlet in area 16 rather than in area 25. By time period six, outlets have been added in areas 1, 3, 6, 14, 25, and 26. The difference in this time period is the existence of an outlet in area 3 and the absence of one in area 21.

When the number of outlets in the solution is left unconstrained, the individual franchisee model yields a pattern containing seventeen outlets. In addition to those open in time period six, this pattern contains outlets in areas 6, 10, and 22. While the same number of outlets are opened as in the franchisor model, a comparison of Figure 10 with Figure 8 reveals several differences in outlet locations and demand assignments.

**Comparison with Actual Location Pattern**

The actual pattern of Wendy's outlet locations in 1975 is shown in Figure 11. The features of this distribution should be noted. First, the three outlets in area 18 (downtown Columbus) serve a special purpose. Two of these outlets are intended to serve the lunchtime business from downtown offices, while the third serves a combined residential and office population to the south. Since in the application of the models the working population was not considered, this phenomenon cannot be expected to be replicated in the model results. Second, there are no outlets in
Location Pattern of Wendy's, 1975
Figure 11
areas 6, 7, 10, 20, and 21. For the most part, this is due to the fact that these are the low income areas of Columbus. Since income was not included in the data for this application of the models, this trend cannot be expected to be reflected in the model results.

The constraints in the location models were set to include the same number of outlets as the actual 1975 pattern in time period six. Comparing this time period in Figures 8 through 10 with the pattern in Figure 11 reveals some major differences. Besides the lack of outlets in the downtown and low income area, the location models all produced patterns with fewer outlets to the east and more to the north. The actual pattern has five outlets east and south of downtown and four outlets north of downtown. The individual franchisee pattern has three outlets east and south of downtown and eight to the north, while the other two patterns have four outlets to the east and south and seven outlets to the north. This implies that Wendy's did not develop the northern part of the city as rapidly as it should have and overbuilt to the east in anticipation of future demand. This has been partly remedied by the recent addition of outlets in areas 5, 8, and 9.

The actual location pattern also can be compared to the unconstrained solutions of time period seven. In all three location models, more outlets were located than are
contained in the actual location pattern. The franchisor and individual franchisee patterns contain three additional outlets, while the master franchisee pattern contains one more outlet. Since the operation of Wendy's in Columbus most closely resembles the master franchisee situation, it is not surprising that the master franchisee location pattern is closest to the actual pattern.

Comparison Between Models

The location patterns from all three models develop in a similar fashion over the first six time periods. This is to be expected, since the number of outlets in the solution is controlled by the budget constraint in all cases. As noted above, minor differences in demand assignment may occur between the franchisor and master franchisee models, though the outlet locations are the same. The individual franchisee model exhibits minor differences in location for each time period. This is primarily due to the fact that no attempt is made to optimize the overall pattern of locations in the individual franchisee model.

Comparison of the result for time period seven reveals the basic differences between the three models. The most noticeable difference is the number of outlets in the solution. Two of the models yield seventeen outlet solutions, the franchisor in order to maximize demand and the individual
franchisee because of the assumed competition between franchisees for excess profits. The master franchisee model, in attempting to maximize system wide profits, yields a solution with only fifteen outlets.

The profits of the franchisor and the franchisees also vary with the location pattern chosen. This can be seen by evaluating the objective functions of all three models for each of the three solutions (Table 4). The values of the objective functions are indexed with the value for the corresponding model set at 100 (for example, the value of the master franchisee objective function is set at 100 for the master franchisee solution and indexed against this value for the other two solutions). The values used for the individual franchisee model are average demand per outlet, since it is the profitability of the average franchisee, not the franchisees taken as a group, which is of interest. It can be readily seen that the franchisor has the most to lose by accepting locations chosen according to one of the other models. The franchisor's profits drop by almost half if the master franchisee model solution is used and by over twenty percent if the individual franchisee model solution is used. This suggests that the efforts by franchisors to control the location selection process (see Chapter 3) are well founded. The master franchisee is only slightly worse off if he accepts the
TABLE 4

INDEX OF OBJECTIVE FUNCTION VALUE
BY MODEL AND SOLUTION

<table>
<thead>
<tr>
<th>Solution</th>
<th>Franchisor</th>
<th>Master Franchisee</th>
<th>Individual Franchisee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Franchisor</td>
<td>100.0</td>
<td>99.8</td>
<td>100.8</td>
</tr>
<tr>
<td>Master Franchisee</td>
<td>54.6</td>
<td>100.0</td>
<td>103.7</td>
</tr>
<tr>
<td>Individual Franchisee</td>
<td>78.9</td>
<td>96.1</td>
<td>100.0</td>
</tr>
</tbody>
</table>
franchisor solution instead of the master franchisee solution, with a decline in profits of only 0.2 percent.

That the individual franchisee is slightly better off using either the franchisor or the master franchisee solution is an indication of the inefficiency of the individual franchisee model when considering the overall location pattern. Each location decision in the individual franchisee model is made on the basis of maximizing demand at a single outlet, with no concern for the other outlets. Therefore, the system wide solution developed by the master franchisee model can be expected to be better for the average franchisee, though a few outlets may obtain lower profits than they would in the individual franchisee solution. The master franchisee model also limits the competition between outlets. In a free entry situation, individual franchisees will continue to enter until no excess profits are available for an additional franchisee. The master franchisee, on the other hand, attempts to maximize the level of excess profits in the region. Therefore, using the master franchisee solution prevents the individual franchisees from eliminating excess profits completely.

The difference between solutions for the average individual franchisee is relatively small, the largest change being less than four percent.
Comparison to Theoretical Patterns

The discussion of central place concepts in Chapter 4 led to some conclusions about the locational preferences of the franchisor, the master franchisee, and the individual franchisee. It was suggested that the franchisor would prefer to have a large number of outlets, each operating at its threshold level, and that the individual franchisee location process would end up with the same pattern, though in this case it would not be the preferred pattern but the result of competition between franchisees. It was noted also that each individual franchisee would prefer to limit entry as much as possible in order to operate at the ideal range rather than the threshold. The master franchisee, it was suggested, would prefer to have fewer outlets in the market with each outlet operating at some level above the threshold level. The master franchisee was viewed as being more concerned with total profits than with total demand.

The results of this application of the location models support the above conclusions. The franchisor and individual franchisee models do have more outlets than the master franchisee model solution, though the average outlet is operating at a level above the threshold. In both cases, the average outlet has an annual demand of approximately
$295,000 while the threshold level is $230,000. This discrepancy is most likely due to the irregular demand surface used in this application of the models.

The difference in franchisor profits, which basically represent revenue from sales at the outlets, between the franchisor and master franchisee solutions illustrates the difference between a demand maximizing and a profit maximizing solution. The difference in master franchisee profits between solutions is not as large as expected. This may be due to the nature of the demand surface and will be examined further in the next chapter.

The preference of the individual franchisee for more restricted entry can be seen by comparing the individual franchisee solution with the master franchisee solution. The average value of the objective function per outlet for the individual franchisee is larger for the master franchisee solution. This indicates that the individual franchisees on the average obtain larger profits with fewer outlets. This point also will be examined further in the next chapter.

