MARKET PREEMPTION AS A BARRIER TO ENTRY IN A GROWING, SPATIALLY EXTENDED MARKET

by

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B.A., University of Michigan, 1975

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A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

in

THE FACULTY OF GRADUATE STUDIES
Department of
ECONOMICS

We accept this thesis as conforming
to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA
July, 1979

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Date July 27, 1979

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ABSTRACT

In recent years, a number of economists have become interested in exploring a type of entry-deterring firm behavior known as preemptive entry. This type of behavior has been associated with established firms expanding their capacity in the neighborhood of existing capacity, either in the form of proliferating brands or similar products or opening new plants, in order to secure the custom derivative from existing or anticipated future demands in that neighborhood. The goal of such behavior is to deter entry, hence securing protection for monopoly profits.

The major theoretical result which may be derived from a model of preemption is that if growth of the market is foreseen, an established firm will always have an incentive to preempt the market at a point in time when it would not pay a potential entrant to enter. We derive this result using a one-dimensional, linear spatial model, and we demonstrate that the result does not depend upon the assumption of a large number of potential entrants or on whether the market is one-dimensional or two-dimensional.

The thesis is devoted to testing the implications of the theory of preemption empirically. The first implication which we examine is a profits implication. Using cost and revenue data from the supermarket

industry, we search for indicative evidence for or against the following null hypothesis which is associated with the profits implication: The profits of a representative new supermarket are less than zero in its first twelve months of operation, where the supermarket is representative in the sense that its profits are calculated using average cost and average revenue data, and the average is over supermarkets. We perform a series of annual net profit calculations for the years 1970-1976 inclusive, and find that in any one of these years, the annual net profits of a representative new supermarket are negative and less than the annual net profits of a representative established supermarket.

The second implication of the theory of preemption is a locational one. Using supermarket location data from the province of British Columbia, we construct two types of tests in order to ascertain the nature and extent of preemption in the Greater Vancouver Regional District (GVRD) of British Columbia. First we use cross section data on store ownership and the neighbor relations between stores in each of the four sub-markets of the GVRD in order to determine if our observations are consistent with a random process based on a set of probabilities which is independent of the neighbor relations between stores. We find that this null hypothesis of randomness may be rejected for the GVRD as a whole and its Vancouver sub-market, but not for the three other sub-markets which comprise the GVRD. Next, we use time series data on the date at which each store was established in the Vancouver sub-market, where that store was located, and which firm owned it in order to determine if our observations are consistent with a state dependent probabilistic process in which the probability that any given store is owned by a given firm depends upon the neighbor relations that that store

had with other stores in the sub-market at the time when it was established. We find that we may accept the hypothesis of state dependence for the Vancouver sub-market. Finally, we conduct an analysis of the probabilities underlying the state dependent process and we obtain the result that preemptive location behavior has taken place in the Vancouver sub-market of the GVRD.

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ACKNOWLEDGEMENTS

I would like to acknowledge the assistance of a number of people who took the time and effort to make invaluable suggestions during the course of my research. First and foremost, I wish to thank Professor B. Curtis Eaton, my research supervisor. His insightful and perceptive comments on previous drafts of the thesis enabled the research to reach its present stage of completion. He was also a constant source of encouragement and enthusiasm during those times when the inevitable snags in a thesis occur. I would also like to thank the other members of my dissertation committee, Professors G.C. Archibald and Terry Wales, for their important comments and suggestions at various stages of my research.

At one time or another, I have had useful discussions about various aspects of the thesis with Professors Charles Blackorby, Russell Uhler, James Forbes, and Russell Davidson. I owe special thanks to Professor Yoshitsugu Kanemoto, who provided me with many penetrating comments on earlier drafts of the thesis.

I would also like to acknowledge the generous computer programming assistance provided by Lewis James, Programmer Analyst for Arts Computing. May McKee and Janet Clark also deserve mention for their superb typing of the manuscript.

I wish to thank the University of British Columbia for financial support provided by a Killam Pre-doctoral Fellowship during the duration of the research.

Finally, I owe a special debt of gratitude to Kathy West, who provided sincere and affectionate support and encouragement during my long months of research.

Chapter 1

INTRODUCTION

In recent years, a number of firms have been charged with prematurely proliferating products or plants in order to deter entry in a growing market. On October 11, 1972, an Information was laid charging that Canada Safeway, Ltd., ". . . was a party to a monopoly in the grocery retailing industry between January 1, 1965, and October 10, 1972. The first count related to the City of Calgary and the second related to the City of Edmonton."[1] On September 17, 1973, the Attorney General of Canada applied for (and was granted), in the Supreme Court of Alberta, Orders of prohibition pursuant to section 30(2) of the Combines Investigation Act. (The Information was therefore withdrawn.) One of the Orders required that

> ". . . Canada Safeway Limited will not significantly over the next three and one-half years increase the total square footage which it operates as retail outlets in each of the two cities, and is restricted to opening only one new outlet in each market during this period. In addition, Canada Safeway is restricted from acquiring new sites for retail outlets during the first two and one-half years of the period in question and is further restricted from opening more than two retail outlets during the year following the expiration of the three and one-half year period. The intent of this prohibition is to allow for the development of competition in the retail grocery trade in Edmonton and Calgary. Further, it is intended to prevent Canada Safeway from

pre-empting prime sites for retail outlets in each of the two markets as these sites become available."[2] (Emphasis added.)

At about the same time that an Information was being laid against Canada Safeway, the United States Federal Trade Commission issued a complaint ". . . charging violations of Section 5 of the Federal Trade Commission Act against the four largest U.S. manufacturers of ready-to-eat cereal (hereinafter simply RTE cereal): Kellogg, General Mills, General Foods, and Quaker Oats. In a section headed 'Brand Proliferation, Product Differentiation and Trademark Promotion', the complaint discussed the brand introduction and sales promotion activities of these firms and charged that 'these practices of proliferating brands, differentiating similar products and promoting trademarks through intensive advertising result in high barriers to entry into the RTE cereal market.'"[3]

The type of entry-deterring behavior which the above cases identify has been variously called preemptive entry, preemptive diversification, or brand proliferation.[4] It has been associated with established firms expanding their capacity in the neighborhood of existing capacity, either in the form of proliferating brands or similar products or opening new plants, in order to secure the custom derivative from existing or anticipated future demands in that neighborhood. The goal of such behavior is to deter entry, hence securing protection for monopoly profits.[5]

It is apparent from the cases cited above that there is a number of industries in which preemption might be an important explanation of firm entry-deterring behavior and, consequently, of firm concentration and capacity in an industry. We have already mentioned that the FTC believes that preemptive diversification or brand proliferation has been partly responsible for the concentration in the RTE cereal market. This possibility has been discussed by Schmalensee [1978]. While the problem was really one for analysis in characteristics space, Schmalensee chose to cast the analysis in terms of location (see section 2.4). One implication of Schmalensee's analysis is that preemptive diversification may be essential to understanding the market structure of those industries where product diversification is of paramount importance (such as the automobile industry, soap industry, cigarette industry, etc.). Indeed, as early as 1975, Archibald and Rosenbluth [1975] discovered that preemptive diversification was a logical implication of their analysis of monopolistic competition in Lancaster [1966]-Baumol [1967] characteristics space (see section 2.4).

The possibility of preemptive strategies is also important in promoting our understanding of the market structure and performance of those retail industries which consist of multi-plant firms. In the past, industrial organization economists have paid scant attention to the retail sector of the economy as a whole, let alone attempting to uncover the different forms of firm behavior which may have been responsible for giving rise to the particular market structures of various retail industries. For example, a cursory examination of the most prominent industrial organization textbooks would indicate that economists have engaged in little substantive analysis of retailing. Bain [1968] limits his discussion of retailing to an examination of the structural evolution in the distributive trades. Scherer's [1970] widely used text contains very little discussion of retailing. What discussion there is revolves around Adelman's study of the anti-trust action brought against the A & P Company in the 1940's. Finally, we could find almost no reference to retailing in Shepherd [1970]. This dearth of analytical and empirical examination is difficult to understand given the important role that this sector plays in the economy.

In the pages which follow, we shall explore the conditions under which firms will engage in preemption as a barrier to entry in a growing, spatially extended market. We revise and extend the theory of preemption due to Eaton and Lipsey [1979]. Their theory of preemption was developed in geographic space and constitutes a new dimension to the literature of spatial competition. We shall focus our attention on deriving the testable implications of the theory and we shall conduct rigorous tests of a number of hypotheses which will allow us to empirically confirm or reject these implications for a particular industry. The theory of preemption does not lend itself to empirical tests based on standard econometric techniques. We have therefore had to design testing procedures which rely heavily on nonparametric techniques. Finally, our empirical research has focused on the supermarket industry. We believe that our research makes an important contribution towards our understanding of the market structure of the supermarket industry, and of other industries as well.

The theory of preemption has its roots in the literature of excess capacity as a barrier to entry and in several papers on sequential entry in spatial markets. It is also related to the concepts of brand proliferation and preemptive diversification. In the next chapter, we shall survey the literature leading up to and associated with the theory of preemption.

In Chapter 3, we construct a model of preemption in space and we demonstrate that the established firm always has the incentive to preempt the market at a point in time just earlier than the earliest date at which a new entrant would find it profitable to do so. We also extend this model by relaxing one of its restrictive assumptions. Next, the two-dimensional analogue of the one-dimensional spatial model is discussed and, finally, we indicate reasons why we might not expect to observe perfect preemption in the real world.

In Chapter 4, we analyze average cost and average revenue data from the supermarket industry in order to investigate the profits implication of the theory of preemption. We examine the null hypothesis that the profits of a representative new supermarket are negative in its first twelve months of operation.

In Chapter 5, we test the locational implications of the theory of preemption. Using supermarket location data from the province of British Columbia, we first devise tests in order to determine if our observations on firm ownership of stores and the neighbor relations between stores are consistent with a random process based on a particular set of state independent probabilities. If we reject the hypotheses of randomness, we proceed to test the hypothesis that our observations are consistent with a state dependent probabilistic process. If we accept the hypothesis of state dependence, we then analyze probabilities underlying the process in order to determine if they are consistent with one or more firms having preempted in the market.

In Chapter 6, we summarize our analysis and empirical results, and we make some concluding remarks.

FOOTNOTES TO CHAPTER 1

1. Consumer and Corporate Affairs [1974 ; 32-33].

2. Ibid.

3. Schmalensee [1978 ; 305]. The case referred to is F.T.C. v. Kellogg et al., Docket No. 8883.

4. Eaton and Lipsey [1979], Archibald and Rosenbluth [1975], and Schmalensee [1978].

5. Other forms of preemption are also possible. Southey [1978 ; 553-557] believes that the development of the wheat industry on the Canadian prairies can be modelled as a free access industry in which rents are dissipated. Southey considers two cases. In the first case, an individual must actually work the land after having homesteaded, while in the second case the homesteader is free to leave the land or sell it once the expenditure on breaking-in the land has occurred. He finds that "In both cases homesteading is premature, as is active farming. All else remaining the same, farming commences earlier in the first case than in the second. In each case no net, capitalized rents are made." The driving force of these results is that as long as the present value of expected rents is positive and sufficient to cover set-up costs, homesteading will occur. Competition among homesteaders for the best land pushes back the date of homesteading to the point where the net present value is equal to zero.

Chapter 2

EXCESS CAPACITY, SEQUENTIAL ENTRY AND MARKET PREEMPTION

2.1 Introduction

In this chapter, we shall examine the major theoretical developments which led to the theory of preemption. We shall begin by focusing on a body of literature which grew out of a dissatisfaction with the theory of limit pricing, and which concerns the possibility of using excess capacity as a barrier to entry. This literature is closely related to the theory of preemption in that the theory of preemption concerns itself with the possibility of an established firm constructing excess capacity in the market in the form of new plants in order to prevent new entry from taking place. Next, we discuss some recent literature on sequential entry in spatially extended markets. While the models discussed in this literature do not explicitly deal with the excess capacity issue, they may be regarded as the precursors of spatial models of preemption. These models generally make the important assumption that capital, once established, is fixed in location, and then proceed to analyze the entry deterring strategies of single plant firms. Had these models relaxed their assumption that each firm is only allowed to own one plant, a theory of preemption could have been derived. Finally, we summarize the theoretical literature which has explicitly discussed preemption.

2.2 Excess Capacity as a Barrier to Entry

An area of economics known as "barriers to entry" has preoccupied the minds of many economists for years (see Bain [1965]).[1] Among the most frequently cited entry barriers are increasing returns to scale, patents, advertising, imperfect capital markets, tying up raw materials, and government licensing and regulation. However, limit pricing has probably received the most extensive theoretical treatment of any of the entry barriers.[2] It is not my intention to summarize the limit pricing literature here, but rather to note that dissatisfaction with limit pricing theory led some economists to speculate upon the possibility of using excess capacity as a barrier to entry. For example, Pashigian [1968] was uneasy over the conventional assumption of limit price theorists that the monopolist cannot charge the monopoly price and yet block entry by threatening to lower price and expand output. Such a strategy would require that the monopolist

> "... be prepared to produce the larger output required to meet demand at the limit price with a plant primarily designed for efficient production of the smaller monopoly output. To achieve this output flexibility, the monopolist will either sacrifice some plant efficiency for greater plant flexibility than is otherwise required, or incur higher short-run cost in trying to produce the larger output with a specialized plant designed for the monopoly output, or carry higher inventories, again at additional cost."[3]

Pashigian, however, dismissed this strategy with the argument that the entrant would then have a cost advantage over the monopolist.

Wenders' [1971] article was inspired by Pashigian's suggestion that a monopolist may wish to pursue a strategy of blocking entry by threatening to lower price and expand output, while still charging the monopoly price. Wenders disagreed with Pashigian's dismissal of this strategy, noting that

> ". . . just because this use of excess capacity involves higher costs, this does not mean that it will be unprofitable; it merely means that excess capacity should be increased only up to that point where the incremental benefits are matched by the incremental costs."[4]

Wenders then proceeded to consider how a monopolist could block entry by building a plant which is large enough to produce efficiently at the limit price, while charging the monopoly price and producing the monopoly quantity when the threat of entry is small. Such a strategy would result in lower monopoly profits relative to what the monopolist could earn if it had built the most efficient plant for the monopoly output and entry were barred, but potentially higher profits than could be earned by using a limit pricing strategy.

Esposito and Esposito [1974], while not focusing upon excess capacity as a barrier to entry, did suggest reasons why excess capacity might appear in different market structures. Excess capacity might arise in oligopolies characterized by substantial seller concentration, substantial barriers to entry and a significant competitive fringe ("partial oligopolies") if the largest firms fail to act collectively and also fail to increase their market share after attempting to do so in response to a permanent increase in demand.[5] (Esposito and Esposito found evidence to support the hypothesis of excess capacity in partial oligopolies.) Excess capacity could also arise in a tight oligopoly if

". . .at least one of the oligopolists views an increase in industry demand as creating a good opportunity to increase his market share. . . . An oligopolist may also create excess capacity in order to retain his own buyers and service his rivals' customers unexpected needs in case unanticipated future increases in demand occur. . . . In turn, fear of future loss of market share may impel rival oligopolists to increase capacity beyond what is needed to meet their current demand."[6]

This last reason for excess capacity comes closest to approximating an argument in support of preemption as a cause of excess capacity, although they do not expand upon this possibility.

Spence [1977], following Wenders, also considers the possibility of an industry carrying excess capacity in order to deter new entry. He established that a result of such a strategy would be a price in excess of the limit price and inefficient production in the sense that the output produced would be less than capacity output and costs would not be minimized for this output. Unlike Wenders, Spence focused more explicitly on comparing the implications of an industry using excess capacity as a barrier to entry with the implications of an industry using a limit pricing strategy. The desirability of such excess capacity is shown to depend upon the level of residual demand and the extent to which such a policy will in fact deter entry.

There are at least two important features of Spence's and Wenders' models of excess capacity as a barrier to entry which differentiate them from models of preemption. First, their models are essentially static. That is, the monopolist is confronted with a once-and-for-all decision of what size plant to build given that the level of residual demand might induce entry. Models of preemption consider the plant construction or capacity expansion strategies of established firms and potential entrants given that they are confronted with an expected increase in demand in the future. The date of entry is thus an important aspect of preemption analysis. Second, and most important, their models are spaceless, while models of preemption have been cast in a spatial framework. By analyzing the decision to preempt in a spatial framework, insights are gained into the incentives which firms have to engage in this type of behavior as opposed to some other form of entry deterring behavior.

2.3 Models of Sequential Entry

Spatial models of sequential entry are the precursors of spatial models of preemption. As mentioned in the introduction to this chapter, these models generally make the important assumption that capital, once established, is fixed in location, and then proceed to analyze the entry deterring location strategies of single plant firms. In addition, these models are generally incapable of analyzing a preemptive strategy since they assume that firms enter the market one at a time and do not compete with each other for the opportunity to establish new plants in the market.