As expected, the average outlet in the master franchisee solution is operating at a higher demand level than the average outlet in the other two solutions. The average annual demand per outlet in the master franchisee solution is approximately $305,000, compared to $295,000 in
the other two solutions.

Summary

The results of an application of the franchisor, master franchisee, and individual franchisee location models have been presented in this chapter. The first part of the chapter was devoted to describing the study region and discussing the derivation of specific parameter values and an estimate of the demand for fast food in the study region. These sections can be viewed as an example of the techniques required to implement the location models.

The results of a sample run of each of the three location models were presented. These results were compared with the actual location pattern of Wendy's restaurant outlets in Columbus, the system used in this example. The results were also compared with each other and with the theoretical patterns developed in Chapter 4. The results of the location models generally verified the theoretical results.

The application of the models reported here was intended as an example of how they might be used in a real world problem. The models were only verified in the sense that they yielded reasonable solutions, given the data employed. Unfortunately, the only true test of the accuracy of this
type of model would be to open outlets at the suggested locations and observe the operating results.

The solutions obtained from the models are likely to vary with the data and parameter values employed. In the next chapter, the sensitivity of the solutions to changes in these values will be examined.
CHAPTER 7
SENSITIVITY ANALYSIS

The specific solutions obtained from the locations models will obviously be affected by the values chosen for the model parameters. In the last chapter, solutions were obtained for the models using a set of parameters describing a unique franchise system. In this chapter, the effect of changes in those parameters will be examined. This discussion will give the user an idea of what to expect from an application when different parameter values are used and which variables are most crucial to the model solutions, requiring precise estimation. In addition, this discussion will further illuminate some of the differences between the models discussed in Chapter 6.

The model parameters can be divided into three classes based on the source of data and the degree of control over the parameter value that is available to the decision maker. Policy parameters are those which can be set by the decision maker and made part of the franchise contract. System parameters are those whose values are determined by the operating characteristics of the companies which make up
the franchise system. Environment parameters are those which represent assumptions about or measures of the economic environment in which the franchise system operates.

Each of the three classes of parameters will be discussed in a separate section. In addition, two parameters which are significant for the theoretical development of the models will be given special attention. These are the parameter in the exponential term which operationalizes the demand cone concept \((\alpha\), which will be referred to in this chapter as the distance coefficient) and the minimum distance required between outlets \((U)\).

**Policy Parameters**

The policy parameters which can be set by the decision maker and made part of the franchise contract are the franchise fee, royalty payment, length of the planning period \((or length of the franchise contract), and minimum distance required between outlets. The latter parameter will be discussed in a separate section.

The franchise fee appears in the franchisor and master franchisee models and represents a one time payment by the franchisee to the franchisor. In the franchisor model, an increase in the franchise fee increases the value of the objective function but may decrease the number of outlets in the solution if the franchisee profitability constraint is binding. This is because the higher franchise fee makes
each outlet less profitable for the franchisee. In the master franchisee model, an increase in the franchise fee decreases the value of the objective function and may decrease the number of outlets in the solution, since more demand is necessary at each outlet to cover this higher fixed cost. In neither case do minor changes in the franchise fee cause significant changes in the solution. In a test run, every thousand dollar increase in the franchise fee above the initial $10,000 resulted in a two percent increase in the franchisor's objective function and only a 0.5 percent decrease in the master franchisee's. The only change in the number of outlets in the solution occurred in the master franchisee model in which the number was reduced by one when the franchise fee was increased by 500 percent. It appears that the level of the franchise fee, within reason, has little effect on the outcome of the location models and can be set at whatever level the franchisees are willing to pay.

The royalty payment acts in the franchisor model through both the objective function, as additional revenue, and the franchisee profitability constraint, as an extra cost. In the master franchisee model it is part of variable costs, which will be discussed in the section on system parameters. Increasing the royalty payment from four to five percent of gross sales increased the
franchisor's objective function by fifteen percent and reduced the number of outlets in the solution by two, as the higher costs caused some additional outlets to become unprofitable for the franchisees. Lowering the royalty rate to three percent caused a 25 percent drop in the franchisor's objective function. The number of outlets in the solution did not change in this case. However, in some cases additional outlets may enter the solution as the lower cost to the franchisee makes them profitable. The royalty rate may be increased to the point where the increased revenue for the franchisor is totally offset by the decrease in demand due to the reduction in the number of outlets. Since these increases add to the franchisee's variable cost, they are likely to be resisted for the reasons stated below.

The length of the planning period has no impact on the solutions of any of the models when the level of demand is relatively stable through time. Fifty percent shifts produced no changes in the model solutions in a test run except, of course, in the values of the objective functions. The only situation in which the choice of a planning period might significantly alter the results is if the period is shorter than the length of time necessary to reach full market penetration. In this case, fewer outlets might be included in the solution. If the franchise fee is large, a short planning period might also make it difficult to
amortize the franchise fee, resulting in fewer outlets.

System Parameters

System parameters have their values determined by the operating characteristics of the companies in the franchise system. They include the franchisor's fixed cost per outlet, the franchisee's fixed and variable costs, and the threshold demand level or minimum profit level for an outlet. The latter parameter can also be a policy parameter if the franchisor decides to guarantee more than normal profits to the franchisees.

The franchisor's fixed cost per outlet affects only the franchisor model. Every thousand dollar increase in this cost decreased the value of the objective function by about five percent in a test run. However, the number of outlets is not reduced as long as the franchisee profitability constraint is binding. Eventually, in order to keep fixed costs below revenues, the optimal number of outlets for the franchisor will be reduced to the point at which all of the outlets are profitable for the franchisees. Beyond this point, further increases in fixed cost will bring reductions in the number of outlets in the solution. In the test run, the number of outlets was constant for fixed costs ranging from zero to $5,000.

The franchisee's fixed and variable costs have a direct impact on the solution of the master franchisee
model and an indirect impact on the franchisor model through the franchisee profitability constraint. The nature of these impacts can be seen by examining the master franchisee model. Increasing fixed costs should reduce the number of outlets in the solution, since it increases the level of demand necessary at each outlet to make a profit. In fact, increasing the franchisee's fixed cost by ten percent in a test run caused the number of outlets in the optimal solution to drop by two and reduced the value of the objective function by five percent.

Increasing variable costs reduces the revenue available to the franchisee to cover fixed cost and, therefore, should decrease the number of outlets in the solution. In the test run, the number of outlets in the solution decreased by two and the value of the objective function decreased by 25 percent for every ten percent increase in the variable cost parameter.

The solutions of the franchisor and master franchisee models are highly sensitive to the values chosen for the fixed and variable cost parameters. However, very accurate figures should be available for these parameters from corporate records. Therefore, the decision maker should not have to worry about an error caused by the values used for any of the fixed or variable cost parameters.

The threshold level of demand in the individual franchisee model and the minimum level of profit per outlet in
the franchisor and master franchisee models are two ways of expressing the same idea. Both represent the minimum level at which an outlet will be allowed to operate. Both have a straightforward effect on the solution obtained from the model.