The first model of sequential entry which we shall comment upon in this section is one constructed by Peles [1974]. Peles shows that excess profits may be a property of both short-run and long-run equilibrium in his model (given that capital is fixed in location or immobile). While not primarily interested in analyzing entry deterring strategies, Peles did note that producers could use part of their excess profits in order to deter entry, while still retaining a monopoly profit. "If producers expect a new entry, they might locate themselves closer together from the beginning, reducing the market area and the maximum profit an intruder can get. The cost of this strategy for the old producer is a lower monopoly profit."[7] Peles did not go on to explore the conditions under which such an entry deterring strategy would be in the best interests of the firm.

A more detailed model of sequential entry was constructed by Rothschild [1976]. Rothschild was primarily interested in investigating the equilibrium configurations which would be generated by N firms locating sequentially on a line segment bounded by two established firms, given that capital is immobile once set in place. He did not concern himself with the question of how competition among firms for the opportunity to establish a new plant in the market might affect the time and place of new plant construction. Rothschild assumes that all locations are occupied by different firms and that since each firm is solely concerned with maximizing the minimum sales which may accrue to it when all have entered, assuming that any successors have similar objectives, each firm locates so that the worst possible outcome for it on these assumptions is as favorable as possible. He thus refrains from analyzing the case in which an established firm might consider opening a new plant in the market as opposed to a new firm opening a plant.

Hay's analysis [1976] appeared at approximately the same time as Rothschild's, and may have been influenced by it. Hay, like Rothschild, focused on the sequential entry of new firms given that plants are fixed in location once set in place. Also like Rothschild, Hay considers only the sequential entry of new firms into a linear market which is large enough to support some unspecified number of firms, given that there is already one firm located in the market. (Imperfection in information is assumed to lead some firms to enter before others.) Hay establishes the result that under various assumptions, spacing of firms will be regular, i.e. market areas will be just less than twice the minimum market necessary for profitable new entry. This type of spacing, under Hay's foresight assumption, is the best entry deterring locational pattern from the point of view of individual firms. (The gap in the market is insufficient to allow new entry to take place.) Hay's analysis is essentially correct in the case in which an entering firm foresees the possibility of new entry, but does nothing itself, once established, to deter entry. Once again, the possibility of an established firm deterring entry by opening new plants in the market prior to the point in time when it would pay a new entrant to enter was not examined.

Prescott and Visscher [1977] also consider a sequential entry model in which each firm's location decision is once-and-for-all. Firms are assumed to enter in sequence because ". . . some entrants become aware of a profitable market before others or require longer periods of time in which to 'tool up.'"[8] They also assumed that the ". . . expectations of the firm about the response of other firms to its own decisions are rational in the sense that the expectations are consistent with the predictions of the model."[9] Prescott and Visscher are interested in using their "solution concept" (i.e., firms entering sequentially and once-and-for-all, with each entering firm correctly anticipating the decisions of the remaining firms in the sequence of entrants) in order to analyze the Hotelling problem and modifications of it. They discuss a number of examples which, for the most part, have little relevance for the present study. However, their fourth example is of some interest to us since it suggests how the relaxation of the one firm - one plant assumption in a sequential entry model can generate a preemption result. For this example, they assume that locations are fixed when chosen and based on the observed locations of established firms and correct expectations of where new entrant firms will enter in the future. They also assume that firms know that prices will be determined noncooperatively in Nash fashion once locations are chosen. Using recursive and numerical methods, they compute equilibria under different assumptions about the size of the fixed costs of entry and demand, and when the equilibrium number of firms is less than or equal to three. They find that the equilibrium sequence is characterized by successive entrants locating further apart and no firm choosing a location arbitrarily close to the location of any other firm. In addition, "Profits and market share are larger the earlier in the sequence that a firm enters . . .". However, Prescott and Visscher note that there may be cases in which it pays a firm to enter later rather than earlier. In commenting on how to resolve this indeterminacy, Prescott and Visscher came up with the following insight:

> In practice, the indeterminacy in such a situation might be resolved by a single firm's obtaining sufficient venture capital to locate at multiple positions such that no remaining potential position offers profits. The result in this case is complete monopoly. Indeed, sequential foresighted entry results in monopoly anytime the number of locations any one firm can choose is not restricted because all equilibrium locations are profitable, and we expect the first firm in the sequence to choose all profitable locations if possible.[10]

Unfortunately, Prescott and Visscher did not provide a more rigorous analysis of this possibility.

Prescott and Visscher, in their fifth example, provide further intuitive discussion of their contention that ". . . making entry into the industry endogenous is crucial and . . . that without a constraint on the number of 'locations' any one firm may occupy, the resulting industry structure is monopoly." In this analysis, they interpret location as corresponding to a choice of physical plant capacity. They assume that firms produce a homogeneous product, that market price is determined by total plant capacity in the industry, that marginal revenue is a decreasing function of industry capacity, that fixed costs are positive and marginal costs are constant. They argue that the first firm in the market " . . . clearly profits more by extending capacity to the ultimate industry size."[11] Prescott and Visscher support this conclusion by noting that if the firm stopped short of building the "limit capacity", additional entry would occur and the market price would be the demand price corresponding to total industry capacity. "Had the first firm chosen the entire industrial capacity, however, market price would be no different, further entry would still be forestalled, yet the first firm would sell more than had it chosen smaller capacity."[12] This analysis, while suggestive, falls short of the analysis of excess capacity as a barrier to entry provided by Spence [1977], which appears in the same issue of the Bell Journal.

Finally, Prescott and Visscher note several reasons why a firm may fail to occupy all the available locations. There may be financial constraints on expansion, diseconomies of scale to multi-plant expansion, uncertainty regarding the extent of the market, or significant costs of rapid expansion of firm size possibly due to the costs of screening new personnel.

Thus, Prescott and Visscher have articulated the incentive which an established firm has to preempt the market, and have also pointed out reasons why we would not expect to observe perfect preemption in the real world. In the next section, we discuss two papers which formally recognize the possibilities of preemption.

2.4 Brand Proliferation and Preemptive Diversification

In the previous two sections, we have examined two bodies of literature which laid the basis for the theory of preemption. The first explicit reference to preemption as a barrier to entry in a spatial context appears to have been made by Archibald and Rosenbluth [1975]. Archibald and Rosenbluth were principally concerned with recasting the theory of monopolistic competition in terms of characteristics space. In doing so, it was hoped that some of the weaknesses of the Chamberlinian theory, such as the definition of a group and the effects of introducing new differentiated products into the group, could be remedied. In discussing the implications of their model, Archibald and Rosenbluth note that limit pricing will not be an effective entry deterring strategy, but preemptive diversification will. That is, it will pay established firms to occupy neighboring positions in characteristics space, provided the market is "dense" enough to support the introduction of a new product. If the point of expected entry is bounded by two existing firms, then it will pay either of the existing firms to preempt the market from a new entrant, mainly because the existing firms would be able to control the price of the new product, although it is not possible to say which firm will act upon the incentive to preempt first. "We may have here an explanation of the proliferation of product variants and brand names in which so many firms engage, apparently even at the expense of economies of scale."[13]

Schmalensee [1978] has also focused on the possibilities of using preemptive diversification or brand proliferation as a barrier to entry. As mentioned in Chapter 1, the lack of significant new entry over a long period of time into the ready-to-eat breakfast cereal industry was believed to be due in part to frequent introductions of new brands by established firms. Schmalensee analyzed the plausibility of such an entry deterring strategy in this context.

Schmalensee makes the following assumptions:

(i) ". . . for individual brands, at least at low levels of output, the unit cost of production and marketing falls with increases in output." (For "illustrative purposes", Schmalensee specifies that long run total cost of producing and marketing a typical brand is given by $C(q) = F + vq$, where F and v are positive constants and q is output of the brand. He does not specify a capacity constraint.)[14]

(ii) Localized rivalry among brands. Since Schmalensee uses a one-dimensional, linear spatial model for his analysis, localized rivalry is ". . . present in an extreme (and thus tractable) form: normally only the two brands between which an entrant locates would be affected by changes in, for instance, its price."[15]

(iii) Brand locations cannot be changed.

He then shows that the optimal entry deterring strategies of established firms are to charge prices which maximize the unconstrained profits of the established brands, and to choose a number of brands which exceeds the unconstrained profit maximizing number. (Schmalensee is able to obtain a determinate solution to the industry's profit maximizing strategy by assuming that established firms collude to deter entry at minimum cost to themselves. Thus, in effect, the oligopoly is treated as a monopoly, and Schmalensee finds that it is in the monopolist's interests to protect its monopoly position by preempting the market.) Schmalensee also argues that brand proliferation is superior to limit pricing in its ability to actually forestall entry. If firms attempt to use limit pricing as a barrier to entry, a potential entrant may nevertheless enter. Given that the new entrant's costs are now sunk, all firms will see that it is to their mutual advantage to raise price. Thus, limit pricing may lack credibility as an entry barrier. On the other hand,

> ". . . if the established firms can crowd economic space with brands before the threat of entry appears, as we have been assuming, the entry-deterring threat is that the brands will not be moved if entry occurs. Since repositioning brands is assumed to involve substantial costs, such a threat is quite credible."[16]

Finally, Schmalensee argues that the structure and performance of the ready-to-eat cereal industry are consistent with established firms actually behaving in a preemptive fashion. After analyzing the welfare implications of entry deterring behavior, he suggests policies which should improve the performance of the industry.

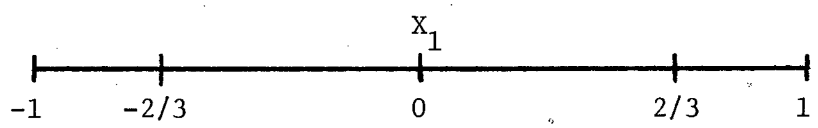
Schmalensee's analysis, while persuasive, does not rigorously test for the existence of preemptive behavior. In a later chapter of this thesis, we shall draw out the empirically testable implications of the theory of preemption and test them using location data and cost and revenue data drawn from the supermarket industry.

2.5 The Eaton and Lipsey Model of Market Preemption

Eaton and Lipsey [1979] have provided us with the most theoretically complete treatment of preemption as a barrier to entry in a growing, spatially extended market. Since this model will form the basis for the theoretical analysis in the next chapter, I shall summarize it in some detail.

Eaton and Lipsey consider a one-dimensional market, two units in length, with a uniform distribution of customers of density δ. This market is represented by Figure 1.

Figure 1



They assumed that each firm has the same cost curve and that production is subject to increasing returns to scale at the plant level over some range of output. Firms maximize profits, and their capital is immobile once set in place due to location specific sunk costs. Consumers are assumed to have identical demand curves, and demand is a function of delivered price, mill price plus transport costs (which are an increasing function of distance). Each consumer buys from the plant with the lowest delivered price.

An established firm, F_1, initially located at the origin, and an infinite number of potential entrants are assumed capable of accurately calculating the flows of costs and revenues that will be associated with any plant. (Eaton and Lipsey call this expectations assumption a form of consistent expectations, or those expectations that are consistent with realizations.) All firms are also assumed to perceive correctly that the market will grow at a time t_2 such that one new plant established in each of the intervals (-1:0) and (0:1) would earn pure profits if established at time t_2. Finally, Eaton and Lipsey assume that density of consumers is initially such that the established firm is earning pure profits, but that entry of new firms will not occur.[17]

The first proposition which they establish is called preemption by new entrants:

> "if the existing monopolist does not establish new capacity to meet the increased demand, competition among potential new entrants will lead to the establishment of new capacity some time before the date at which demand increases."

Recall that the market is expected to grow discretely at time t_2 and assume that the established firm does nothing to block entry. Given that there is a large number of potential entrants competing for the opportunity to establish a new plant in the market, the time of entry will be pushed back to a time $t_1 < t_2$ such that the present value of each of the plants established in the intervals (-1:0) and (0:1) will be zero.

The second proposition established by Eaton and Lipsey is called monopoly preemption:

> "the existing monopolist will always find it profitable to preempt the market by establishing new capacity at a time just earlier than the earliest date at which any potential new entrant would find it profitable to do so."

Suppose that the established firm, F_1, foresees the possibility of new firm entry. If the established firm's prices and locations were precisely the same as those of new entrants, then the opportunity to establish new plants in the market would be worth as much to the established firm as they would be to the new entrants. However, the established firm would not adopt the same prices and locations as new entrants. First, the established firm would locate its plants at the joint profit maximizing locations (-2/3 and 2/3), while the new entrants would locate new plants to the right of -2/3 and to the left of 2/3 for the reasons advanced by Hotelling [1929] in his pioneering article on spatial competition. Second, the established firm would select the joint profit maximizing prices, while entry by a new firm would be expected to result in prices which are either permanently or temporarily depressed below the monopoly prices which the established firm would charge if it owned the new plants. Eaton and Lipsey then state that "The value to F_1 of monopoly preemption depends on the difference between the profitability of the market when three plants are owned by F_1 and when two of the plants are owned by new entrants," and the preceeding argument clearly demonstrates that this difference is positive. Thus firm F_1 will have an incentive to establish new plants in the market just prior to t_1, which is the earliest date at which a new entrant would find it profitable to enter.

In the remainder of their paper, Eaton and Lipsey consider extensions of the analysis, discuss the role that expectations play in the model, and also compare their spatial model of preemption with spaceless models. However, it is the model presented above which we will find most useful as the basis for our theoretical discussion in the next chapter.

FOOTNOTES TO CHAPTER 2

1. Perhaps surprisingly, many well known entry barriers have yet to be scrutinized by marketing researchers and retail geographers. Marketing researchers seem to have been preoccupied with the calculation of trade areas, to the exclusion of the analysis of firms' strategic alternatives which affect these trade areas (see Applebaum and Cohen [1960, 1961], Bucklin [1967], Cohen and Lewis [1967], and Huff [1963]). Retail geographers have been principally concerned with extending and revising Berry's reformulation of Christaller's theory of central places (see Berry and Garrison [1958a, 1958b, 1958c], Berry [1958, 1963], and Berry, Barnum and Tennant [1962]). A good deal of this effort has gone into refining various indices of centrality and identifying the nature and existence of hierarchies of centers (or central places). (For a representative sample of this literature, see Garner [1966], Simmons [1964, 1966], Brush and Gauthier [1968], Nystuen [1959], and Marshall [1969].) Hence, most of the literature is empirical, with a very weak underlying theoretical base. Indeed, most central place theorists do not have a theory of firm behavior, as they generally take the economic landscape as already given.

2. On the subject of limit pricing, see Baron [1972, 1973], Bhagwati [1970], Kamien and Schwartz [1971, 1972], Modigliani [1958], Osborne [1964, 1973], Pashigian [1968], Pyatt [1971], Sherman and Willett [1967], Shubik [1959], and Bain [1965]. Latsis [1976] has echoed the sentiments of many critics of limit pricing theory in the following passage: "Thus the theory does not explain why a potential entrant

should not call the bluff of the established firms by entering the industry when the limit price is being charged. The theory can give no reason why the established firms would continue to produce the limit quantity in the changed circumstances, since their profits might well be larger if they reduced their output and co-existed peacefully with the new entrant, particularly if it were clear that the new entrant was prepared to endure a long period of unprofitable operations. If it were to be inferred from the theory that the established firms would be prepared to suffer losses in order to force out the new entrant rather than accommodate him in this industry, a further question is raised. Without setting the price at the level of the limit price, the established firms could communicate the threat that they would deal with the problem of new entry by enforcing losses on any new entrant who enters their industry. The theory does not explain why the communication of such a threat should be ruled out, nor why the only effective communication of a threat is that implicit in the adoption of the limit price."

3. Pashigian [1968; 166].

4. Wenders [1971; 15].

5. Esposito and Esposito [1974; 189].

6. "High seller concentration, high barriers to entry and an insignificant competitive fringe characterize tight oligopolistic markets." Esposito and Esposito [1974; 188-189].

7. Peles [1974; 628].

8. Prescott and Visscher [1977; 379].

9. *Ibid.*, pp. 379-380.

10. *Ibid.*, p. 390.

11. *Ibid.*, pp. 390-391.

12. *Ibid.*, p. 390.

13. Archibald and Rosenbluth [1975; 589].

14. Schmalensee [1978; 307-308].

15. *Ibid.*, p. 310.

16. *Ibid.*, p. 314.

17. For a thorough discussion of the possibility of excess profits in a free entry equilibrium, see Eaton and Lipsey [1978].

Chapter 3

THE THEORY OF MARKET PREEMPTION

3.1 Introduction

In the previous chapter, we discussed the Eaton and Lipsey model of preemption in some detail. This model will form the basis for our analysis of preemption in this chapter. The analysis commences with a discussion of the possibility of preemption in spaceless models. We argue that while firms do not have any incentive to preempt in a perfectly competitive world, incentives to preempt exist in a market characterized by natural monopoly. In section 3.2, we develop a model of preemption in space which uses the same basic specification as the Eaton and Lipsey model. We demonstrate that the established firm will always have an incentive to preempt the market. In section 3.3, we develop a model of preemption which relaxes the infinite competitive fringe assumption of the model constructed in section 3.2. In section 3.4, we discuss the two-dimensional analogue of the one-dimensional spatial model. Finally, in section 3.5, we indicate reasons why we might not expect to observe perfect preemption in the real world.

3.2 Preemption in a Spaceless Market

Preemption of the market is a logical possibility in a spaceless world. It will be argued below that while preemption can occur in the neoclassical perfectly competitive world, there is no incentive for firms to engage in this type of behavior. Other types of market structure are necessary in order to provide firms with such an incentive. It is useful to consider the problem of preemption in a spaceless market intuitively, as it will provide some background to the spatial models developed in the later sections of this chapter.

In the neoclassical theory of perfect competition, it is assumed that there are many firms, each producing a homogeneous product. Each firm believes that it is too small, relative to the market, to have any influence on price. In the short run, firms may be making above normal profits. However, these pure profits attract entry into the market by other firms. Quantity supplied is increased and price decreases until the familiar long run equilibrium with no incentive for entry or exit is achieved. In the scenario outlined above, we may think of each firm as being characterized by constant returns to scale or returns to scale which are insignificant with respect to the market.

Suppose that all firms (existing firms and potential entrants) anticipate that at some time in the future, t_2, there will be a discrete increase in demand such that new capacity could be profitably established in the market to meet that anticipated increase in demand.[1] (We consider a discrete rather than continuous increase in demand in order to simplify the exposition. We should also note that even though the increase in demand is discrete, the present value of profits to a firm will still be a continuous function of time.) It is clear that capacity expansion would occur at time t_2, and not before. If any firm contemplated establishing enough new capacity prior to time t_2, such that it would supply a substantial amount of the anticipated discrete increase in demand, then it would expect its flow profits (the difference between its current revenues and current costs inclusive of normal profits) to be negative. When the increase in demand occurs at time t_2, capacity expansion would take place such that above normal profits would be eliminated. Thus, the firm that established new capacity prior to t_2 could not expect to balance off losses prior to t_2 against above normal profits after t_2. This implies that there is no incentive in the perfectly competitive model for any firm to preempt the market. Each firm would be indifferent as to whether or not any other firm preempted the market since market preemption cannot guarantee an above normal rate of return to a firm in a perfectly competitive world.

Now, consider a market in which each firm is characterized by increasing returns to scale at the plant level. For simplicity, it is assumed that at time t_0 (the initial condition), there is only one firm serving the market. As in the case discussed above, a discrete increase in demand at time t_2 is anticipated by all firms such that positive flow profits could be earned by establishing a new plant in the market at time t_2. Either the existing firm or a new entrant could establish a new plant in the market prior to t_2. Since there are many potential entrants, the actual time of new firm entry would occur at $t_1 < t_2$ such that the present value of profits to the new entrant is equal to zero.

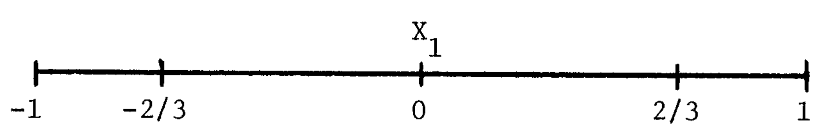
In the above model, preemption can occur and firms have the incentive to preempt the market. The monopolist's incentive to preempt derives from the prospect of obtaining a higher present value by preempting the market than it would obtain if it allowed a new firm to enter. Potential entrants have an incentive to preempt due to the prospect of obtaining a present value greater than or equal to zero by doing so. In contrast to the competitive case, the incentive to preempt the market would lead the existing firm or a new entrant to establish a new plant in the market at a time prior to the actual increase in density.

3.3 A Spatial Model of Preemption

When space is introduced into an economic model of firm behavior, the decision variables of the firm and set of strategic alternatives are augmented. This expansion of the choice set makes it possible to explain some firm behavior which might otherwise appear to be inexplicable or perverse in the context of a spaceless model. Perhaps the most fundamental characteristic of all location problems is the recognition of indivisibilities. If indivisibilities were nonexistent and if transportation were costly, all production would take place at the point of consumption. This implies that "... without recognizing indivisibilities - in the human person, in residences, plants, equipment, and in transportation - urban location problems, down to those of the smallest village cannot be understood."[2] Capital indivisibilities in a spatial world also permit firms to make pure profits without attracting additional entry into the market.[3] It will be argued that firms have an incentive to protect their pure profits by preempting a growing spatially extended market.

Attention will be confined in this section to a one-dimensional market, two units in length, as described by Figure 2.

Figure 2



It is analytically convenient to conduct the analysis using a linear market. However, the results do generalize to a two-dimensional landscape, as will become apparent in a later section. The analysis of this section will be based upon the following assumptions:

(i) The firm maximizes its present value at each moment in time. It does so by choosing a location for the establishment of a new plant, and the prices to be charged by all of its plants in the market.

(ii) Demand is a function of delivered price: $Q = y(q)$, where $q = p + zX$, p = an index of the firm's price, z = transport costs which are constant per unit of distance per unit of the good, and X is the distance the consumer travels to the plant. This assumption implies that all consumers have identical tastes.

(iii) Assumption (ii) implies that utility maximizing consumers will patronize the plant offering the goods they desire to purchase at the lowest delivered price.

(iv) The cost function faced by each of the firm's plants is characterized by increasing returns to scale over some range of output.[4]

(v) The firm's plants, once established, are fixed in location due to location specific sunk costs. The firm's capital is indivisible and immobile once set in place.[5]

(vi) Firms are able to foresee the outcome of the competitive process, and are thus able to calculate their own and their competitors' returns contingent upon the pursuit of various strategies. Thus, we follow Eaton and Lipsey [1979] and assume that firms have what they call "consistent expectations": expectations that are consistent with realizations.

An important implication of the above assumptions in the context of a spatial model is that initial conditions do not wash out. In a spatial model, the assumptions of indivisibilities and sunk costs imply that the initial distribution and size of firms have an impact upon the equilibrium configuration which is eventually attained.

We now specify a set of initial conditions. One firm, which will be referred to as F_1, initially has a plant located at the origin at time t_0. At time t_0, the customer density, δ_0 (which is assumed uniform), is such as only to allow the profitable operation of one plant at the origin, and even though the firm may be making above normal (or pure) profits, no potential entrant would find it profitable to enter.[6] It is assumed that F_1 and an infinite number of potential entrants correctly perceive that at some time in the future, t_2, customer density will increase to δ_1 such that two new plants, one in the interval (-1:0) and the other in the interval (0:1), would earn pure profits if established at t_2. Since the market is symmetric about the origin, the following analysis will be confined to examining the possibilities for entry on the right hand side of the market.

Let us now begin the argument by inquiring as to when a potential entrant would establish a new plant in the market described by Figure 2. It is clear that if the opportunity were available, a new entrant would like to enter the market at time t_2, when the present value of profits is positive and pure profits can be made. However, since the increase in density at t_2 is foreseen, and since there are many new entrants competing for the opportunity to set up a new plant in the market, the potential entrant that actually enters the market will do so at time t_1, such that the present value of its profits is equal to zero, and it earns a normal rate of return. In other words, the only way for the successful new entrant to enter the market at time t_1 is for it to preempt the market from its competitors by constructing a plant in the market at that date.

The potential entrant or competitor, F_2, would thus enter the market at time t_1 and choose its price and location in order to maximize the present value of its profits:

$$\text{(3.1)} \qquad \max_{(p_{22},\, X_{22})} \int_{t_1}^{\infty} \Pi^2(p_{22}, X_{22};\, p_{11}, X_{11})\, e^{-rt}\, dt = V^2,$$

where

$X_{i\ell}$ = the location of plant ℓ when it is owned by firm F_i ($\ell = 1$ refers to the established plant, while $\ell = 2$ refers to the new plant)

$p_{i\ell}$ = the mill price charged at plant ℓ when it is owned by firm F_i

r = the firm's discount rate

Π^2 = F_2's profit function.

F_2 maximizes the present value of its profits, taking the initial location of $F_1(X_{11})$ as given.

If F_2 had successfully entered the market at time t_1, then F_1 would simply maximize the present value of its profits:

$$(3.2) \qquad \max_{(p_{11})} \int_{t_1}^{\infty} \Pi^1(p_{11};\, X_{11},\, p_{22},\, X_{22})\, e^{-rt}\, dt = V^1.$$

F_1 maximizes its present value, taking as given the location of its plant (X_{11}), and the location of firm F_2's plant (X_{22}).

Suppose F_1 had established the new plant in the market at time t_1 rather than F_2. Then F_1 would wish to maximize the present value of its profits over the entire market:

$$(3.3) \qquad \max_{(p_{11},\, p_{12},\, X_{12})} \sum_{\ell=1}^{2} \int_{t_1}^{\infty} \Pi_{\ell}^1\, (p_{11},\, p_{12},\, X_{12};\, X_{11})\, e^{-rt}\, dt = \tilde{V}^1,$$

where Π_{ℓ}^1 = F_1's profit function for its ℓth plant. That is, F_1 would choose the location of its new plant and prices p_{11} and p_{12} in order to maximize the present value of profits of both plants. (We place a tilde over the V to distinguish joint present value maximization on the part of F_1 from individual present value maximization on the part of F_1 and F_2.)

We now enquire as to whether or not F_1 has an incentive to preempt the market, i.e. to establish a new plant in the market at time $t_1 - \varepsilon$ (where ε is arbitrarily small) before the potential entrant would find it profitable to enter. First, we know that it must be the case that

$$(3.4) \qquad \tilde{V}^1(p_{11},\, p_{12},\, X_{12};\, X_{11})$$

$$\geq V^1(p_{11};\, X_{11},\, p_{22},\, X_{22}) + V^2(p_{22},\, X_{22};\, p_{11},\, X_{11})$$

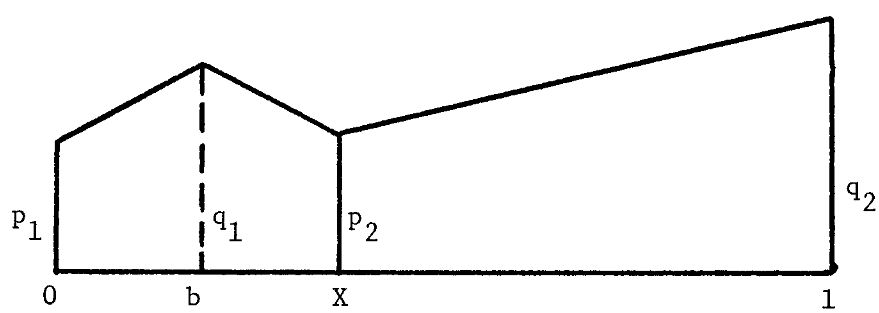
or

$$(3.5) \quad \tilde{V}^1(p_{11}, p_{12}, X_{12}; X_{11}) - V^1(p_{11}; X_{11}, p_{22}, X_{22}) \geq 0$$

since $V^2(p_{22}, X_{22}; p_{11}, X_{11}) = 0$. That is, the jointly maximized present value of profits of F_1 must be greater than or equal to the sum of the independently maximized present value of profits of F_1 and F_2. However, we shall argue that, in general, (3.5) would hold as a strict inequality. This means that the present value of profits to F_1 obtained by preempting the market at time t_1 is strictly greater than the present value of profits which it could obtain if it did not preempt the market at time t_1. (In other words, V^1 is the opportunity cost of pursuing the preemptive strategy.) Thus, we may conclude from this that if (3.5) holds as a strict inequality, F_1 will have an incentive to preempt the market at time $t_1 - \varepsilon$.

Consider the market described by Figure 3.

Figure 3



For expository convenience, we have suppressed all subscripts on p and X which refer to the firm. In addition, we shall let X represent the location of the new plant. Actual mill prices are thus represented by

p_i, while q_i represent expected delivered prices at the market boundaries. We denote the market boundary between F_1's plant located at the origin and the plant located at X as b. The delivered prices at b and 1 are

$$q_1 = 1/2\,(p_1 + p_2 + zX) \tag{3.6}$$

$$q_2 = p_2 + z(1 - X) \tag{3.7}$$

respectively, where z = transport costs which are constant per unit of distance per unit of the good.[7] We may calculate the quantity demanded at any point in time from F_1's plant at the origin, given that there is another plant at location X, as follows:

$$Q_1 = \delta \int_0^{\tilde{b}} y(p_1 + zb)\,db = \delta/z \int_{p_1}^{q_1} y(p)\,dp = \delta/z[Y(q_1) - Y(p_1)], \tag{3.8}$$

where $y(p_1 + zb)$ is the demand function and $[Y(q_1) - Y(p_1)]$ is the definite integral from p_1 to q_1.[8] The quantity demanded from the plant at X is then

$$\begin{aligned} Q_2 &= \delta/z[\int_{p_2}^{q_1} y(p)\,dp + \int_{p_2}^{q_2} y(p)\,dp] \\ &= \delta/z[Y(q_1) + Y(q_2) - 2Y(p_2)]. \end{aligned} \tag{3.9}$$

The cost function of a given plant is obtained as follows: Assume that input prices are constant. Then the firm must choose capital (K) and labor (L) in order to

$$\min_{(K,\ L)} \left\{\bar{r}K + \bar{w}L\right\} \tag{3.10}$$

subject to the constraint that Q = Q(K, L), where $\bar{r}$ = the interest rate and $\bar{w}$ = the wage rate. Cost minimization yields the minimum total cost function for each plant C(Q), where we have suppressed input prices since they are assumed constant. We assume that the cost function is continuous, twice differentiable, non-decreasing in Q, and that it satisfies the following conditions:

$$
\begin{aligned}
(3.11)\quad & C' > 0,\ C'' < 0 \quad \text{for any output less than } \tilde{Q} \\
& C' > 0,\ C'' = 0 \quad \text{for output equal to } \tilde{Q} \\
& C' > 0,\ C'' > 0 \quad \text{for any output in the interval } (\tilde{Q}:\tilde{\tilde{Q}}) \\
& C' > 0,\ C'' = 0 \quad \text{for any output greater than or equal to } \tilde{\tilde{Q}}.
\end{aligned}
$$

These conditions imply that the average cost function is decreasing in output for any output less than $\tilde{\tilde{Q}}$, and becomes horizontal for any output greater than or equal to $\tilde{\tilde{Q}}$.[9] The empirical phenomenon which we wish to capture with this particular specification of the cost function is increasing returns to scale at the plant level over some range of output.