Increasing the threshold level of demand in the individual franchisee model will simply cut off the location process at an earlier solution. Raising the threshold level will allow fewer outlets to be located in the region. Lowering it will allow additional individual franchisees to enter the market.

The minimum level of profits per outlet in the franchisee profitability constraint of the franchisor model and the objective function of the master franchisee model has much the same effect as the threshold level of demand in the individual franchisee model. Raising the level of profit will force additional outlets out of the solution. Lowering the level will allow more outlets to enter. The specific number to enter or leave the solution will depend on the number of outlets in the solution with profit levels between the old and the new parameter values.

The calculation of a normal return on investment and the demand level required to supply it is relatively easy with data normally available to corporate decision makers. Therefore, the likelihood of an error due to the specifica tion of these parameters should be low.
Environment Parameters

The environment parameters describe the economic system in which the franchise system operates. These include the discount rate, the cost of closing an outlet, and the elements which make up the demand estimate. Most of these parameters represent assumptions made by the decision maker about the economy and consumer behavior. One member of this class of parameters, the distance coefficient, is of major theoretical importance and will be treated in a separate section.

The discount rate represents the decision maker's assumption about alternative investment opportunities which compete with the franchise system for the capital of both the franchisor and the franchisees. Its effect on the solutions of the models is to increase or decrease the importance of demand in the later years of the planning period. It has little effect on the model solutions unless the growth of demand is allowed to vary by area as well as through time. In this case, the discount rate will affect the spatial distribution of total demand over the planning period.

The cost of closing an outlet has an effect on the solutions similar in magnitude to the franchise fee. In the franchisor model it acts to offset some of the effect of the franchise fee and discourage the moving of outlets. In the
master franchisee model its effect is added to that of the franchise fee. In neither case is the magnitude of the effect significant, with less than one percent changes in the objective functions resulting from 100 percent changes in the closing cost.

Except for the distance coefficient, the demand parameters serve only to estimate the level of demand by area and time period. These parameters include the effect of competition and the growth in demand over time, as well as the elements of the estimate of potential demand. As a group, these parameters and data items determine the demand available to the franchise system and so are important factors in the solution of the models. However, their determination is unique to each application of the models. No general statement can be made about the relative importance of each item. The accuracy of the demand estimate determines the accuracy of the revenue figures calculated in the models and, therefore, is extremely important in determining the usefulness of the results.

**Distance Coefficient**

The concept of the demand cone is operationalized in the location models through an exponential function of distance, \( e^{-\alpha d_{ij}} \). In this function, the parameter \( \alpha \), or the distance coefficient, determines the rate at which demand will decline with increasing distance between the consumer
in area $j$ and an outlet in area $i$. The higher the value of the distance coefficient, the steeper this decline will be. In effect, the value of the distance coefficient determines the rate at which an outlet can realize potential demand from the surrounding areas. When the value of the distance coefficient is low, consumers can be drawn from large distances. When its value is high, consumers can only be drawn from a restricted area. The way in which this parameter affects the solution varies somewhat among the models.

Ignoring the franchisee profitability constraint for the moment, the optimal location pattern for the franchisor is to have an outlet in every area. This totally eliminates the effect of distance and maximizes the overall demand in the market. However, the franchisor cannot achieve this situation in most cases because some of the outlets would lose money for the franchisees. Therefore, the franchisee profitability constraint must be introduced.

When the franchisee profitability constraint is introduced in the franchisor model, the distance coefficient has a distinct effect on the solution obtained. This effect is expressed through the profitability of each outlet. As the value of the coefficient increases, the slope of the demand cone also increases. This indicates two things. First, the ideal range for the outlet will be reduced. Second, the amount of demand available from the nearest
surrounding areas is reduced. The latter tends to increase the threshold distance for the outlet. The result is that fewer outlets can be supported in the market at a given profit level. Up to a point, the number of outlets will be reduced by competition for existing demand. Beyond that point, outlets will be eliminated because their threshold has extended beyond the ideal range.

As a test of the effect of the distance coefficient, the location models were solved using the parameter values from Chapter 6 and values of the distance coefficient ranging from 0.6 to 1.2. The results are shown in Table 5. For this table, the objective function values have been indexed against their values when the distance coefficient is 1.1. The expected decline in the number of outlets in the solution for the franchisor model did not occur. In fact, the franchisor model was not affected by changes in the distance coefficient. This appears to be because the threshold distance is within a single area in most cases, thereby negating the effect of distance on threshold demand. The situation is approaching the case in which an outlet can operate in every area with normal profits.

The distance coefficient acts on the solution of the master franchisee model in a more direct and noticeable manner. As the distance coefficient approaches zero, the distance from which the outlet can draw customers without
TABLE 5

NUMBER OF OUTLETS AND INDEX OF OBJECTIVE FUNCTION VALUE, OPTIMAL SOLUTION, BY MODEL AND LEVEL OF DISTANCE COEFFICIENT

<table>
<thead>
<tr>
<th>Distance Coefficient</th>
<th>Franchisor Number</th>
<th>Franchisor Index</th>
<th>Master Franchisee Number</th>
<th>Master Franchisee Index</th>
<th>Individual Franchisee Number</th>
<th>Individual Franchisee Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.6</td>
<td>21</td>
<td>102.9</td>
<td>13</td>
<td>132.3</td>
<td>21</td>
<td>102.9</td>
</tr>
<tr>
<td>0.7</td>
<td>21</td>
<td>102.0</td>
<td>14</td>
<td>121.1</td>
<td>21</td>
<td>102.0</td>
</tr>
<tr>
<td>0.8</td>
<td>21</td>
<td>101.3</td>
<td>15</td>
<td>113.5</td>
<td>21</td>
<td>101.3</td>
</tr>
<tr>
<td>0.9</td>
<td>21</td>
<td>100.8</td>
<td>15</td>
<td>107.7</td>
<td>21</td>
<td>100.8</td>
</tr>
<tr>
<td>1.0</td>
<td>21</td>
<td>100.4</td>
<td>15</td>
<td>103.1</td>
<td>21</td>
<td>100.4</td>
</tr>
<tr>
<td>1.1</td>
<td>21</td>
<td>100.0</td>
<td>17</td>
<td>100.0</td>
<td>21</td>
<td>100.0</td>
</tr>
<tr>
<td>1.2</td>
<td>21</td>
<td>99.7</td>
<td>18</td>
<td>97.7</td>
<td>21</td>
<td>99.7</td>
</tr>
</tbody>
</table>
any appreciable loss in individual demand approaches infinity. With a sufficiently small distance coefficient, therefore, the master franchisee can serve the entire market from a single outlet. This is to his advantage, since only one set of fixed costs needs to be paid and outlets have been assumed to have unlimited capacity. As the distance coefficient increases, demand falls off at a greater rate with distance from the outlet. It is now to the franchisee's advantage to open additional outlets, as long as the increase in demand generated thereby will increase revenues sufficiently to cover the extra fixed cost. In the extreme, the decline in demand will be so steep that the ideal range will be reduced to the threshold level and the master franchisee's pattern will approach that of the franchisor.