Now suppose that F_1 establishes a new plant in the market at time t_1. F_1 would then choose its prices, p_1 and p_2, and the location of the new plant, X, in order to maximize the present value of profits:

$$
(3.12)\quad \tilde{V}^1 = \int_{t_1}^{t_2} [p_1\tilde{Q}_1 + p_2\tilde{Q}_2 - C_1(\tilde{Q}_1) - C_2(\tilde{Q}_2)]\ e^{-rt}\ dt
$$

$$
+ \int_{t_2}^{\infty} [p_1\tilde{Q}_1 + p_2\tilde{Q}_2 - C_1(\tilde{Q}_1) - C_2(\tilde{Q}_2)]\ e^{-rt}\ dt
$$

$$
= \Bigg\{ \frac{p_1\delta_0}{z}\ [Y(q_1) - Y(p_1)] + \frac{p_2\delta_0}{z}\ [Y(q_1) + Y(q_2) - 2Y(p_2)]
$$

$$- C_1(\delta_0/z[Y(q_1) - Y(p_1)]) - C_2(\delta_0/z[Y(q_1) + Y(q_2)$$

$$- 2Y(p_2)])\Big\} \int_{t_1}^{t_2} e^{-rt}\, dt + \Big\{ \frac{p_1\delta_1}{z} [Y(q_1) - Y(p_1)]$$

$$+ \frac{p_2\delta_1}{z} [Y(q_1) + Y(q_2) - 2Y(p_2)] - C_1(\delta_1/z[Y(q_1) - Y(p_1)])$$

$$- C_2(\delta_1/z[Y(q_1) + Y(q_2) - 2Y(p_2)])\Big\} \int_{t_2}^{\infty} e^{-rt}\, dt,$$

where δ_0 = the customer density in the market between t_1 and t_2 and δ_1 = the customer density in the market at t_2 and after. The first order conditions for joint profit maximization by F_1 are as follows:

$$(3.13) \quad \frac{\partial \tilde{V}^1}{\partial X} = \left\{ \frac{\hat{p}_1 y(\hat{q}_1)}{2} + \hat{p}_2[\frac{y(\hat{q}_1)}{2} - y(\hat{q}_2)] - \frac{\partial C_1}{\partial X}\Big|_{\delta_0} \frac{y(\hat{q}_1)}{2} \right.$$

$$\left. - \frac{\partial C_2}{\partial X}\Big|_{\delta_0} [\frac{y(\hat{q}_1)}{2} - y(\hat{q}_2)] \right\} \delta_0/z \int_{t_1}^{t_2} e^{-rt} dt + \left\{ \frac{\hat{p}_1 y(\hat{q}_1)}{2} \right.$$

$$\left. + \hat{p}_2[\frac{y(\hat{q}_1)}{2} - y(\hat{q}_2)] - \frac{\partial C_1}{\partial X}\Big|_{\delta_1} \frac{y(\hat{q}_1)}{2} - \frac{\partial C_2}{\partial X}\Big|_{\delta_1} [\frac{y(\hat{q}_1)}{2} - y(\hat{q}_2)] \right\}$$

$$\delta_1/z \int_{t_2}^{\infty} e^{-rt} dt = 0$$

$$(3.14)\quad \frac{\partial\tilde{V}^1}{\partial p_1} = \left\{\tilde{Q}_1\Big|_{\delta_0} + \frac{\hat{p}_1\delta_0}{z}\left[\frac{y(\hat{q}_1)}{2} - y(\hat{p}_1)\right] + \frac{\delta_0\hat{p}_2 y(\hat{q}_1)}{2z}\right.$$

$$\left. - \frac{\partial C_1}{\partial p_1}\Big|_{\delta_0} \delta_0/z\left[\frac{y(\hat{q}_1)}{2} - y(\hat{p}_1)\right] - \frac{\partial C_2}{\partial p_1}\Big|_{\delta_0} \frac{\delta_0 y(\hat{q}_1)}{2z}\right\} \int_{t_1}^{t_2} e^{-rt}dt$$

$$+ \left\{\tilde{Q}_1\Big|_{\delta_1} + \frac{\hat{p}_1\delta_1}{z}\left[\frac{y(\hat{q}_1)}{2} - y(\hat{p}_1)\right] + \frac{\delta_1\hat{p}_2 y(\hat{q}_1)}{2z}\right.$$

$$\left. - \frac{\partial C_1}{\partial p_1}\Big|_{\delta_1} \delta_1/z\left[\frac{y(\hat{q}_1)}{2} - y(\hat{p}_1)\right] - \frac{\partial C_2}{\partial p_1}\Big|_{\delta_1} \frac{\delta_1 y(\hat{q}_1)}{2z}\right\} \int_{t_2}^{\infty} e^{-rt}dt = 0$$

$$(3.15)\quad \frac{\partial\tilde{V}^1}{\partial p_2} = \left\{\tilde{Q}_2\Big|_{\delta_0} + \frac{\hat{p}_2\delta_0}{z}\left[\frac{y(\hat{q}_1)}{2} + y(\hat{q}_2) - 2y(\hat{p}_2)\right] + \frac{\delta_0\hat{p}_1 y(\hat{q}_1)}{2z}\right.$$

$$\left. - \frac{\partial C_1}{\partial p_2}\Big|_{\delta_0} \frac{\delta_0 y(\hat{q}_1)}{2z} - \frac{\partial C_2}{\partial p_2}\Big|_{\delta_0} \delta_0/z\left[\frac{y(\hat{q}_1)}{2} + y(\hat{q}_2) - 2y(\hat{p}_2)\right]\right\} \int_{t_1}^{t_2} e^{-rt}dt$$

$$+ \left\{\tilde{Q}_2\Big|_{\delta_1} + \frac{\hat{p}_2\delta_1}{z}\left[\frac{y(\hat{q}_1)}{2} + y(\hat{q}_2) - 2y(\hat{p}_2)\right] + \frac{\delta_1\hat{p}_1 y(\hat{q}_1)}{2z}\right.$$

$$\left. - \frac{\partial C_1}{\partial p_2}\Big|_{\delta_1} \frac{\delta_1 y(\hat{q}_1)}{2z} - \frac{\partial C_2}{\partial p_2}\Big|_{\delta_1} \delta_1/z\left[\frac{y(\hat{q}_1)}{2} + y(\hat{q}_2) - 2y(\hat{p}_2)\right]\right\} \int_{t_2}^{\infty} e^{-rt}dt$$

$$= 0.$$

We use hats over variables to represent optimal values. In addition, we use the notation $Q|_{\delta}$, $\left.\frac{\partial C}{\partial p}\right|_{\delta}$ and $\left.\frac{\partial C}{\partial X}\right|_{\delta}$ to represent the fact that output and the partial derivatives of the cost function with respect to price and location are dependent on the particular density in the market. It can be shown that F_1 would select a location of 2/3 for its second plant, and both plants would charge the same price. This solution would maximize the joint present value of profits of F_1.[10]

We now suppose that F_2, instead of F_1, is able to enter the market characterized by Figure 3 at time t_1. We may capture the oligopolistic interdependence by making the price F_1 would charge a function of F_2's price and location,

$$(3.16) \qquad p_1 = g(p_2, X),$$

and the price F_2 would charge a function of F_1's price,

$$(3.17) \qquad p_2 = h(p_1).$$

(Note that F_1's plant location does not appear in (3.17) since it is fixed by assumption.) We shall call the function $g(\cdot)$ F_1's price response function and the function $h(\cdot)$ F_2's price response function. Conditions on F_1's and F_2's price response functions will be derived such that if these conditions hold, F_1 would have no incentive to preempt the market. We then ask if these conditions are reasonable.

F_2 would choose a location and price to maximize the present value of its profits:

$$(3.18)\quad V^2 = \int_{t_1}^{t_2} [p_2Q_2 - C_2(Q_2)]\, e^{-rt}dt + \int_{t_2}^{\infty} [p_2Q_2 - C_2(Q_2)]\, e^{-rt}dt$$

$$= \left\{ \frac{p_2\delta_0}{z} [Y(q_1) + Y(q_2) - 2Y(p_2)] - C_2(\delta_0/z[Y(q_1) + Y(q_2) - 2Y(p_2)]) \right\} \int_{t_1}^{t_2} e^{-rt}dt + \left\{ \frac{p_2\delta_1}{z}[Y(q_1) + Y(q_2) - 2Y(p_2)] - C_2(\delta_1/z[Y(q_1) + Y(q_2) - 2Y(p_2)]) \right\} \int_{t_2}^{\infty} e^{-rt}dt.$$

Maximizing (3.18) with respect to X, we obtain

$$(3.19)\quad \frac{\partial V^2}{\partial X} = \left\{ \hat{p}_2[\frac{y(\hat{q}_1)}{2} - y(\hat{q}_2)] + \frac{\hat{p}_2 y(\hat{q}_1) g_2(\hat{p}_2,\hat{X})}{2z} - \frac{\partial C_2}{\partial X}\bigg|_{\delta_0} [\frac{y(\hat{q}_1)}{2} - y(\hat{q}_2)] - \frac{\partial C_2}{\partial X}\bigg|_{\delta_0} \frac{y(\hat{q}_1) g_2(\hat{p}_2,\hat{X})}{2z} \right\} \delta_0/z \int_{t_1}^{t_2} e^{-rt}dt + \left\{ \hat{p}_2[\frac{y(\hat{q}_1)}{2} - y(\hat{q}_2)] + \frac{\hat{p}_2 y(\hat{q}_1) g_2(\hat{p}_2,\hat{X})}{2z} - \frac{\partial C_2}{\partial X}\bigg|_{\delta_1} [\frac{y(\hat{q}_1)}{2} - y(\hat{q}_2)] - \frac{\partial C_2}{\partial X}\bigg|_{\delta_1} \frac{y(\hat{q}_1) g_2(\hat{p}_2,\hat{X})}{2z} \right\} \delta_1/z \int_{t_2}^{\infty} e^{-rt}dt = 0.$$

We now ask what must be true of F_1's price response function in order that the optimal location which satisfies the joint present value maximization condition (3.13) also satisfies (3.19). In other words, the value of X which satisfies (3.19) must also satisfy (3.13), evaluated at optimal prices, in order to rule out the preemptive entry strategy. Solving (3.13) and (3.19) jointly for g_2, we obtain

(3.20) $g_2(\hat{p}_2,\hat{X}) =$

$$\frac{z\left\{\frac{\hat{p}_1 y(\hat{q}_1)}{2} - \frac{\partial C_1}{\partial X}\Big|_{\delta_0}\frac{y(\hat{q}_1)}{2}\right\}\delta_0/z\int_{t_1}^{t_2} e^{-rt}dt + \left\{\frac{\hat{p}_1 y(\hat{q}_1)}{2} - \frac{\partial C_1}{\partial X}\Big|_{\delta_1}\frac{y(\hat{q}_1)}{2}\right\}\delta_1/z\int_{t_2}^{\infty} e^{-rt}dt}{\left\{\frac{\hat{p}_2 y(\hat{q}_1)}{2} - \frac{\partial C_2}{\partial X}\Big|_{\delta_0}\frac{y(\hat{q}_1)}{2}\right\}\delta_0/z\int_{t_1}^{t_2} e^{-rt}dt + \left\{\frac{\hat{p}_2 y(\hat{q}_1)}{2} - \frac{\partial C_2}{\partial X}\Big|_{\delta_1}\frac{y(\hat{q}_1)}{2}\right\}\delta_1/z\int_{t_2}^{\infty} e^{-rt}dt}.$$

A second first order condition of F_2's present value maximization is derived by maximizing F_2's present value with respect to price:

$$(3.21)\quad \frac{\partial V^2}{\partial p_2} = \left\{Q_2 + \frac{\hat{p}_2\delta_0}{z}\left[\frac{y(\hat{q}_1)}{2} + y(\hat{q}_2) - 2y(\hat{p}_2)\right] + \frac{\delta_0\hat{p}_2 y(\hat{q}_1)g_1(\hat{p}_2,\hat{X})}{2z}\right.$$

$$- \frac{\partial C_2}{\partial p_2}\Big|_{\delta_0}\delta_0/z\left[\frac{y(\hat{q}_1)}{2} + y(\hat{q}_2) - 2y(\hat{p}_2)\right]$$

$$\left.- \frac{\partial C_2}{\partial p_2}\Big|_{\delta_0}\frac{\delta_0 y(\hat{q}_1)g_1(\hat{p}_2,\hat{X})}{2z}\right\}\int_{t_1}^{t_2} e^{-rt}dt + \left\{Q_2 + \frac{\hat{p}_2\delta_1}{z}\left[\frac{y(\hat{q}_1)}{2}\right.\right.$$

$$\left. + y(\hat{q}_2) - 2y(\hat{p}_2)\right] + \frac{\delta_1\hat{p}_2 y(\hat{q}_1)g_1(\hat{p}_2,\hat{X})}{2z} - \frac{\partial C_2}{\partial p_2}\Big|_{\delta_1}\delta_1/z\left[\frac{y(\hat{q}_1)}{2}\right.$$

$$\left.\left. + y(\hat{q}_2) - 2y(\hat{p}_2)\right] - \frac{\partial C_2}{\partial p_2}\Big|_{\delta_1}\frac{\delta_1 y(\hat{q}_1)g_1(\hat{p}_2,\hat{X})}{2z}\right\}\int_{t_2}^{\infty} e^{-rt}dt = 0.$$

We now derive a second condition on F_1's price response function such that the optimal price which satisfies the joint present value maximization condition (3.15) also satisfies (3.21). Solving (3.15) and (3.21) jointly for g_1, we obtain

(3.22) $g_1(\hat{p}_2,\hat{X}) =$

$$\frac{\left\{\frac{\delta_0\hat{p}_1 y(\hat{q}_1)}{2z} - \frac{\partial C_1}{\partial p_2}\bigg|_{\delta_0}\frac{\delta_0 y(\hat{q}_1)}{2z}\right\}\int_{t_1}^{t_2} e^{-rt}dt + \left\{\frac{\delta_1\hat{p}_1 y(\hat{q}_1)}{2z} - \frac{\partial C_1}{\partial p_2}\bigg|_{\delta_1}\frac{\delta_1 y(\hat{q}_1)}{2z}\right\}\int_{t_2}^{\infty} e^{-rt}dt}{\left\{\frac{\delta_0\hat{p}_2 y(\hat{q}_1)}{2z} - \frac{\partial C_2}{\partial p_2}\bigg|_{\delta_0}\frac{\delta_0 y(\hat{q}_1)}{2z}\right\}\int_{t_1}^{t_2} e^{-rt}dt + \left\{\frac{\delta_1\hat{p}_2 y(\hat{q}_1)}{2z} - \frac{\partial C_2}{\partial p_2}\bigg|_{\delta_1}\frac{\delta_1 y(\hat{q}_1)}{2z}\right\}\int_{t_2}^{\infty} e^{-rt}dt}.$$

F_1 would choose its price in order to maximize the present value of its profits, given that F_2 has entered the market at time t_1 and given equation (3.17).

(3.23) $$V^1 = \int_{t_1}^{t_2}[p_1Q_1 - C_1(Q_1)]e^{-rt}dt + \int_{t_2}^{\infty}[p_1Q_1 - C_1(Q_1)]e^{-rt}dt$$

$$= \left\{\frac{p_1\delta_0}{z}[Y(q_1) - Y(p_1)] - C_1(\delta_0/z[Y(q_1) - Y(p_1)])\right\}\int_{t_1}^{t_2} e^{-rt}dt$$

$$+ \left\{\frac{p_1\delta_1}{z}[Y(q_1) - Y(p_1)] - C_1(\delta_1/z[Y(q_1) - Y(p_1)])\right\}\int_{t_2}^{\infty} e^{-rt}dt.$$

$$(3.24)\quad \frac{\partial V^1}{\partial p_1} = \left\{ Q_1\Big|_{\delta_0} + \frac{\hat{p}_1\delta_0}{z}\left[\frac{y(\hat{q}_1)}{2} - y(\hat{p}_1)\right] + \frac{\delta_0\hat{p}_1 y(\hat{q}_1)h'(\hat{p}_1)}{2z}\right.$$

$$\left. - \frac{\partial C_1}{\partial p_1}\Big|_{\delta_0} \delta_0/z\left[\frac{y(\hat{q}_1)}{2} - y(\hat{p}_1)\right] - \frac{\partial C_1}{\partial p_1}\Big|_{\delta_0} \frac{\delta_0 y(\hat{q}_1)h'(\hat{p}_1)}{2z}\right\}\int_{t_1}^{t_2} e^{-rt}dt$$

$$+ \left\{ Q_1\Big|_{\delta_1} + \frac{\hat{p}_1\delta_1}{z}\left[\frac{y(\hat{q}_1)}{2} - y(\hat{p}_1)\right] + \frac{\delta_1\hat{p}_1 y(\hat{q}_1)h'(\hat{p}_1)}{2z}\right.$$

$$\left. - \frac{\partial C_1}{\partial p_1}\Big|_{\delta_1} \delta_1/z\left[\frac{y(\hat{q}_1)}{2} - y(\hat{p}_1)\right] - \frac{\partial C_1}{\partial p_1}\Big|_{\delta_1} \frac{\delta_1 y(\hat{q}_1)h'(\hat{p}_1)}{2z}\right\}\int_{t_2}^{\infty} e^{-rt}dt$$

$$= 0.$$

We now derive a condition on F_2's price response function such that the optimal price which satisfies the joint present value maximization condition (3.14) also satisfies (3.24). Solving (3.14) and (3.24) jointly for h' yields

$$(3.25)\quad h'(\hat{p}_1) =$$

$$\frac{\left\{\frac{\delta_0\hat{p}_2 y(\hat{q}_1)}{2z} - \frac{\partial C_2}{\partial p_1}\Big|_{\delta_0}\frac{\delta_0 y(\hat{q}_1)}{2z}\right\}\int_{t_1}^{t_2} e^{-rt}dt + \left\{\frac{\delta_1\hat{p}_2 y(\hat{q}_1)}{2z} - \frac{\partial C_2}{\partial p_1}\Big|_{\delta_1}\frac{\delta_1 y(\hat{q}_1)}{2z}\right\}\int_{t_2}^{\infty} e^{-rt}dt}{\left\{\frac{\delta_0\hat{p}_1 y(\hat{q}_1)}{2z} - \frac{\partial C_1}{\partial p_1}\Big|_{\delta_0}\frac{\delta_0 y(\hat{q}_1)}{2z}\right\}\int_{t_1}^{t_2} e^{-rt}dt + \left\{\frac{\delta_1\hat{p}_1 y(\hat{q}_1)}{2z} - \frac{\partial C_1}{\partial p_1}\Big|_{\delta_1}\frac{\delta_1 y(\hat{q}_1)}{2z}\right\}\int_{t_2}^{\infty} e^{-rt}dt}.$$

It was noted above that the joint present value maximizing solution for F_1 involves choosing a location at 2/3 and the charging of common prices at both plants. If (3.20), (3.22), and (3.25) are evaluated at the joint present value maximizing prices and location, we obtain

$$g_2 = z \tag{3.26}$$

$$g_1 = 1 \tag{3.27}$$

$$h' = 1. \tag{3.28}$$

Equation (3.27) states that F_1 will match all price decreases or price increases by F_2. Equation (3.28) states that F_2 will match all price increases or price decreases by F_1. Equation (3.26) states that if F_2 locates marginally closer to F_1 (to the left of 2/3), F_1 will lower its price enough such that F_2's market area remains unchanged (i.e. a small change in F_2's location has the same qualitative effect as a price change). We shall now argue that there are reasons to believe that conditions (3.26), (3.27), and (3.28) will not be simultaneously satisfied.

Let us focus on the plausibility of condition (3.26). According to Hotelling's principle of minimum differentiation, under certain assumptions, F_2 will have an incentive to locate its store to the left of the joint profit maximizing location because, by doing so, it can expand its market area. If, however, the optimal values which satisfy the joint present value maximization conditions are also to satisfy the independent present value maximization conditions, condition (3.26) must hold, thus leaving F_2 with no incentive to move. That is, a marginal change in F_2's location from the joint present value maximizing one would induce F_1 to lower its price such that F_2's market boundary with F_1 does not change. To see this more clearly, consider the derivation of the delivered price, q_1. We know that at the market boundary, b, the following equality holds:

(3.29) $$p_2 + z(X - b) = p_1 + zb.$$

Solving for b we obtain

(3.30) $$b = \frac{1}{2z}(p_2 - p_1 + zX).$$

Evaluating how b will change given a small change in X yields

(3.31) $$\frac{db}{dX} = \frac{1}{2z}\left(-\frac{\partial p_1}{\partial X} + z\right).$$

If this expression is evaluated at joint present value maximizing prices, $\frac{\partial p_1}{\partial X} = g_2 = z$, and $\frac{db}{dX} = 0$. Thus, a small change in X will not result in a change in the market boundary.

Condition (3.26) may be interpreted as a threat which is communicated to F_2, but we shall argue that F_2 would not regard this threat as credible. Recall that assumption (v) above stated that the firm's plants, once established, are fixed in location due to location specific sunk costs. The firm's capital is indivisible and immobile once set in place. Thus, once F_2 picks a location, and constructs its plant, its capital costs are sunk. If F_2 had chosen to locate to the left of the joint present value maximizing location, then F_1 could retaliate against F_2 by lowering its price. However, such retaliatory action on the part of F_1 would have an adverse effect on F_1's profits. F_1 must eventually recognize that price-cutting behavior on its part would not alter the location already chosen by F_2, since F_2 would be irrevocably committed.[11] Thus, while F_1 may initially engage in price-cutting behavior, it must soon learn that it cannot increase its profits by doing so, since F_2 will not change its location, thereby increasing the market area of F_1. Once a new entrant's plant is in place, it would be mutually advantageous for both F_1 and F_2 to increase their prices if these prices were driven below the present value maximizing levels by the new entrant's entry.[12] Hence, condition (3.26) would be violated, since F_1 would not in general behave according to this condition on its price response function.

Since the conditions which are necessary for the joint present value maximizing solution to be equivalent to the independent present value maximizing solution would not be expected to hold simultaneously, and since joint present value maximization over all plants in the market will yield the maximum profits, we may conclude that the joint present value maximizing solution yields profits which are strictly greater than a summation of the profits obtained from F_2 and F_1 independently maximizing their present value of profits.

There are two further comments which are relevant to the above argument. First, we have argued that condition (3.26) is unreasonable, and the logic supporting this conclusion is very similar to that employed by the critics of Sylos' postulate. Sylos' postulate states that "Established sellers think potential entrants will expect them to maintain their output in the face of new entry, letting the price fall and the market be ruined for all."[13] Critics have argued that if new entry does in fact take place, the established sellers cannot reasonably be expected to adhere to Sylos' postulate.[14] Second, the argument advanced in this section resembles the one put forth by Thomas Schelling [1956] in his classic essay on bargaining. In his discussion of the concept that irrevocable commitments reduce the credibility of threats, Schelling has stated, "Similar techniques may be available to the one threatened. His best defense, of course, is to carry out the act before the threat is made; in that case there is neither incentive nor commitment for retaliation. If he cannot hasten the act itself, he may commit himself to it; if the person to be threatened is already committed, the one who would threaten cannot deter with his threat, he can only make certain the mutually disastrous consequences that he threatens."[15]

I shall now conclude this section by reviewing the procedure which has been pursued. The purpose of this section has been to show that the present value of profits to F_1 obtained by preempting the market at time t_1 is strictly greater than the present value of profits which it could obtain if it did not preempt the market at time t_1. It was argued that if this was the case, then F_1 would have an incentive to preempt the market at time $t_1 - \varepsilon$. The validity of this proposition was demonstrated as follows: First, the joint present value maximization conditions were derived for F_1, given that it was able to open a new store in the market prior to F_2. Then, the independent present value maximization conditions for F_2 and F_1 were derived, given that F_2 was able to enter the market prior to F_1. Necessary conditions on the price response functions of F_1 and F_2 were then derived such that the optimal values of prices and location which satisfied the joint present value maximization conditions would also satisfy the independent present value maximization conditions. It was then argued that one would not, in general, expect all of these conditions on F_1's and F_2's price response functions to be simultaneously satisfied, and thus that the joint present value maximizing solution yields profits which are strictly greater than a summation of the profits obtained from F_2 and F_1 independently maximizing their present value of profits. By implication, then, (3.5) would in general hold as a strict inequality, and F_1 would have an incentive to preempt the market. Intuitively, this is the solution one would expect. That is, if entry by F_2 would lead to some price competition, and if F_2 would adopt a location different from that of F_1, then F_1 would find it profitable to preempt the market at time $t_1 - \varepsilon$.

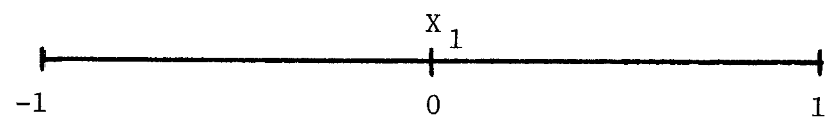
3.4 An Alternative Model of Preemption[16]

In the Eaton and Lipsey model of preemption and in the model developed in the previous section, it was assumed that there exists a large number of firms which would compete for the opportunity to enter the market if entry were profitable. In this section, we relax this restrictive assumption by analyzing the preemption decision in the context of a two-person, non-constant sum, non-cooperative game. Our reason for focusing upon the "infinite competitive fringe" assumption is as follows: Casual empiricism informs us that many retail markets are oligopolistic in nature. In particular, the retail grocery trade, which is the industry to be examined for supportive evidence of the preemption hypothesis, does tend to be highly oligopolistic in many urban markets. It is thus of practical importance to investigate whether or not the monopolistic preemption result survives the relaxation of the infinite competitive fringe assumption.

In the following analysis, we shall continue to maintain assumptions (i) through (vi) of section 3.3. It is assumed that the market is one-dimensional, two units in length, with a uniform density of customers, δ_0.

This market is described by Figure 2, which we reproduce below as Figure 4.

Figure 4



We depart from our earlier model specification by assuming that there are only two firms, F_1 and F_2, competing for the opportunity to serve the market. We also assume that each firm makes its decisions on the basis of a maximin strategy.

Initially, at time t_0, F_1 is assumed to have a plant located at the center of the market (at 0), and the density of customers, δ_0, is large enough so that F_1 earns pure profits on its one plant, but small enough so that another plant could not be profitably operated in the market. We are interested in exploring the potential entry strategies of the established firm, F_1, and a competitor, F_2, given that the density in the market is correctly anticipated to increase from δ_0 to δ_1 at some time in the future t_2. The increase in density is large enough so that F_2 could earn pure profits on a plant established in each of the intervals (-1:0) and (0:1) at time t_2, provided that F_1 has not already opened new plants in these intervals. In addition, the increase in density is not large enough to support two new plants in each interval at time t_2. Since the market is symmetric about the origin, the following analysis will be confined to examining the possibilities for entry on the right hand side of the market.

Let us define $V^2(t)$ to be the present value to F_2 of establishing a plant in the market at time t when F_1 does not establish a new plant. Since the potential entrant, F_2, cannot profitably enter the market when density is δ_0 between t_0 and t_2, and since F_2 can earn pure profits on a plant established in the market when density is δ_1, there must be some time t_1, $t_0 < t_1 < t_2$, such that F_2 could obtain a present value equal to zero if it entered the market at time t_1. That is,

(3.32)
$$\begin{aligned} &V^2(t_1) = 0 \\ &V^2(t) < 0 \quad \text{for} \quad t < t_1 \\ &V^2(t) > 0 \quad \text{for} \quad t > t_1. \end{aligned}$$

Given that t_1 is the earliest date at which F_2 would consider entering the market, we shall confine our attention to analyzing a game in which the only possible times of entry are $\hat{t}$ and $\tilde{t}$ such that

(3.33)
$$\begin{aligned} &t_0 < \hat{t} < t_1 \quad \hat{t} = t_1 - \varepsilon \\ &t_1 < \tilde{t} < t_2 \quad \tilde{t} = t_1 + \varepsilon. \end{aligned}$$

Consider the following payoff matrix:

(3.34)

F_2 \ F_1	(B,B)	(B,N)	(N,B)	(N,N)
(B,B)	*	*	*	*
(B,N)	*	*	*	*
(N,B)	*	v_0^2 \ v_0^1	v_2^2 \ v_2^1	v_3^2 \ v_3^1
(N,N)	*	0 \ v_1^1	0 \ v_4^1	0 \ v_5^1

Each cell of the payoff matrix contains entries representing the present values of F_1 and F_2, contingent upon the selection of particular strategies at both $\hat{t}$ and $\tilde{t}$. The columns represent possible strategies for F_1, while the rows represent possible strategies for F_2. Strategies are described by ordered pairs in which the first element is an action taken at time $\hat{t}$ and the second element an action taken at time $\tilde{t}$. We let B represent the action of building a plant and N represent the action of not building a plant. Thus the strategy (B,N) consists of building a plant at $\hat{t}$ and not building a plant at $\tilde{t}$.

We wish to reduce the dimensionality of the game and we do so by ruling out any strategy which promises at best a negative present value to the firm adopting that strategy. First, recall that t_1 represents the date at which F_2 could construct a new plant in the market with a present value equal to zero. Since $\hat{t} < t_1$, F_2 would never consider choosing a strategy which required it to build a plant at $\hat{t}$, and thus we have placed asterisks in the cells containing the payoffs to F_2 and F_1 which result from F_2 selecting its first or second strategy. Second, recall our assumption that the market will grow in density at time t_2 such that at most one new plant could earn pure profits if established in the interval (0:1) at time t_2. This implies that F_1 would never select its first strategy since this strategy would entail building two new plants, one at time $\hat{t}$ and one at $\tilde{t}$. Hence, we have placed asterisks in the cells containing payoffs to F_1 and F_2 which result from F_1 selecting its first strategy.

The sequential nature of the game also permits us to rule out the outcome in the third row and second column of the payoff matrix. Suppose that F_1 has taken the action B at time $\hat{t}$ and F_2 has taken action N at time $\hat{t}$. Then F_2 would not adopt the strategy of building a plant at time $\tilde{t}$ since the market can only profitably support the addition of one new plant, and since F_1 has already built a new plant, v_0^2 must be negative. We thus place an asterisk in the appropriate cell of the reduced payoff matrix

(3.35)

F_2 \ F_1	(B,N)	(N,B)	(N,N)
(N,B)	*	v_2^2 \ v_2^1	v_3^2 \ v_3^1
(N,N)	0 \ v_1^1	0 \ v_4^1	0 \ v_5^1

Let us first consider the possible payoffs for F_2. In row two, all of the payoffs to F_2 are zero since row two represents the actions of not building at $\hat{t}$ and not building at $\tilde{t}$. If F_2 selected its first strategy and built a new plant at $\tilde{t}$, and if F_1 selected its second strategy and also built a plant at $\tilde{t}$, then F_2 must receive a negative present value because the density at t_2 is not large enough to support two new plants. If F_1 chooses the action N at times $\hat{t}$ and $\tilde{t}$ (its third strategy), and if F_2 chooses N at $\hat{t}$ and B at $\tilde{t}$, then F_2 would obtain a present value equal to v_3^2. Since the worst that F_2 can do by choosing its first strategy is to receive a negative present value, while the worst it can do by choosing its second strategy is to receive nothing, F_2's maximin strategy must be its second.

We now consider possible payoffs for F_1. If F_1 adopts strategy (B,N), the worst and only possible outcome is v_1^1. If F_1 chooses strategy (N,B), the worst possible outcome is v_2^1 since the density at t_2 is not large enough to support two new plants. If F_1 chooses strategy (N,N), the worst possible outcome is v_3^1 since F_1's profits would fall abruptly at the point in time when F_2 opens a new plant.

Recalling that we have assumed maximin behavior on the part of both F_1 and F_2, we wish to compare v_1^1, v_2^1, and v_3^1 in order to find the best of the worst possible outcomes for F_1. First, we note that $v_3^1 > v_2^1$ since the density at t_2 is large enough to support one, but not two, new plants. Next, we will show that there exists some $\bar{\varepsilon} > 0$ such that $v_1^1 > v_3^1$ and $v_1^1 > 0$ for $\varepsilon < \bar{\varepsilon}$. We do so as follows: First recall from (3.33) that $\hat{t} = t_1 - \varepsilon$ and $\tilde{t} = t_1 + \varepsilon$. Then $v_3^2 = V^2(t_1 + \varepsilon)$, where V^2 is defined in (3.32). Define $V^1(t)$ to be the present value of F_1 when it establishes a new plant at time t and F_2 does not establish a new plant. Then $v_1^1 = V^1(t_1 - \varepsilon)$. Define V(t) to be the present value of both firms when F_2 establishes a new plant at t and F_1 does nothing. Then $v_3^1 = V(t_1 + \varepsilon) - V^2(t_1 + \varepsilon)$. Consider

(3.36)

$$\lim_{\varepsilon \to 0} (v_1^1 - v_3^1) = \lim_{\varepsilon \to 0} (V^1(t_1 - \varepsilon) - V(t_1 + \varepsilon) + V^2(t_1 + \varepsilon))$$

$$= V^1(t_1) - V(t_1) > 0.$$

The inequality (3.36) is strict for the reasons advanced in the previous section. That is, F_1 will choose the joint present value maximizing location and prices while F_2 in general would select a location to the left of the joint present value maximizing location and would be expected to engage in some price competition if it entered the market. Given (3.36) and our definitions of V^1, V^2, and V, there must exist some $\bar{\varepsilon} > \varepsilon$ such that

$$V^1(t_1 - \bar{\varepsilon}) - V(t_1 + \bar{\varepsilon}) + V^2(t_1 + \bar{\varepsilon}) = 0. \tag{3.37}$$

We have thus shown that there exists some arbitrarily small ε such that $v_1^1 > v_3^1$ and $v_1^1 > 0$. This implies that F_1's maximin strategy is (B,N). Since we have already shown that F_2's maximin strategy is (N,N), the outcome of the game is for F_1 to preempt the market at time $t_1 - \varepsilon$. The monopolistic preemption result that the existing firm has an incentive to preempt the market just prior to the earliest date at which a new entrant would find it profitable to enter survives the relaxation of the infinite competitive fringe assumption.

In the model discussed above, attention was confined to the situation where an existing firm and a potential entrant consider building a new plant in a market segment bounded by a plant owned by the established firm and the market boundary. Our results would have been unaltered if we had considered the possibilities of entry in a market which was bounded by two plants owned by an established firm. It also would have been possible to analyze the situation where F_1 and F_2 consider building a new plant in a market bounded by one plant owned by F_1 and one plant owned by F_2. The implication which such an initial configuration of plants would have for the preemption analysis will be discussed in the next section in the context of a two-dimensional model.

3.5 Extension of the Model to Two Dimensions

In this section, the two-dimensional analogue of the one-dimensional model is discussed. The possibilities of market preemption are explored, given different assumptions about the locational configuration of existing firms. This analysis will assist us in drawing out empirically testable hypotheses.