The tendency of the master franchisee solution to converge on the number of outlets in the franchisor solution can be observed in Table 5. The number of outlets in the master franchisee solution increases in a relatively regular manner from a low of thirteen when the coefficient is 0.6 to a high of eighteen when the coefficient is 1.2. The change in the index of the objective function value shows the effect of the additional fixed costs incurred when extra outlets are opened.
As seen in Table 5, the effect of the distance coefficient on the solution to the individual franchisee model is the same as its effect on the solution to the franchisor model. The method by which the coefficient acts on the solution, however, is different. Competition for excess profits leads to a location pattern for individual franchisees in which each outlet is operating at its threshold level. The distance coefficient can only affect this pattern if it changes the distance which contains the threshold demand level. This can only occur when the coefficient is increased to the point where the ideal range is smaller than the threshold distance and the outlet cannot operate with normal profits. In the extreme, outlet locations will be restricted to those areas which contain the threshold level of demand within them.

**Minimum Distance Parameter**

The minimum distance parameter controls the distance which outlets are required to be separated in the individual franchisee model. Its effect on the number of outlets in the solution is obvious. In a fixed land area, the larger the required distance between outlets, the smaller the number of outlets that can be contained in the area. An examination of the demand per outlet column in Table 6 makes it quite clear that it is to the advantage of the individual franchisee to have the minimum distance
### TABLE 6

**NUMBER OF OUTLETS, DEMAND, AND DEMAND PER OUTLET BY MINIMUM DISTANCE BETWEEN OUTLETS, INDIVIDUAL FRANCHISEE MODEL**

<table>
<thead>
<tr>
<th>Minimum Distance</th>
<th>Number of Outlets</th>
<th>Demand</th>
<th>Demand per Outlet</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>21</td>
<td>$5,925,517</td>
<td>$282,167</td>
</tr>
<tr>
<td>3</td>
<td>17</td>
<td>4,996,712</td>
<td>293,924</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>2,299,434</td>
<td>328,491</td>
</tr>
</tbody>
</table>
constraint as large as possible. The best situation for the individual franchisee is to have a minimum distance equal to twice the ideal range, so that the outlet obtains all of the potential demand available to it.

It has been seen that the franchisor prefers a large number of outlets, which requires close spacing. This is in direct conflict with the individual franchisee's goals. In the case described by Table 5, both the franchisor and the individual franchisee have 21 outlets with no minimum distance constraint. If the minimum distance is increased to six miles, the individual franchisee's solution contains only seven outlets. If the franchisor accepts this solution, profits are decreased by 61 percent while the individual franchisees' average profit per outlet increases by sixteen percent. If the three mile constraint used in Chapter 6 is employed, the franchisor's profit decreases by sixteen percent while the individual franchisees' average increases by four percent. The level chosen for this parameter will be determined by the relative bargaining power of the franchisor and the individual franchisees.

Summary

In this chapter, three classes of parameters have been examined both to check the sensitivity of the solutions described in the previous chapter to changes in parameter values and to gain a better understanding of the way in
which each parameter influences the solutions obtained from the location models. The most significant effects were observed to be due to the distance coefficient in the demand estimation function and the threshold and distance parameters in the constraint sets of the franchisor and individual franchisee models. The remaining parameters were seen to have relatively small impacts on the location patterns obtained from the models.

The parameters were examined separately. It is, of course, possible that two or more parameters will change at the same time. Using the information in this chapter, it should be possible to reason out how these changes might counteract or enhance each other.

The implications of the results presented in the last two chapters and the earlier discussions of central place theory and the development of the location models will be discussed in the next chapter. The discussion will focus on their implications for location research, urban research, and the operation of franchise systems.
CHAPTER 8
CONCLUSION

The implications of the research reported in the previous chapters for both location and urban research and the study of franchise systems will be discussed in this chapter. First, a summary of the research will be presented. This will be followed by sections dealing with the implications of the research for location research and techniques of locations analysis, for urban research, and for the study and operation of franchise systems.

Summary

The focus of this research has been the selection of an optimal pattern of locations for retail outlets in an urban area. Drawing on three concepts from central place theory and the technique of location-allocation modeling, four normative models of the location problem have been developed. Three of the models were developed based on the objectives of the three types of companies in a franchise system: the franchisor, the master franchisee, and the individual franchisee. The fourth model represents a compromise solution, taking into account the objectives of
all three types of companies. While the models were
developed for a franchise system, they apply to other
types of activities as well. The master franchisee model
can be applied to a chain of retail or service facilities,
while the individual franchisee model can be used to study
the location of a group of independently owned facilities.

Central place theory was used as a theoretical base for
the models. The concepts of threshold and range were used
to study the problem of packing the market areas of outlets
in the city. The demand cone concept was used to describe
the spatial distribution of demand in the city.

The central place concepts were combined with location-
allocation techniques based on Weberian least cost theory to
obtain location models which emphasize the importance of
determining a system of outlet locations. This approach
differs from previous retail location studies which concen-
trate on the location of single facilities. The use of
central place concepts in conjunction with a least cost
based model allows the extension of techniques which have
been common in industrial location research to retail
location problems.

The demand maximizing spatial distribution of outlet
locations, preferred by the franchisor, was shown to occur
when the potential trade areas of the outlets overlap to the
extent that each outlet is operating at its threshold level.
This arrangement minimizes the distance between any consumer and an outlet and, therefore, maximizes demand. However, it also eliminates the possibility of excess profits for the franchisees who operate the outlets.

The profit maximizing demand level for the outlets is obtained by selecting the profit maximizing demand level for the outlets and restricting the number of outlets to obtain trade areas for the outlets which contain that level of demand. For the individual franchisee, a single outlet is considered and the trade area will be at or near the ideal range for the good. The master franchisee considers the level of profits from all of the outlets taken together and can, therefore, trade profits at the individual outlet for an increased number of outlets. The master franchisee's optimal pattern will contain more outlets and smaller trade areas than the individual franchisee's, but fewer outlets and larger trade areas than the franchisor's.

It was also shown that in a system with free entry of franchisees, the individual franchisees will develop a pattern of outlet locations similar to that preferred by the franchisor, even though this pattern is not in the best interest of any individual franchisee. This occurs because of the competition between franchisees for excess profits. As long as excess profits exist in the system, new franchisees will be willing to enter. This process continues
until the number of franchisees reduces the trade area for each outlet to the threshold level and excess profits are eliminated. To avoid this, it was seen to be in the interest of the individual franchisee to insist on the guarantee of an exclusive territory as part of the franchise contract.

Based on the central place concepts and the characteristics of franchise systems, normative location models were developed for the franchisor, the master franchisee, and the individual franchisee. The first two were developed as mathematical programming models. The third was designed as a sequential location model based on the gravity model. Each model was described in both static and dynamic contexts and solution techniques were suggested. Elements of the franchisor and master franchisee models were combined to obtain a location model for the entire franchise system which incorporates the goals of all three types of participants.

The three individual location models were calibrated for a specific franchise system, Wendy's, and applied to the problem of selecting outlet locations in Columbus, Ohio. The results obtained from the three models were compared to the actual distribution of Wendy's outlets, to each other, and to the theoretical patterns developed in the discussion of central place concepts. As expected,
the franchisor model yielded the largest number of outlets and the individual franchisee model developed the same pattern due to competition between franchisees. The results of the master franchisee model most closely resembled the actual pattern of Wendy's outlet locations.