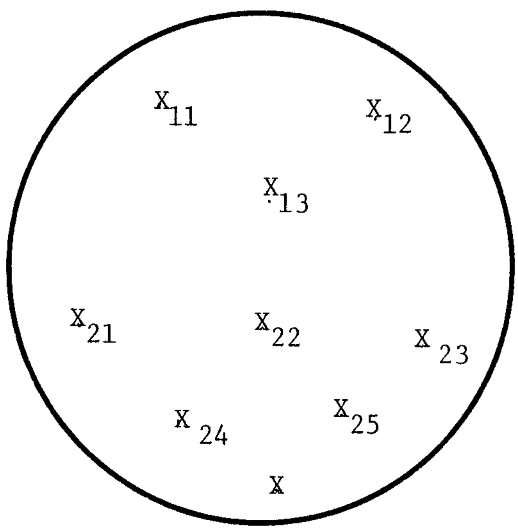
In order to simplify the exposition, it is assumed that the market is a circle with diameter equal to one. (It will soon be evident that this assumption in no way affects the results.) Assumptions (i) through (vi) of section 3.3 are retained, while noting that distance must be suitably redefined to reflect the fact that the model of this section is two-dimensional instead of one-dimensional. In addition, it is assumed that at time t_o, there are two multi-plant firms established in the market and an infinite competitive fringe which would compete with each other for the opportunity to enter the market if they expected a present value greater than or equal to zero by doing so. (We shall refer to the competitive fringe collectively as F_j.) As in the previous models, customer density is expected to increase at some time in the future t_2 such that a new plant could profitably be established in the market at that time in the 'neighborhood' of X (see Figure 5).

There are two general types of locational configurations which will be considered in the ensuing analysis. Case I represents the type in which a competitive fringe firm would have as its neighbors the plants of only one other firm. Case II represents the type in which a competitive fringe firm would have as its neighbors the plants of at least two other firms. We shall consider the Case I type of locational configuration first.

Case I

Consider Figure 5.

Figure 5



The initial locations of firms F_1 and F_2 in the market of Figure 5 are denoted by $X_{1\ell}$ and $X_{2\ell}$ respectively, where $X_{i\ell}$ represents the location of plant ℓ when it is owned by F_i. These locations constitute the initial conditions.

We now inquire as to when a competitive fringe firm would like to establish a new plant in the market of Figure 5. As in the one-dimensional model, competition among competitive fringe firms would push back the time of entry to t_1, such that the present value of profits to the successful new entrant would be equal to zero. The competitive fringe firm F_j would thus enter the market at time t_1 and choose its price and location in order to maximize the present value of its profits:

$$\text{(3.38)} \quad \max_{(p_{j1},X_{j1})} \int_{t_1}^{\infty} \Pi^j(p_{j1},X_{j1};p_{21},\ldots,p_{2n_2},X_{21},\ldots,X_{2n_2},p_{11},\ldots,p_{1n_1},$$

$$X_{11},\ldots,X_{1n_1})\, e^{-rt}dt = V^j,$$

where

X_{j1} = F_j's location, defined by a pair of polar coordinates, R and θ (where R is the length of a radius and θ is the measure of an angle)

$X_{2\ell}$ = the ℓth location of a plant owned by F_2, defined by a pair of polar coordinates (ℓ = 1, 2, ..., n_2)

$X_{1\ell}$ = the ℓth location of a plant owned by F_1, defined by a pair of polar coordinates (ℓ = 1, 2, ..., n_1)

p_{j1} = F_j's mill price

$p_{2\ell}$ = $h(p_j,X_j,p_{11}, \ldots, p_{1n_1})$ = a function describing F_2's price response at its ℓth plant to the selection of a price and location by F_j and the selection of prices by F_1

$p_{1\ell}$ = $g(p_j,X_j,p_{21}, \ldots, p_{2n_2})$ = a function describing F_1's price response at its ℓth plant to the selection of a price and location by F_j and the selection of prices by F_2

$\Pi^j(\cdot)$ = F_j's profit function

r = the firm's discount rate

n_i = the number of plants owned by F_i.

If F_j had entered the market at time t_1, then F_2 would simply maximize the present value of its profits:

$$(3.39) \qquad \max_{(p_{21}, \ldots, p_{2n_2})} \sum_{\ell=1}^{n_2} \int_{t_1}^{\infty} \Pi_\ell^2(p_{21}, \ldots, p_{2n_2}; X_{21}, \ldots, X_{2n_2},$$

$$p_{j1}, X_{j1}, p_{11}, \ldots, p_{1n_1}, X_{11}, \ldots, X_{1n_1}) \; e^{-rt}dt = V^2,$$

where $p_{j1} = d(p_{21}, \ldots, p_{2n_2}, p_{11}, \ldots, p_{1n_1})$ = a function describing F_j's price response to the selection of prices by F_2 and F_1. F_2 maximizes the present value of the sum of profits of its n_2 plants initially located in the market.

Suppose that F_2 had established the new plant in the market at time t_1 rather than F_j. Then F_2 would wish to maximize the present value of its profits over its entire operation:

$$(3.40) \qquad \max_{(p_{21}, \ldots, p_{2(n_2+1)}, X_{2(n_2+1)})} \sum_{\ell=1}^{n_2+1} \int_{t_1}^{\infty} \tilde{\Pi}_\ell^2(p_{21}, \ldots, p_{2(n_2+1)},$$

$$X_{2(n_2+1)}; X_{21}, \ldots, X_{2n_2}, p_{11}, \ldots, p_{1n_1}, X_{11}, \ldots,$$

$$X_{1n_1}) \; e^{-rt}dt = \tilde{V}^2,$$

where $p_{1\ell} = \tilde{g}(p_{21}, \ldots, p_{2(n_2+1)}, X_{2(n_2+1)})$ = a function describing F_1's price response at its ℓth plant to the selection of a location and prices by F_2.

We now inquire as to whether or not F_2 has any incentive to preempt the market at time $t_1 - \varepsilon$. First, we know that it must be true that

(3.41) $$\tilde{V}^2 \geq V^2 + V^j.$$

That is, the present value of F_2's jointly maximized profits must be greater than or equal to the sum of F_2's and F_j's independently maximized present value of profits. Equation (3.41) is exactly analogous to equation (3.4) in the one-dimensional model. In the one-dimensional case, it was argued that F_2 would pick the location of its new plant and the prices of all of its plants in order to maximize the present value of its profits over its entire operation, while F_j would select its price and location in order to maximize the present value of its one plant. Since the equilibrium prices and location which satisfied F_2's joint present value maximization conditions would not be expected simultaneously to satisfy the independent present value maximization conditions of F_2 and F_j, the inequality (3.4) would be strict. A strict inequality implies that F_2 would have an incentive to preempt the market at time $t_1 - \varepsilon$.

Case II

The second locational configuration which is considered is described by Figure 6.

Figure 6

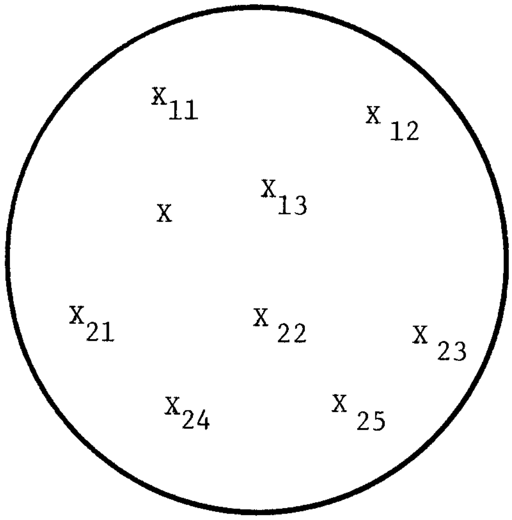


Figure 6 is the same as Figure 5, except that we now examine the case where a competitive fringe firm located in the neighborhood of X would have as its neighbors the plants of two firms.

Consider the competitive fringe entry strategies. As in Case I above, competition among competitive fringe firms would push the time of entry back to t_1 such that the successful competitive fringe entrant would earn a zero present value by maximizing (3.38) with respect to price and location.

We now ask whether F_2 would have an incentive to preempt the market at time $t_1 - \varepsilon$. First, if F_j had entered the market at time t_1, then F_2 would simply maximize the present value of its profits with respect to the n_2 prices of its n_2 plants. That is, F_2 would maximize (3.39). If F_2 had entered the market with a new plant at time t_1, then it would maximize the present value of its profits over its entire operation. In other words, it would select its location $X_{2(n_2+1)}$ and prices $p_{21}, \ldots, p_{2(n_2+1)}$ in order to maximize (3.40). In order for F_2 to have an incentive to preempt the market, inequality (3.41) must be strict. The inequality (3.41) would be strict as long as F_j would select a price and location which differed from the joint present value maximizing location and price which F_2 would select. It will be argued intuitively below that, in general, this condition will hold. The argument proceeds as follows: First, it is established that if F_2 selected the same location as that which maximized F_j's present value, F_2 would not be expected to charge the same price as F_j. Then, it is argued that F_2's present value maximizing location would differ from F_j's. For the reasons advanced in section 3.3, we would then expect the joint present value maximization to yield greater profits to F_2 than the profits which could be obtained if F_j and F_2 independently maximized their present value of profits. This then implies that (3.41) would hold as a strict inequality and F_2 would have an incentive to preempt the market.

In order to simplify the argument, it is assumed that the plant located at X would have one F_1 plant and one F_2 plant as its neighbors. If F_2 established a plant at the location that maximized F_j's present value, F_2 would not in general charge the same price as F_j. F_j would attempt to charge a price lower than that which F_2 would charge in the hope of attracting customers who previously patronized the plants owned by F_1 and F_2. F_2 would charge a higher price than F_j because if F_2, instead of F_j, located at X at time t_1, it would have one of its own plants as one of its neighbors, and customers attracted from its old plant to its new plant by lower prices could not be counted as net additions to F_2's clientele. With respect to location, the same sort of logic would lead us to expect F_2's joint present value maximizing location to be different from F_j's independent present value maximizing location. In particular, F_2 would be expected to locate closer to F_1 than would F_j. F_j would pick its location to maximize its present value of profits, taking into account that it would have as its neighbors plants owned by F_1 and F_2. F_2 would select its location to maximize the present value of its entire operation, taking into account that one of the neighbors of its new plant would be one of its old plants. Thus, F_2 would not select a location that would excessively encroach upon the market area of its old plant, while F_j would select its location to encroach upon the market areas of both F_2 and F_1.

From these arguments, we may conclude that inequality (3.41) would be strict and that F_2 would have an incentive to preempt the market at time $t_1 - \varepsilon$. In an exactly analogous manner, the above argument could have been cast in terms of F_1 and F_j. By implication, then, both F_1 and F_2 have an incentive to preempt the market at time $t_1 - \varepsilon$. However, the assumptions underlying the model do not permit the identification of which firm will actually preempt.

Let us now briefly summarize the discussion of this section. First, if there is an anticipated increase in density in the market such that a new plant could be profitably established in that market, and if the new plant would have as its neighbors the plants of one existing firm, then the existing firm will have an incentive to preempt the market. Second, if there is an anticipated increase in density in the market such that a new plant could be profitably established in that market, and if the new plant would have as its neighbors the plants of more than one existing firm, then any of the existing firms will have an incentive to preempt the market.

3.6 Anomalies

Perhaps the strongest implication of the theory developed in section 3.3 is that one firm will tend to dominate each spatially separated market, and that as the market grows, that firm will have an incentive to strengthen its grip over that market by preempting it. However, casual empiricism informs us that spatially separated markets are not always dominated by one firm. One is therefore led to ask how "anomalies" may come about. An anomaly is defined as existing when a multi-plant firm has established a new plant in the market such that the new plant has as its neighbors only plants owned by other firms.

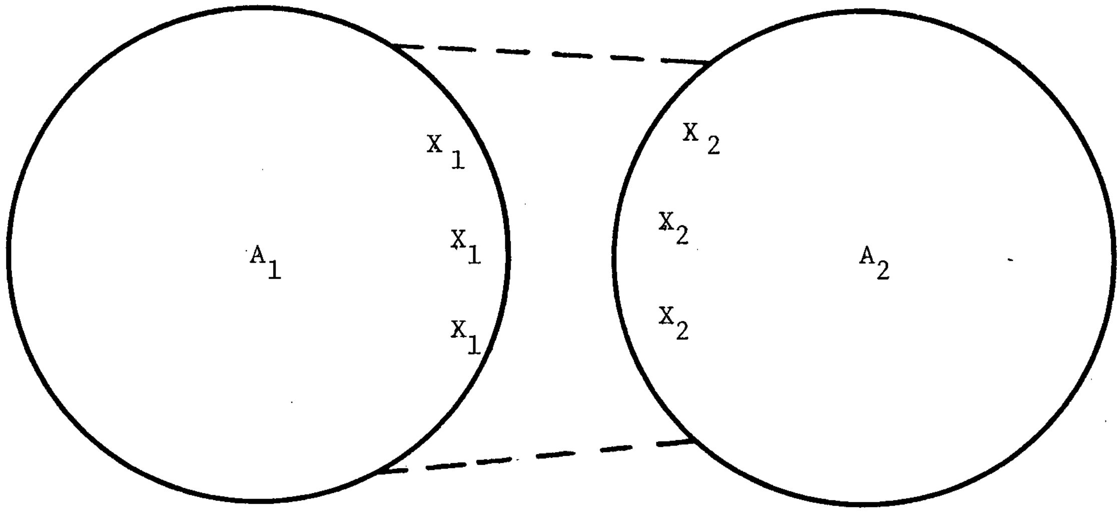
There are three important sources of anomalies which may be identified. The first source of anomalies is unexpected increases in consumer density in the market. It will be recalled that all of the models discussed above were constructed on the assumption that all firms (established firms as well as potential entrants) correctly anticipate that there will be a discrete increase in density at time t_2. Each firm then selects its present value maximizing strategy, given this anticipated growth in the market. If an increase in density occurred at a time $t < t_2$ which was not anticipated, then the logic of previous arguments is short-circuited in that the firm which enters the market will be the one which first perceives the profitability of entry and acts upon that perception. That is, in the case of unexpected increases in consumer density, it is impossible to say which firm will preempt the market.

The second source of anomalies is "capital constraints" which bind. Consider a market which at time t_0 is dominated by the plants of only one firm. It is assumed that there are an infinite number of potential entrants which would compete with each other for the opportunity to establish a plant in the market if they could obtain a present value greater than or equal to zero by doing so. Suppose density is anticipated to increase at a time t_2 such that two new plants could be profitably established in the market. The theory of market preemption suggests that the established firm will have an incentive to preempt the market at a time $t_1 - \varepsilon$ by constructing two new plants. However, the ability of the established firm to preempt the market implies that there is no capital constraint which might prevent it from opening two new plants at $t_1 - \varepsilon$. If such a capital constraint was binding on the established firm such that it could only open one new plant at time $t_1 - \varepsilon$, then one of the potential entrants would have an opportunity to open up the second plant at time t_1. Thus capital constraints which bind may prevent the effective implementation of a preemptive strategy.

The above argument has been cast in terms of capital constraints. However, the second type of anomaly could also arise from constraints on the growth of the managerial team ("managerial growth costs") or any other constraint which would effectively limit the rate of growth of the firm.

A third source of apparent anomalies is related to the consolidation of spatially separate markets. Consider Figure 7:

Figure 7



Suppose that at time t_0, there exist two spatially separated markets, A_1 and A_2, which are dominated by the plants of F_1 and F_2 respectively. Suppose that F_1 and F_2 correctly anticipate that market A_1 will grow in extent at time t_2 such that the two markets will no longer be spatially separated and such that a new plant could be profitably established in the market at time t_2. Our discussion of the two-dimensional model in section 3.5 leads us to conclude that both F_1 and F_2 will have an incentive to preempt the market, although it is impossible to say which firm will actually preempt. However, depending upon when our observations are made, it may be possible to observe what looks like an outside entrant preempting a market which was previously dominated by one firm. Hence, this third source of anomalies is really a source of pseudo-anomalies. That is, the locational configuration may appear anomalous if observed at one point in time, but would not be anomalous if the history of growth of the market and of the plants serving the market were known.

Finally, a fourth possible source of anomalies may be the fear on the part of one established firm of retaliatory responses on the part of another established firm. Consider Figure 6. In section 3.5, it was established that, in general, if there is an anticipated increase in density in the market such that a new plant could be profitably established in that market, and if the new plant would have as its neighbors the plants of more than one existing firm, then any of the existing firms will have an incentive to preempt the market. Thus, in the market described by Figure 6, we should observe F_1 and F_2 preempting the market. However, if F_1 and F_2 believe that preemption will generate a retaliatory price response from the preempted firm, they may be reluctant to take the initiative. Thus, some other firm, F_j, might be allowed to enter the market. This is only one of many alternative scenarios which could arise depending upon the assumptions made regarding the established firms' expectations. We shall find it useful, however, to maintain our simplifying assumption that firms are able to correctly foresee the outcome of the competitive process. Hence, we shall not consider the fourth possible source of anomalies in any greater detail in the later stages of this work.

FOOTNOTES TO CHAPTER 3

1. It is assumed in this section, and in the remainder of this chapter, that firms are able to foresee the outcome of the competitive process, and are thus able to calculate their own and their competitor's returns contingent upon the pursuit of various strategies. See section 3.3.

2. Koopmans [1957] prefaced this statement with the following remarks: "If we imagine all land to be of the same quality, both agriculturally and in amount and accessibility of mineral resources, then an activity analysis model of production that includes the proportionality postulate would show a perfectly even distribution of activities to be most economical. Each square inch of area would produce the same bundle of activities, and all transportation would then be avoided. If this model is modified so as to reflect continuous distribution of soil fertility and of mineral content, transportation does become economical if its resource requirements are not too high in relation to the advantage to be gained by transportation. However, even then there will be no reason for having concentrated cities unless mineral deposits (or possibly soil fertility) were to be highly concentrated. This suggests that without recognizing indivisibilities - in the human person, in residences, plants, equipment, and in transportation - urban location problems, down to those of the smallest village, cannot be understood."

3. This proposition has been carefully analyzed by Eaton and Lipsey [1978]. In the context of a one-dimensional spatial model, they demonstrate that pure profits will not necessarily be driven to zero

by price competition and/or free entry of new firms.

4. Our particular choice of a cost function will be specified at a later point in the analysis. One type of cost function frequently used in models of spatial competition is of the following form:

$$ATC = K/Q + c \qquad Q < \bar{Q}, \tag{1}$$

where K = fixed costs, Q = output, c = a constant marginal cost, and $Q < \bar{Q}$ is a capacity constraint. (The capacity constraint is not always imposed, however.) The reasons for using this type of cost function have been stated by Eaton and Lipsey [1976]: "The empirical phenomenon which is of interest to us is that average total costs of production decline over some range of output. We know that nearly all production involving machines is characterized by indivisibilities which give falling ATC at least at low levels of output. More important for the retailing sector are economies of scale in the construction of buildings and in the management of inventories. The assumptions reflected in the cost function of equation (1) are the simplest and most manageable way of incorporating economies of scale up to some minimum output level."

5. The reasons for making this particular assumption have been stated by Eaton and Lipsey [1978]. Consider a number of firms equally spaced on a line of finite length. If there are no sunk costs, and a new firm enters, all other firms woud move until they were again equally spaced. That is, they can all increase the quantity demanded by moving to the mid-point of their market areas. However, if there are sunk costs,

and if the profits of existing firms in their original locations are greater than they would be if these firms moved, then the new entrant cannot expect existing firms to move. That is the rationale for the zero conjectural variation with respect to location assumption. It depends on the existence of location specific sunk costs and may yield the result of excess profits in equilibrium.

6. The possibility of a firm making pure profits without inducing further entry into the market has been discussed by Eaton and Lipsey [1978]. This possibility was also discussed in their 1976 paper, "The Theory of Market Preemption: Barriers to Entry in a Growing Spatial Market": "This geographical dispersion of firms effectively segments the market and confers on each firm an element of monopoly power over segments of the market that are closer to that firm than to any other firm. The dispersion of firms also means that any new entrants must fit into a space between existing firms and as a result will sell significantly less at any point than would an existing firm have sold at the same price before entry occurred. This result, in combination with characteristic (i), decreasing LRATC over some range, implies that it is quite possible for potential entrants to anticipate negative profits while firms already in the market enjoy positive pure profits."

7. Equation (3.6) is obtained as follows:

$$p_2 + z(X - b) = p_1 + zb$$

$$zb = p_2/2 - p_1/2 + zx/2$$

$$p_1 + zb = p_2/2 + p_1/2 + zx/2$$

$$q_1 = 1/2(p_2 + p_1 + zx).$$

8. Equation (3.8) is obtained as follows:

$$Q_1 = \delta \int_0^{\tilde{b}} y(p_1 + zb)\, db\ .$$

If we set $u = p_1 + zb$, then $du = z\,db$, or $db = 1/z\,du$. When $b = 0$, $u = p_1$. When $b = \tilde{b}$, $u = p_1 + z\tilde{b} = q_1$. After making the appropriate substitutions, we obtain

$$Q_1 = \delta/z \int_{p_1}^{q_1} y(p)\, dp\ .$$

9. It is well known that if the production function is homothetic, then the minimization problem

$$\min_{(K,L)} \left\{ rK + wL \mid Q = Q(K,L) \right\}$$

yields a minimum total cost function of the following form:

$$C = c(Q)\, \psi\, (r,w).$$

This cost function is such that it may embody the properties and satisfy the conditions listed in the text.

10. The proof that joint profit maximization by F_1 involves choosing a location at 2/3 and the charging of common prices at both of its plants may be found in Eaton and Lipsey [1976].

11. This argument is in the spirit of Eaton and Lipsey's no mill-price undercutting assumption, which is discussed in Eaton and Lipsey [1978] and an explicit assumption in their preemption model. Eaton and Lipsey argue that no potential entrant, prior to entry, can expect to charge a price low enough to drive the established firm out of the

market and expect to earn non-negative pure profits charging such a price. This argument relies on the fact that the established firm has sunk costs, while the potential entrant's costs are all avoidable prior to entry.

12. A similar argument has been advanced by Schmalensee [1978; 313]. "Suppose, for instance, that established firms attempt to deter entry by some variant of limit pricing, holding prices below the short-run profit maximizing level so that the expected profit of an entrant brand that takes those prices as fixed would be negative. Suppose further that entry nevertheless occurs. Once the entrant is in place, it is relatively immobile. Both its profits and those of its immediate rivals can then generally be raised by increasing price. As only a small group of firms is involved, such mutually beneficial price increases are not implausible. But if potential entrants come to recognize this possibility, limit pricing ceases to be an effective deterrent, since low preentry prices cease to convey a credible threat of low postentry prices."

13. Osborne [1973].

14. See Latsis [1976], Pashigian [1968], and Wenders [1971].

15. See Schelling [1956; 294-295].

16. The model presented in this section represents a revised version of one which was originally developed as part of the author's dissertation prospectus. The revision was undertaken by B. Curtis Eaton and myself.

Chapter 4

THE PROFITS TEST

4.1 Introduction

In the previous chapter, the following general result of preemptive firm behavior was derived: if an existing firm and potential entrants anticipate that the market will grow at some time in the future such that a new plant could be profitably established in that market, and if the existing firm does nothing to block entry, then competition among potential entrants will lead to a new plant being established in the market at a point in time when the present value of that plant is equal to zero. This implies that the negative profits which would accrue to the new entrant's plant prior to the increase in density would be balanced off by the positive pure profits earned by the new entrant's plant after the increase in density takes place. If an existing firm preempted the market instead of a potential entrant, we know that the present value of profits of the new plant would be less than the present value of profits of a plant established at the date when the increase in density occurs. However, we are unable to infer whether the profits of the existing firm's new plant would be negative or positive prior to the increase in density.

In this chapter, we shall perform a series of annual net profit calculations for stores belonging to the supermarket industry. We shall derive estimates of the annual profits of a "representative new supermarket" and a "representative established supermarket". Given the general implication of preemptive behavior, as stated above, we would regard negative estimates of new supermarket profits as being evidence which is consistent with preemptive behavior on the part of some firm or firms in the industry. This, then, would provide us with a basis for engaging in a more detailed examination of the locational implications of preemption, with the goal of determining whether preemption has occurred in some spatially extended market, and, if so, which supermarket firm or firms have pursued this type of behavior. On the other hand, positive estimates of new supermarket profits, while possibly consistent with preemptive behavior on the part of existing firms, would not provide us with sufficient incentive to pursue the locational analysis of preemption for the supermarket industry.

In section 4.2, we state the null hypothesis to be examined in this chapter, as well as our reasons for selecting it. In section 4.3, we discuss the data sources to be used in our net profit calculations. Section 4.4 contains a detailed description of how the profits of a representative new supermarket and a representative established supermarket may be estimated using the available data. In section 4.5, we present the results of our profit calculations, while in section 4.6, we interpret our results and make some concluding remarks.

4.2 Statement of the Null Hypothesis

The industry we have chosen as the basis for our examination of the profits implication of the theory of preemption is the supermarket industry. Ideally we would like to have cost and revenue data for individual supermarkets covering their first twelve months of operation. (The selection of a year as the period of time over which the initial profits of new supermarkets would be calculated is arbitrary, but suggested by the nature of the data.) Such data would enable us to test directly the null hypothesis that the initial profits of new supermarkets are negative in their first twelve months of operation. However, as might be expected, we do not have access to such a body of data, and therefore some approximation to the ideal test becomes necessary. The approximation we have in mind is to examine the following null hypothesis: For any given year, the "average" profits of new supermarkets in the United States and Canada are negative in the first twelve months of operation of these supermarkets. By average profits we mean average total revenue minus average total costs, where the average is over supermarkets.

The alternative hypothesis is that for any given year, the average profits of new supermarkets in the United States and Canada are non-negative in the first twelve months of operation of these supermarkets.

Acceptance of the null hypothesis would be consistent with the proposition that a large percentage (although not necessarily the majority) of new supermarkets established in the year for which the test is conducted could not cover their costs in their first twelve months of operation. This proposition is, in turn, consistent with the profits implication of the theory of preemption.

In the next section, we describe the data sources to be used for our net profit calculations.

4.3 Description of Data Sources

The data which we use for our net profit calculations are drawn from three sources. Two of these sources are published by the Food Marketing Institute, a United States based supermarket trade association. The first one is called <u>The Super Market Industry Speaks</u> (SMIS) and is published annually. The data contained in this publication are based on industry surveys of the Institute's member companies (which may also be regarded as a sample of supermarkets taken from the population of all supermarkets in operation in a given year). We are primarily interested in the Institute's calculations of average operating results of supermarkets, where a supermarket is defined in SMIS as a departmentalized food store doing at least one million dollars a year in sales, or about twenty thousand dollars weekly.[1]

The second publication of the Food Marketing Institute of interest to us is called Facts About New Super Markets Opened in (year) (FANSM), which is published annually. Again, the data contained in this publication are based on a survey of member companies which have opened new stores during the year for which the survey was conducted.[2] The type of data reported in FANSM varies from year to year, but sales information is always reported. The problem which we confront in the next section of this chapter is how to estimate the average profits of new supermarkets given the incomplete nature of the cost data reported in FANSM.

The third publication which we make use of is called Operating Results of Food Chains (ORFC), published annually between 1956 and 1961 by Harvard University, and since 1962 by Cornell University.[3] This publication reports detailed breakdowns of costs as a percentage of sales for a sample of supermarkets taken from the population of all supermarkets in operation in a given year.[4]

For given years, we shall find it useful to derive estimates of the net profits of new supermarkets and the net profits of established supermarkets.[5] The bulk of the data contained in all three of the aforementioned publications is in the form of averages, where an average is defined to be a mean in ORFC and a median in FANSM and SMIS, and where the average is over all supermarkets in the respective sample. Since our data are in the form of averages, our net profit calculations for a given year will be regarded as constituting estimates of the net profits of a representative new supermarket and a representative established supermarket in that year. Our net profit calculations will be made under the following assumptions: (i) the ORFC and SMIS data are based on random samples of supermarkets taken from the same population of supermarkets in operation in a given year; (ii) the FANSM data are based on a random sample of supermarkets taken from the population of new supermarkets opened in a given year; (iii) all of the independent variables comprising the net profit function are random variables which are independently distributed.

In the next section, we define the profit function which we use to calculate the net profits of a representative new supermarket and the net profits of a representative established supermarket. We also discuss the assumptions that are necessary in order to obtain an estimate of the net profits of a representative new supermarket.

4.4 Procedures for Estimating Net Profits

In this section, we shall discuss the procedures which we use to estimate the net profits of a representative new supermarket, and the net profits of a representative established supermarket. The general form of the profit function to be calculated in all cases is as follows:

$$\Pi = AS - O - K - PC - IC, \tag{4.1}$$

where Π = profits per square foot of selling area per week, AS = average sales per square foot of selling area per week, O = operating costs per square foot of selling area per week, K = capital costs per square foot of selling area per week, PC = product costs per square foot of selling area per week, and IC = inventory costs per square foot of selling area per week. All variables are defined in units of dollars per square foot of selling area per week since our sales data are in those units. (Ideally we would like to be able to calculate (4.1) for different store size categories since we would not expect costs and revenues to be independent of store size. However, as stated in section 4.3, our data are in the form of averages, where the averages are over all supermarkets in the sample irrespective of store size.) In what follows, we use subscript N to refer to new supermarkets and subscript E to refer to established supermarkets.

We begin our discussion by examining the procedure that is used to obtain estimates of each component of equation (4.1) for a representative established supermarket. Data on the first component of equation (4.1), average sales per square foot of selling area per week, are obtained directly from SMIS.

The second component of equation (4.1), operating costs per square foot of selling area per week, is defined to include direct operating costs, DO, and indirect operating costs, IO. Data on direct operating costs as a percentage of average annual sales per established store, do_E, are obtained directly from ORFC, and include labor costs of employees assigned to stores, supplies and services consumed at the stores, and similar direct store costs, covering receipt, handling, preparation for sale, display and sale of merchandise and the related customer services.[6] Data on indirect operating costs as a percentage of average annual sales per established store, io_E, are also obtained from ORFC, and include the costs of warehouse operations,[7] transportation operations,[8] merchandising and buying,[9] advertising and sales promotion,[10] accounting and office services,[11] general administration,[12] field supervision,[13] employee benefits,[14] and non-store occupancy.[15] In order to obtain an estimate of O_E using ORFC data, we must perform the following calculation:

$$(4.2) \qquad \begin{aligned} O_E &= DO_E + IO_E \\ &= AS_E\ (do_E + io_E), \end{aligned}$$

where do_E = direct operating costs as a percentage of sales and io_E = indirect operating costs as a percentage of sales. We will assume that all of the costs included in O_E are variable costs. That is, all of these costs will be assumed to vary proportionally with the opening of a new store by a firm.[16]

The third component of equation (4.1) is capital costs per square foot of selling area per week. Data on capital costs as a percentage of average annual sales per established store, k_E, are available from ORFC. ORFC defines capital costs to include all of the company's non-capitalized costs relating to store real estate, buildings, fixtures and equipment (including utilities, insurance, taxes, licenses, property and equipment rentals, depreciation and amortization, repairs, and credits and allowances).[17] To put these costs on a per square foot of selling area per week basis, we must perform the following simple calculation:

$$K_E = AS_E\,(k_E)\ . \tag{4.3}$$

The fourth component of equation (4.1), product costs per square foot of selling area per week, may be calculated as follows:

$$PC_E = (1 - gm_E)\,AS_E\ , \tag{4.4}$$

where gm_E = gross margin as a percentage of sales. ORFC reports data on the gross margin as a percentage of average annual sales per established store and defines the gross margin as the amount remaining after the deduction of net cost of merchandise sold from net sales.[18] In our notation,

$$AS - PC = GM, \tag{4.5}$$

where GM = gross margin per square foot of selling area per week. If we assume that $P \cdot Q = AS$ and $c \cdot Q = PC$, where P = price, Q = quantity sold, and c = the unit cost of goods sold, then we could rewrite (4.5) as follows:

$$\frac{P - c}{P} = gm. \tag{4.6}$$

We should point out that our definition of gross margin differs from the standard definition of the term, which usually defines the margin as a mark-up on costs.

The final component of equation (4.1) is inventory costs per square foot of selling area per week, and represents the cost to the firm of tying up capital in the form of unsold inventory. Inventory costs may be calculated using the following equation:

$$(4.7) \qquad IC_E = \frac{AS_E\ (1 - gm_E)r}{ITR_E} ,$$

where ITR_E = inventory turnover rate (or stockturns).[19] Data on ITR_E may be obtained directly from ORFC. The interest rate, r, to be used in our calculation of IC_E is the U.S. prime lending rate plus one percent. The particular choice of interest rate was arbitrary, but it will have very little impact on our net profit calculations since IC_E constitutes a very small component of total costs per square foot of selling area per week.

Using equations (4.2) - (4.7), we may now rewrite equation (4.1) as follows:

(4.8)

$$\Pi^E = AS_E - AS_E(do_E + io_E) - AS_E(k_E) - (1 - gm_E)AS_E - \frac{AS_E(1 - gm_E)r}{ITR_E}$$

$$= AS_E(gm_E - do_E - io_E - k_E - \frac{(1 - gm_E)r}{ITR_E}).$$

From equation (4.8), we find that whether our calculation of the net profits of a representative established supermarket is positive or negative depends solely on the costs as percentage of sales data reported in ORFC and also the interest rate, and not on the absolute level of AS_E. However, we shall find it useful to have an estimate of Π^E in order to compare it with the net profits of a representative new supermarket, Π^N.