The relationship between the parameters of the models and the results obtained was examined. The key parameters were identified as those controlling the minimum distance between outlets and threshold demand level in the individual franchisee model, that controlling the level of profit required at each outlet in the franchisor model, and that describing the rate at which demand declines with distance from the outlet in all of the models.

**Implications for Location Research**

This research has demonstrated the need for the consideration of more complex forms of business organization in location research. Most location theories assume that the location decision is made by a single company. The franchise method of distribution is one example of a situation in which several interconnected companies make the decision. The form of the marketing channel, the location of power within the channel, and procedures used to resolve conflicts within the channel all have impacts on the choice of locations. The results of the location models developed here show that there can be major
differences in the location patterns preferred by different members of the channel.

Previous research on the retail location process has concentrated on the location of single facilities. This research has shown, however, that the level of demand in a market depends on the locations of all of the company's outlets in that market. The location analyst must be concerned with finding the best overall pattern of outlets as well as selecting individual sites. The degree to which the potential trade areas should be allowed to overlap is an important consideration affecting the overall profitability of a chain of outlets. The models developed in Chapter 5 provide a means to carry out this analysis. They may be used to select general areas in which outlets should be located before the search for specific sites begins.

When used to select actual outlet locations, the models developed in this research must be applied in conjunction with other techniques. After the models have been used to select areas in which outlets should be located, a technique such as the checklist method must be employed to evaluate the individual sites available within each of those areas.

On a more technical level, this research has made two contributions to the techniques available to the location analyst. First, the extension of mathematical programming techniques to the analysis of retail location problems
provides a powerful technique, well established in other areas of location research, which can be applied to the selection of optimal retail location patterns. Second, the use of profit maximizing models allows the optimal number of outlets and the optimal locations to be determined in a single procedure. The common approach has been to view the determination of the number of outlets and the selection of locations as separate steps in the location decision process.

Implications for Urban Research

In operationalizing the central place concepts of threshold and range for use in the location models, this research has demonstrated the applicability of central place theory to the study of intra-urban topics. This applicability has been suggested in the past (see, for example, Berry, 1967), but the concepts have only been used in a descriptive fashion. As used here, however, the central place concepts provide a method of investigating the structure of urban areas, or at least its retail component.

This research also provides a means of rationalizing the distribution of certain types of retail outlets. Understanding the forces which control the location decisions of retail firms is important for the planning of future growth in urban areas. Viewing this location process
as the selection of a pattern of outlet locations rather than individual locations will have an effect on the way in which commercial areas are assigned to new developments.

**Implications for Franchising**

This research has several implications for the study and operation of franchise systems. These implications relate both to the exposing of problems inherent in the system and to the development of better operating policies for franchise companies.

The potential for conflict between the franchisor and the franchisees over locational goals has been emphasized in all aspects of this research. It was shown that these goals coincide only under a very limited set of circumstances, such as unrestricted entry of individual franchisees. The literature on conflicts within franchise systems is extensive, but the locational aspect of conflict has been given little attention.

The results of the location models demonstrate the effect of the location of power within the franchise system on the distribution of outlet locations. A system with a strong franchisor is likely to develop a pattern more favorable to the franchisor than is a system in which the franchisor is relatively weak. Over time, power tends to shift to the franchisor if the system is successful. This should be accompanied by a shift from a franchisee oriented
location policy to a more franchisor oriented policy in later years.

The models developed in this research provide a means to evaluate alternative location strategies. This research has concentrated on the relationship between the franchisor and the franchisees. However, a franchisor intending to buy back outlets at some future time might want to examine the master franchisee model to evaluate the trade off between the loss of current earnings as a franchisor and the gain in future earnings as an operator using the location pattern suggested by the master franchisee model.

The models may also be used to evaluate the effects of various policy changes. For example, the individual franchisee model could be used to measure the effect of an increase in the minimum distance between outlets on both franchisor and franchisee profits. The results of this analysis could be used to determine the company's bargaining position with respect to this issue.

The bargaining positions of the franchisor and the franchisees may be affected in another way by the results of this research. It was noted that the franchisees are often inexperienced in the particular line of business for which they are seeking a franchise. For this reason, they must rely on the expertise of the franchisor in many areas. In some cases, this can result in the franchisor taking
advantage of the franchisee's ignorance to impose policies which benefit only the franchisor. It is important that the franchisee be given enough information to be able to make good business decisions when obtaining a franchise. Part of this information pertains to items in the franchise contract relating to location. For example, the franchisee should be able to recognize that an exclusive territory based on a minimum distance between outlets is more to his advantage than a contract clause relating the number of outlets to the population of the market. If the franchisee is going to allow the franchisor to make the outlet location decision, he should know on what basis that decision will be made. A general knowledge of the location question, such as is provided by this research, should give the prospective franchisee a better idea of what to look for in a franchise contract.

The information developed in this research can also provide the franchisor with a better understanding of the consequences of his location decision policies. For example, the loss of revenue involved in allowing the franchisee to make uncontrolled location decisions is readily apparent from the results of the models (for example, examine the relationship between total demand and demand per outlet in Table 6).
In addition to their potential application within franchise systems, the concepts and models outlined in this research provide students of franchising with additional methods for examining the nature of franchise systems and the relationship of these systems to consumers and the political system.

Conclusion

While most of this research has been concerned with retail location, and especially franchising, the results are applicable to a wider range of location problem. Any facility which serves a widely dispersed population, offers its product or service for an f.o.b. price, and is interested in maximizing some sort of profit or demand level has the characteristics of a firm described by at least one of the models developed here. While specific parameters might have to be changed to fit the situation, the model structure and the nature of the results apply as well to the location decision involving these facilities as to the franchise location decisions used to demonstrate the application of the models.

The spatial behavior of consumers is a key element determining the location of many types of facilities. While, as noted in Chapter 2, a considerable amount of research has been done on this behavior, our understanding of the movement of consumers in space is still far from
complete. In this research, the demand cone concept from central place theory was used to describe the spatial component of consumer behavior. Much work remains to be done, however, to verify that the demand cone is an adequate description of this behavior and, if so, to explain why.

The models developed in this study provide a useful tool for examining the distribution of power in the marketing channel. The results of a concentration of power in one part of the channel on the profits of the other parts can be determined using the models. Applying the models in this way allows the student of marketing channels to evaluate the potential for conflict and the means by which conflict might be avoided or reduced.

The results of this research provide a middle step in the location of a facility. Diffusion research has provided a basis for studying the process of selecting a city or market (Craig and Brown, 1975). Chapter 2 contains several examples of techniques for selecting an individual site. This research has added an approach to establishing an optimal pattern of locations within a market which can then be used to guide the search for individual sites. It remains to provide the links between these three levels in order to obtain a comprehensive description of the location decision process.

To summarize, this research has produced three contributions to location research. First, it was shown
that the selection of an optimal pattern of facility locations can be explained in terms of the application of elementary central place concepts. Second, four models were developed which can be applied to the problem of selecting retail locations. Third, an approach has been developed which can be used to study the relationships between members of a marketing channel.
LIST OF REFERENCES


Losch, A. The Economics of Location. Translated by W.H. Woglon. New Haven, Conn.: Yale University Press, 1954.


________. "Site Acceptance Request." Columbus, Ohio, 1974 (Mimeographed).

PLEASE NOTE:
Dissertation contains computer print-outs with broken and indistinct print.
Filmed as received.

UNIVERSITY MICROFILMS
APPENDIX

COMPUTER PROGRAMS

********************************************************************************
FRANCHISOR MODEL - THIS PROGRAM PREPARES DATA FOR INPUT TO THE
LINEAR PROGRAMMING PACKAGE AND PRINTS RESULTS
********************************************************************************

DIMENSION X(50), D(50), DIST(50,50), VAL2(50,50)
DIMENSION X2(50,50), AL(50), BI(50)
DIMENSION DBUD(20)
REAL*8 ANAME, BASIS(2), VALUE NAME, CNAME

ESTABLISH LENGTH OF PLANNING PERIOD (PP)
INTEGER T, X, X2, PP/20/

ESTABLISH LOGISTIC PARAMETERS FOR GROWTH OF DEMAND THROUGH TIME
DATA GAMMA/0.0/, DEL/0.44/

ENTER MAXIMUM NUMBER OF OUTLETS BY YEAR (<20)
DATA MBUG/2, 4, 6, 8, 10, 14, 17, 20, 19/

ESTABLISH MODEL PARAMETERS
ALPHA = DISTANCE COEFFICIENT
F = FRANCHISEE FEE
C1 = COST OF CLOSING OUTLETS (FRANCHISOR)
C2 = COST OF CLOSING OUTLETS (FRANCHISEE)
DISC = DISCOUNT RATE
FCOST = FRANCHISEE'S FIXED COST
VCOST = FRANCHISEE'S VARIABLE COST
ROYAL = ROYALTY PAYMENT
M = NUMBER OF AREAS (POTENTIAL LOCATIONS)
COMP = COMPETITION MULTIPLIER
DEPC = PER CAPITA ANNUAL DEMAND
S = FRANCHISOR'S FIXED COST PER OUTLET
DMIN = MINIMUM DISTANCE BETWEEN OUTLETS
G = MINIMUM PROFIT PER OUTLET

DATA ALPHA/1.1/, F/10000.0/, C1/10000.0/, C2/10000.0/, DISC/0.08/, FCOS/1.1/, VCOST/0.61/, ROYAL/0.04/, M/27/, COMP/0.25/, DEPC/39.52/, S/10000.0/, DMIN/0.0/, G/9818.0/
IDFLG=0
IFFLG=0

ZERO OUT OLD OUTLET VECTORS
READ DATA AND CALCULATE POTENTIAL DEMAND BY AREA
POP = AREA POPULATION
AREA X CO-ORDINATE
AREA Y CO-ORDINATE
RENEW 3
DO 20 I=1,M
READ (3,500) POP, A(I), B(I)
DI(I)=POP*COMP*EPC
20 CONTINUE
CALCULATE DISTANCE MATRIX
DO 40 I=1,M
DO 30 J=1,M
INDEX(J)=0
A=AI(J)
B=BJ(J)
DIST(I,J)=SORT(A**2+B**2)
CONTINUE
GO TO 280
GET TIME PERIOD DATA FROM LP PACKAGE
CALL GETARG (T, ISTOP, ISTART, IBUDG)
IF (T.GT. ISTART) GO TO 50
AREA NUMBER FOR PREVIOUSLY OPENED OUTLETS GO HERE (X(I)=1.0)
GO TO 280
CALCULATE FRANCHISEE PROFITABILITY CONSTRAINT COEFFICIENTS
RENEW 8
READ PRIOR SOLUTION IF ONE EXISTS
IF (T.GT. ISTART) READ (8,480) X2, IDFLG
IF (IDFLG.EQ.1) READ (8,490) INDEX
IF (IDFLG.EQ.1) IDFLG=1
IDFLG=0
DO 90 J=1,PP
V2(I,J)=0.0
CONTINUE
GO TO 80
CONTINUE
OBTAIN SOLUTION FOR PREVIOUS ITERATION FROM LP PACKAGE
N=0
I=1
CALL ARRAY (I, INP, ANAME, NCOL)
DO 100 J=1,5
CHECK DISTANCE CONSTRAINT

180  ISUM=0
       DO 210 I=1,M
            DO 200 J=1,M
                IF(I.EQ.J) GO TO 200
                IF(X(I).NE.1.0 .OR. X(J).NE.1) GO TO 190
                IF(INDEX(I,J).LT.DEF) INDEX(I,J)=1
                INDSUM(I)=INDSUM(I)+INDEX(I,J)
       CONTINUE
       ISUM=ISUM+INDSUM(I)
       CONTINUE

190  IF DISTANCE CONSTRAINT IS VIOLATED, WRITE MESSAGE
     AND RERUN TIME PERIOD CONSTRAINTING OFFENDING PAIRS OF OUTLETS
       IF(ISUM.EQ.0) GO TO 230
       IDFLG=1
       WRITE (6,520)
            X(1)*X(I)
       DO 220 I=1,M
            X(I)=1
       CONTINUE
       T=T-1
       IBUDG=IBUDG-1
       REWIND 6
       WRITE (6,520) X,IDFLG
       WRITE (8,490) INDEX
       GO TO 280

195  IF DISTANCE CONSTRAINT IS NOT VIOLATED, ZERO OUT INDEX ARRAY
       DO 250 I=1,M
            INDEX(I,J)=0
       CONTINUE
       IF(IFLAG.EQ.2) GO TO 130
       REWIND 8
       WRITE (8,480) X,IOFLG
       WRITE (8,490) INDEX
       GO TO 280

200  IF MAXIMUM TIME PERIOD (7) IS PAST, STOP
       IF(IT.GT.7) GO TO 270
       IF(N.LT.M) GO TO 280
       ISTOP=1
       CALL PUTARG (IT,ISTOP,ISTART)
       RETURN

205  WRITE INPUT DATA FOR LP PACKAGE
       REWIND 4
       WRITE (4,600)

210  CALCULATE OBJECTIVE FUNCTION COEFFICIENTS
       DO 320 I=1,M
            VAL2(I,I)=(1-F)*X(I)*F
            DO 290 J=1,M
                VAL2(I,J)=VAL2(I,J)+F*DISC**(-J)*S*ROYAL**D(I)/1.0*EXP(IMA)
                +VAL2(I,J-1,1))
       CONTINUE
       DO 310 J=1,M
            IF(J.EQ.1) GO TO 310
            VAL2(I,J)=0.0
       CONTINUE

215  IF OUTLETS ARE OPEN IN EVERY AREA, STOP
       IF(N.LT.M) GO TO 280
       ISTOP=1
       CALL PUTARG (IT,ISTOP,ISTART)
       RETURN

220  WRITE INPUT DATA FOR LP PACKAGE
REWRIND 4
RETURN CONTROL TO LP PACKAGE
CALL PUTARG (T,ISTOP,ISTART,IBUDG)
RETURN

&5112
50 FORMAT (50I0/I)
510 FORMAT (* FRANCHISEE PROFITABILITY CONSTRAINT VIOLATED*)
520 FORMAT (* DISTANCE CONSTRAINT VIOLATED*)
530 FORMAT (* L DIST*,Z12)
540 FORMAT (4X,'YR',I2,'C',I2,3X,'DIST',Z12,2X,'1.0')
550 FORMAT (4X,'RHS1*6K',Z12,2X,'1.0')
560 FORMAT (' TIME PERIOD 1,J2// OBJECTIVE FUNCTION F15.2//1')
570 FORMAT (' *** ERROR - ELEMENT',I2,*','I2,*')
580 FORMAT (* BASIS(I',I2,'=',I2)*)
590 FORMAT (3P18.0)
600 FORMAT ('NAME=',10X,*FRANCHOR*)
610 FORMAT (*ROWS*/' N ROBJ')
620 FORMAT (*E CYJ',I2)
630 FORMAT (* G CYJ',I2,'C',I2)
640 FORMAT (* L BUDGET*)
650 FORMAT (* COLUMNS*)
660 FORMAT (4X,'YR',I2,'C',I2,3X,'ROBJ',4X,'F12.2')
670 FORMAT (4X,'YR',I2,'C',I2,3X,'CYJ',I2,5X,'1.0')
680 FORMAT (4X,'YR',I2,'C',I2,3X,'CYJ',I2,5X,'1.0')
690 FORMAT (4X,'YR',I2,'C',I2,3X,'CYJ',I2,5X,'1.0')
700 FORMAT (4X,'YR',I2,'C',I2,3X,'BUDGET',4X,'1.0')
710 FORMAT (* RHS*)
720 FORMAT (4X,'RHS1*6K',4X,'CYJ',I2,5X,'1.0')
730 FORMAT (4X,'RHS1*6K',4X,'CYJ',I2,5X,'1.0')
740 FORMAT (4X,'RHS1*6K',4X,'BUDGET',4X,'F5.1')
750 FORMAT (*ENDATA*)
END

******************************************************************************
MASTER FRANCHISEE MODEL - THIS PROGRAM PREPARES INPUT FOR
THE LP PACKAGE AND PRINTS RESULTS
******************************************************************************
DIMENSION X(50), D(50), DIST (50,50)
DIMENSION V(50,50), AI(50), BI(50)
DIMENSION MBUDG(20), INDEX(50,50), INDSUM(50)
SET LENGTH OF PLANNING PERIOD (PP)
REAL*8 ANAME, BIASI21, NAME, CNAME, VALUE
INTEGER T,PP/20/
SET PARAMETERS FOR LOGISTIC FUNCTION FOR GROWTH OF DEMAND
DATA GAMMA/0.6/, DEL/-0.44/
SET MAXIMUM NUMBER OF OUTLETS BY YEAR ( < 20)
G = NO CONSTRAINT
DATA MBUDG/2,4,6,8,10,14,14/*
ESTABLISH PARAMETER VALUES
ALPHA = DISTANCE COEFFICIENT
F = FRANCHISE FEE
C = COST OF CLOSING AN OUTLET

200
C DISC = DISCOUNT RATE
C FCOST = FIXED COST
C R = VARIABLE COST
C M = NUMBER OF AREAS (POTENTIAL LOCATIONS)
C COMP = COMPETITION MULTIPLIER
C DEPC = PER CAPITA ANNUAL DEMAND
C DMIN = MINIMUM DISTANCE BETWEEN OUTLETS
C G = MINIMUM PROFIT PER OUTLET

DATA ALPHA/1.1./,F/10000.0.,C/10000.0.,DISC/0.08.,FCOST/78600.0./,R/
10.61./,H/27./,COMP/0.250./,DEPC/39.52./,DMIN/6.0./,G/98181.0./

C ZERO OUT OLD OUTLET VECTOR
C
DO 10 I=1,M
X(I)=0.0
INDSUM(I)=0
10 CONTINUE
N=0
C
C GET TIME COUNTERS FROM LP PACKAGE
C
CALL GETARG (T,ISTOP,ISTART,IBUG)
IF(T.GT.ISTART) GO TO 20
C
C PREVIOUSLY ESTABLISHED OUTLETS GO HERE (XII)=1.0
C
C GO TO 70
C
C GET SOLUTION FROM LP PACKAGE
C
C 20 I=N+1
C
CALL ARRAY (1,IND,ANAME,NCOL)
DO 30 J=1,5
CALL ELEMT (1,IND,ANAME,NNAME,VALUE)
30 CONTINUE
WRITE (6,360) I,VALUE
CALL ARRAY (1,IND,ANAME,NCOL)
DO 50 I=1,M
DO 60 J=1,M
CALL VECTOR (1,IND,BASIS)
50 CONTINUE

WRITE ERROR MESSAGE IF BASIS IS NOT 0 OR 1
C
IF(BASIS(1).GE.0.001.AND.BASIS(2).LE.0.999) WRITE (6,370) I,J,BASI
ISE(2)
BASIS(2)=BASIS(2)+0.001
L=BASIS(2)
IF(L.LE.1) GO TO 40
C
WRITE BASIS VALUE IF 1
C
WRITE (6,380) I,J,L
IF(L.GE.1) GO TO 40
C
RECORD OUTLET LOCATION
C
X(I)=1.0
N=N+1
40 CONTINUE
C
CONTINUE
C
IF ITERATION IS PAST MAXIMUM (T), STOP
C
IF(T.GT.7) GO TO 60
C
IF AN OUTLET IS OPEN IN EVERY AREA, STOP
C
IF(N.LT.M) GO TO 70
C
ISTOP=1
C 60
PROGRAM (*NO*)

* THIS MPS/360 PROGRAM IS USED TO SOLVE BOTH THE FRANCHISOR
  AND THE FRANCHISEE MODELS

* INITIALIZE VARIABLES AND ASSIGN INPUT DATA SET

  INITIAL
  ASSIGN('INPUT', 'FTP0001', 'CARD')
  MOVE(IKDATA, 'FRANCHOR')
  MOVE(KPNAME, 'ORP001')
  MOVE(KOBJ, 'OB02')
  MOVE(KRHS, 'RHS1')
  XGLOKS=0

  ASSIGN TEMPORARY COMMUNICATION FILE

  TLOOP ASSIGN('TEMP', 'FTP0001', 'COMM')

  CALL FORTRAN PROGRAM TO UPDATE DATA

  UPDATEIT, ISTOP, ISTART, IBUDG)

  IF FORTRAN PROGRAM SIGNALS END OF JOB, GO TO EXIT

  IF(ISTOP.EQ.1, EX) CLOSEF('TEMP')

  SET UP PROBLEM

  CONVERT('FILE', 'INPUT')
  SETUP('MAX')
  IF(1.EQ.ISTART, ON1)

  READ OLD BASIS IF ONE EXISTS

  ASSIGN 'OLDBSIS', 'FTP001', 'CARD')
  INSERT('FILE', 'OLDBSIS')
  CLOSEF('OLDBSIS')
  GOTO(OIN2)

  ESTABLISH INITIAL BASIS

  ON1 CRASH

  SOLVE DUAL PROGRAM

  ON2 DUAL

  SOLVE PRIMAL PROGRAM

  PRIMAL

  RECORD SOLUTION
ASSIGN(*TEMP*, *FILE*001*, *COMM*)
PREPOUT(*TEMP*)
SOLUTION(*FILE*001*, *CSECT*, '2/40', *RMASK*'. ')
CLOSE(*TEMP*)
ASSIGN('OLD_BASIS*', 'FILE*001*')
PUNCH(*FILE*, '0DBASIS')
CLOSE(*OLD_BASIS*)

UPDTE TIME COUNTERS

T=T+1
IBUDG=IBUDG+1

START NEXT ITERATION

GOTO(1LOOP)

EX
EXIT

ESTABLISH TIME COUNTERS

DC(20)

DIMENSION 0EMP0TI50), D1ST150,50 I, AI50), B150), I0EM I50), ILOC(150), O150)

INDIVIDUAL FRANCHISEE MODEL

DEMP0T(50), D1ST(50), AI(50), B1(50), I0EM(50), ILOC(150), O150)

ESTABLISH PARAMETER VALUES

M = NUMBER OF AREAS (POTENTIAL OUTLETS)

THRESH = THRESHOLD DEMAND LEVEL

ALPHA = DISTANCE COEFFICIENT

DEPC = PER CAPTIA ANNUAL DEMAND

DIMENSION STORE(10)

DATA STORE/O.3,3.0, 6.0/ DATA M/27/,IDEL/1/,THRESH/229701.0/,ALPH/1.1/,DEPC/39.52/

READ DATA AND CALCULATE DEMAND BY AREA

DO 10 I=1,M
READ (5,250) POP,A1(I),B1(I)
DI(I)=POPA1I,DEPC
10 CONTINUE

CALCULATE DISTANCE MATRIX

DO 30 J=1,M
DO 31 J=1,M
DIST(I,J)=SQRT((AI(I)-AI(J))**2+(B1(I)-B1(J))**2)
31 CONTINUE
30 CONTINUE

START OF LOOP FOR MINIMUM DISTANCE VALUES

DO 40 ISKP=1,3
DMIN=STORE(ISKP)
WRITE (6,230)DMIN
40 CONTINUE
C SET ITERATION COUNTER
C ITER=1
C
C CALCULATE DEMAND AT EACH POTENTIAL OUTLET LOCATION
C
DO 50 I=1,M
ILOC(I)=0
IDEM(I)=0
DEMPOT(I)=0.0
DO 40 J=1,M
DEMPOT(I)=DEMPOT(I)+0.0*exp(-ALPH*DIST(I,J))
40 CONTINUE
50 CONTINUE
C
C SORT POTENTIAL OUTLET LOCATIONS BY DEMAND
C
DO 60 I=1,M
DO 70 J=1,M
IF (IDEM(I).LE.0) GO TO 80
IF (DEMPOT(I).GT.DEMPOT(IDEM(J))) GO TO 80
70 CONTINUE
60 CONTINUE
DO 80 J=1,M
DO 90 K=1,M
L=M-K+1
IDEM(I)=IDEM(I-1)
80 CONTINUE
90 CONTINUE
I=1
DO 100 I=1,M
100 CONTINUE
C IF HIGHEST DEMAND SITE ALREADY HAS AN OUTLET GO TO NEXT ONE
C
IF (ILOC(IDEM(I)).GT.0) GO TO 130
C IF HIGHEST DEMAND IS BELOW THRESHOLD, STOP
C
IF (DEMPOT(IDEM(I)).LT.THRESH) GO TO 210
DO 120 J=1,M
IF (ILOC(J).LE.0) GO TO 120
120 CONTINUE
110 CONTINUE
C CHECK DISTANCE CONSTRAINT
C
IF (DIST(I,J).LT.DMIN) GO TO 130
C LOCATE OUTLET IN AREA IDEM(I)
C
ILOC(IDEM(I))=I
WRITE (6,260) IDEM(I),I,DEMPOT(IDEM(I))
I=I+1
GO TO 140
C
110 CONTINUE
120 CONTINUE
130 CONTINUE
GO TO 210
C
C CALCULATE DEMAND AT EXISTING OUTLETS
C
DO 140 I=1,M
DO 150 J=1,M
IF (ILOC(J).LE.0) GO TO 170
DEM=0.0
150 CONTINUE
170 CONTINUE
140 CONTINUE
GO TO 100
A 206
150 IF(DIST(I,J) .GT. DIST(K,J)) IND=1
  CONTINUE
  IF(IND.EQ.1) GO TO 160
  C WRITE AREAS SERVED BY LOCATION I
  C WRITE (6*270) I,J
  DEM=DEM(O,J)*EXP(-ALPH*DIST(I,J))/IFAC
  CONTINUE
  C WRITE OUTLET DEMAND
  C WRITE (6*280) I,DEM
  DEM2=DEM2+DEM
  IF(DEM2.GT.0.01*OR.IDEL.NE.1) GO TO 170
  C CLOSE OUTLET IF DEMAND IS LESS THAN THRESHOLD
  AND CLOSING IS PERMITTED
  C ILOC(I)=0
  WRITE (6*290) I,ITER
  CONTINUE
  C WRITE TOTAL DEMAND
  C WRITE (6*240) DEM2
  C RECALCULATE POTENTIAL DEMAND BY POTENTIAL OUTLET
  DO 200 I=1,M
  IDEM(I)=0
  DEMPOT(I)=0(I)
  DO 190 J=1,M
  IF(I.EQ.J) GO TO 190
  IFAC=1
  IF(ILOC(I)).LE.0 OR I,EQ.K) GO TO 180
  IF(DIST(I,J).EQ.DIST(K,J)) IFAC=IFAC+1
  IF(DIST(I,J).GT.DIST(K,J)) IND=I
  CONTINUE
  IF(IND.EQ.1) GO TO 190
  DEMPOT(I)=DEMPOT(I)+O(I)*EXP(-ALPH*DIST(I,J))/IFAC
  CONTINUE
  190 CONTINUE
  200 CONTINUE
  GO TO 60
  C WRITE MATRIX OF OUTLET OPENING TIMES
  C GO TO NEXT MINIMUM DISTANCE LEVEL
  C
  210 WRITE (6*300) (ILOC(I)),I=1,M
  220 CONTINUE
  STOP
  C
  230 FORMAT (**1MINIMUM DISTANCE = **F5.1)
  240 FORMAT (** TOTAL DEMAND = **F15.2)
  250 FORMAT (3P10.0)
  260 FORMAT (**LOCATION = **I2,10X,**TIME = **I2,10X,**DEMAND = **F12.2)
  270 FORMAT (** SITE **I2,** serves cell **I2)
  250 FORMAT (** DEMAND AT OUTLET IN CELL **I2, * = **F12.2)
  290 FORMAT (** DELETE SITE **I2,10X,**TIME = **I2)
  300 FORMAT (**I/*( **I, F110/)
  END