In the remainder of this section, we shall discuss the procedure that is used to calculate the net profits of a representative new supermarket, Π^N. This calculation will require a number of simplifying assumptions due to the nature of the cost data which we must use. As before, we shall proceed by considering how we might obtain estimates of each component of equation (4.1).

Data on the first component of equation (4.1), average sales per square foot of selling area per week, are obtained directly from FANSM.

Data on the second component of equation (4.1), operating costs per square foot of selling area per week, cannot be obtained from FANSM. We do have data on do_E and io_E from ORFC, but we cannot use this data directly in order to calculate O_N for the following reasons: The ORFC figures on operating costs as a percentage of sales are based on the sales of established supermarkets. However, from FANSM and SMIS, we find that the average sales per square foot of selling area per week for new supermarkets are less than the average sales per square foot of selling area per week for established supermarkets in any given year, and several studies have shown that average costs as a percentage of sales are not constant for various levels of average sales per square foot (the utilization rate). In particular, Mallen and Haberman [1975] have estimated long run and short run cost functions using cost data from 130 supermarkets owned by a major Canadian supermarket chain. They found that average costs as a percentage of sales declined significantly over almost the entire range of utilization rates for which they had data (holding store size constant), while average costs as a percentage of sales initially decrease and then increase with store size for fixed utilization rates. (It should be noted that the change in average costs with store size is very small relative to the change in average costs due to changing utilization rates. In fact, the long run average cost function appears to be almost L-shaped.)[20] Savitt [1975], in an independent study of the cost functions of a large number of Canadian supermarkets, arrived at similar conclusions.[21]

Thus, given that average costs as a percentage of sales would be expected to decline with increasing utilization rates (over some range), and given that new supermarkets in general have lower utilization rates than established supermarkets, we cannot use ORFC data on operating costs as a percentage of sales in order directly to estimate O_N. We can, however, use the ORFC data in order to construct upper and lower bounds on O_N. First, since the average utilization rates of new supermarkets are, in general, lower than for established supermarkets, we would expect the operating costs of a representative new supermarket to be absolutely lower than the operating costs of a representative established supermarket with its higher utilization rate. Thus,

$$O_N \leq AS_E(do_E + io_E). \tag{4.9}$$

However, it is also true that

$$AS_N(do_E + io_E) \leq O_N \tag{4.10}$$

since average costs as a percentage of sales for a representative established supermarket should be lower than average costs as a percentage of sales for a representative new supermarket. Having derived these upper and lower bounds on O_N, we can perform our profit calculations using these bounds in order to obtain a range estimate of Π^N.

The third component of equation (4.1), capital costs per square foot of selling area per week, must also be estimated for a representative new supermarket using ORFC and SMIS data. It will be recalled that ORFC's figures on capital costs as a percentage of sales, k_E, are defined to include all of the company's non-capitalized costs relating to store real estate, buildings, fixtures and equipment. Now, there does not seem to be any compelling reason to believe that the capital costs per square foot for new supermarkets would differ significantly from the capital costs per square foot for established supermarkets. Thus, we shall estimate K_N as follows:

$$K_N = AS_E(k_E). \tag{4.11}$$

The fourth component of equation (4.1) is product costs per square foot of selling area per week, or $PC = (1 - gm)AS$. Since FANSM does not report gross margin data, we must once again use ORFC data in order to obtain an estimate of gm_N. This raises the question of whether gm_E is a good estimator of gm_N, and we answer this question in the following way: First, the unit costs of goods sold by new supermarkets and established supermarkets might be different. However, given that almost all supermarkets have access to some warehouse facilities, we would not expect the unit cost of goods sold to differ significantly for different firms. That is, most supermarkets can take advantage of lower costs of distribution (i.e. through quantity discounts on the purchase of large volumes of goods, rationalization of inventory management, etc.) even if they do not own their own warehouses. Second, if new supermarkets were primarily being opened by established firms, then the theory of preemption suggests that these stores will be located in their joint profit maximizing locations and will charge the joint profit maximizing prices. We would also expect these prices to be higher than those charged by new entrants into the market. If the prices charged by new supermarkets are higher, on average, than those charged by all established firms, then by equation (4.6) we would expect $gm_N > gm_E$. If, on the other hand, established firms have had the opportunity to adjust their prices to the joint profit maximizing prices, and if new supermarkets are primarily being opened by these firms, then we would not expect much difference between established supermarket and new supermarket prices in any given time period. Hence, gm_E would be a good estimator of gm_N. Therefore, under the assumption that established firms preempt their markets, we could use ORFC data in order to calculate PC_N as follows:

$$PC_N = AS_N(1 - gm_E). \tag{4.12}$$

Furthermore, gm_E would be a good estimator of gm_N if new supermarkets are primarily opened by new entrants and if price competition prevents established firms from charging the profit maximizing prices. (In other words, new entrants and established firms charge the same prices.) We shall use (4.12) to estimate PC_N for our representative new supermarket, while recognizing that depending on actual circumstances, (4.12) might overestimate or underestimate true PC_N.[22]

The last component of equation (4.1) is inventory costs per square foot of selling area per week. The calculation of IC_N would be a straightforward matter were it not for the fact that FANSM does not supply us with information on the inventory turnover rate. Data on ITR_E

may be obtained from ORFC, but we would expect ITR_E to exceed ITR_N due to the higher utilization rate for a representative established supermarket. Thus, the best we can do is to construct a lower bound estimate of IC_N as follows:

$$IC_N \geq \frac{AS_N(1 - gm_E)r}{ITR_E}. \tag{4.13}$$

We may now combine equations (4.9) - (4.13) to obtain upper and lower bound estimates of Π^N:

(4.14)

$$\Pi^N_{UB} = AS_N - AS_N(do_E + io_E) - AS_E(k_E) - (1 - gm_E)AS_N - \frac{AS_N(1 - gm_E)r}{ITR_E}$$

$$= AS_N(gm_E - do_E - io_E - \frac{(1 - gm_E)r}{ITR_E}) - AS_E(k_E)$$

(4.15)

$$\Pi^N_{LB} = AS_N - AS_E(do_E + io_E) - AS_E(k_E) - (1 - gm_E)AS_N - \frac{AS_N(1 - gm_E)r}{ITR_E}$$

$$= AS_N(gm_E - \frac{(1 - gm_E)r}{ITR_E}) - AS_E(do_E + io_E + k_E).$$

The only difference between equation (4.8) and equation (4.14), aside from average sales per square foot of selling area per week, lies in the fact that capital costs per square foot of selling area per week will be a larger percentage of AS_N than of AS_E. The differences between equation (4.8) and equation (4.15) are, aside from average sales per square foot of selling area per week, reflected in the fact that operating costs as well as capital costs will be a larger percentage of AS_N than of AS_E.

In the next section, we report the results of calculations of Π^E, Π^N_{UB}, and Π^N_{LB} for a seven year period.

4.5 Test Results of the Null Hypothesis of Negative Initial Profits

In this section, we report the results of our calculations of Π^E, Π^N_{UB}, and Π^N_{LB} for the years 1970-1976 inclusive.[23] Before reporting our results, we should note three conventions which were employed in all of our calculations. First, SMIS and FANSM report AS_E and AS_N respectively, for stores operating in a given calendar year, whereas ORFC data is based on a fiscal year, May - April. The only means of reconciling the data sets is an arbitrary one, and we therefore use, for example, ORFC data from the 1976-77 fiscal year in order to calculate net profits in 1976. Second, in order to get an estimate of the annual prime lending rate charged by U.S. banks, we found it necessary to take the average of average monthly prime lending rates. The interest rate, r, is then obtained by adding one percent to our estimate of the U.S. prime lending rate. Finally, ORFC reports ITR_E data for three categories of firms doing different levels of sales (for example, for firms with sales below $100 million, with sales between $100 million and $500 million, and with sales above $500 million). Our estimate of the inventory turnover rate is the simple unweighted average of these three figures. As for the interest rate, the way in which we estimate the inventory turnover rate will have very little impact on our net profit calculations since IC constitutes a very small component of total costs per square foot of selling area per week.

In Table I, we report the results of our net profit calculations.

Table I

NET PROFIT CALCULATIONS: 1970-1976

1970

$$\Pi^E = AS_E(gm_E - do_E - io_E - k_E - \frac{(1 - gm_E)r}{ITR_E})$$

$$= 4.16\ (.2139 - .0939 - .0783 - .0347 - \frac{(1 - .2139)\ .0834}{14.39})$$

$$= .0101674$$

$+\ \Pi^E$ as % of AS_E = .24441%

$$\Pi^N_{UB} = AS_N(gm_E - do_E - io_E - \frac{(1 - gm_E)r}{ITR_E}) - k_E(AS_E)$$

$$= 3.44\ (.2139 - .0939 - .0783 - \frac{(1 - .2139).0834}{14.39}) - .0347(4.16)$$

$$= -\ .0165763$$

$-\Pi^N_{UB}$ as % of AS_N = .48186%

$$\Pi^N_{LB} = AS_N(gm_E - \frac{(1 - gm_E)r}{ITR_E}) - AS_E(do_E + io_E + k_E)$$

$$= 3.44(.2139 - \frac{(1 - .2139).0834}{14.39}) - 4.16(.0939 + .0783 + .0347)$$

$$= -\ .1405603$$

$-\ \Pi^N_{LB}$ as % of AS_N = 4.08605%

Table I

NET PROFIT CALCULATIONS: 1970-1976

1971

$$\Pi^E = AS_E(gm_E - do_E - io_E - k_E - \frac{(1 - gm_E)r}{ITR_E})$$

$$= 4.55(.2153 - .0953 - .0791 - .0347 - \frac{(1 - .2153).0661}{15.01})$$

$$= .012487$$

$+ \Pi^E$ as % of AS_E = .27444%

$$\Pi^N_{UB} = AS_N(gm_E - do_E - io_E - \frac{(1 - gm_E)r}{ITR_E}) - k_E(AS_E)$$

$$= 3.50(.2153 - .0953 - .0791 - \frac{(1 - .2153).0661}{15.01}) - .0347(4.55)$$

$$= - .0268296$$

$- \Pi^N_{UB}$ as % of AS_N = .76656%

$$\Pi^N_{LB} = AS_N(gm_E - \frac{(1 - gm_E)r}{ITR_E}) - AS_E(do_E + io_E + k_E)$$

$$= 3.50(.2153 - \frac{(1 - .2153).0661}{15.01}) - 4.55(.0953 + .0791 + .0347)$$

$$= - .2099496$$

$- \Pi^N_{LB}$ as % of AS_N = 5.99856%

Table I

NET PROFIT CALCULATIONS: 1970-1976

1972

$$\Pi^E = AS_E(gm_E - do_E - io_E - k_E - \frac{(1 - gm_E)r}{ITR_E})$$

$$= 4.34(.2093 - .0968 - .0774 - .0341 - \frac{(1 - .2093).0524}{13.53})$$

$$= - .0089499$$

$- \Pi^E$ as % of AS_E = .20622%

$$\Pi^N_{UB} = AS_N(gm_E - do_E - io_E - \frac{(1 - gm_E)r}{ITR_E}) - k_E(AS_E)$$

$$= 3.48(.2093 - .0968 - .0774 - \frac{(1 - .2093).0524}{13.53}) - .0341(4.34)$$

$$= - .0365025$$

$- \Pi^N_{UB}$ as % of AS_N = 1.04892%

$$\Pi^N_{LB} = AS_N(gm_E - \frac{(1 - gm_E)r}{ITR_E}) - AS_E(do_E + io_E + k_E)$$

$$= 3.48(.2093 - \frac{(1 - .2093).0524}{13.53}) - 4.34(.0968 + .0774 + .0341)$$

$$= - .1863145$$

$- \Pi^N_{LB}$ as % of AS_N = 5.35386 %

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*In 1972, average sales per square foot of selling area per week were reported by FANSM for conventional supermarkets, combination supermarkets, and food departments, and not for all new supermarkets in general. To obtain an estimate of AS_N, we took the unweighted average of AS for these three separate categories.

Table I

NET PROFIT CALCULATIONS: 1970-1976

1973

$$\Pi^{E} = AS_{E}(gm_{E} - do_{E} - io_{E} - k_{E} - \frac{(1-gm_{E})r}{ITR_{E}})$$

$$= 4.71(.2090 - .0960 - .0790 - .0329 - \frac{(1-.2090).0772}{13.77})$$

$$= - .0157059$$

$- \Pi^{E}$ as % of AS_{E} = .33346%

$$\Pi^{N}_{UB} = AS_{N}(gm_{E} - do_{E} - io_{E} - \frac{(1-gm_{E})r}{ITR_{E}}) - k_{E}(AS_{E})$$

$$= 3.75(.2090 - .0960 - .0790 - \frac{(1-.2090).0772}{13.77}) - .0329(4.71)$$

$$= - .0440888$$

$- \Pi^{N}_{UB}$ as % of AS_{N} = 1.1757%

$$\Pi^{N}_{LB} = AS_{N}(gm_{E} - \frac{(1-gm_{E})r}{ITR_{E}}) - AS_{E}(do_{E} + io_{E} + k_{E})$$

$$= 3.75(.2090 - \frac{(1-.2090).0772}{13.77}) - 4.71(.0960 + .0790 + .0329)$$

$$= - .2120888$$

$- \Pi^{N}_{LB}$ as % of AS_{N} = 5.6557%

Table I

NET PROFIT CALCULATIONS: 1970-1976

1974

$$\Pi^{E} = AS_E(gm_E - do_E - io_E - k_E - \frac{(1-gm_E)r}{ITR_E})$$

$$= 5.09(.2115 - .0969 - .0744 - .0339 - \frac{(1-.2115).1175}{13.75})$$

$$= - .0022294$$

$- \Pi^{E}$ as % of AS_E = .0438%

$$\Pi^{N}_{UB} = AS_N(gm_E - do_E - io_E - \frac{(1-gm_E)r}{ITR_E}) - k_E(AS_E)$$

$$= 4.22(.2115 - .0969 - .0744 - \frac{(1-.2115).1175}{13.75}) - .0339(5.09)$$

$$= - .0313414$$

$- \Pi^{N}_{UB}$ as % of AS_N = .74268%

$$\Pi^{N}_{LB} = AS_N(gm_E - \frac{(1-gm_E)r}{ITR_E}) - AS_E(do_E + io_E + k_E)$$

$$= 4.22(.2115 - \frac{(1-.2115).1175}{13.75}) - 5.09(.0969 + .0744 + .0339)$$

$$= - .1803724$$

$- \Pi^{N}_{LB}$ as % of AS_N = 4.27422 %

Table I

NET PROFIT CALCULATIONS: 1970-1976

<u>1975</u>

$$\Pi^E = AS_E(gm_E - do_E - io_E - k_E - \frac{(1-gm_E)r}{ITR_E})$$

$$= 5.33(.2122 - .0965 - .0762 - .0347 - \frac{(1-.2122).0886}{14.63})$$

$$= .0001551$$

$+ \Pi^E$ as % of AS_E = .00291%

$$\Pi^N_{UB} = AS_N(gm_E - do_E - io_E - \frac{(1-gm_E)r}{ITR_E}) - k_E(AS_E)$$

$$= 4.50(.2122 - .0965 - .0762 - \frac{(1-.2122).0886}{14.63}) - .0347(5.33)$$

$$= -\ .0291201$$

$- \Pi^N_{UB}$ as % of AS_N = .64711%

$$\Pi^N_{LB} = AS_N(gm_E - \frac{(1-gm_E)r}{ITR_E}) - AS_E(do_E + io_E + k_E)$$

$$= 4.50(.2122 - \frac{(1-.2122).0886}{14.63}) - 5.33(.0965 + .0762 + .0347)$$

$$= -\ .172011$$

$- \Pi^N_{LB}$ as % of AS_N = 3.82246%

Table I

NET PROFIT CALCULATIONS: 1970-1976

1976

$$\Pi^E = AS_E(gm_E - do_E - io_E - k_E - \frac{(1 - gm_E)r}{ITR_E})$$

$$= 5.50(.2135 - .10 - .0763 - .0335 - \frac{(1 - .2135).0784}{13.66})$$

$$= - .004477$$

$- \Pi^E$ as % of AS_E = .0814%

$$\Pi^N_{UB} = AS_N(gm_E - do_E - io_E - \frac{(1 - gm_E)r}{ITR_E}) - k_E(AS_E)$$

$$= 4.78(.2135 - .10 - .0763 - \frac{(1 - .2135).0784}{13.66}) - .0335(5.50)$$

$$= - .028011$$

$- \Pi^N_{UB}$ as % of AS_N = .586%

$$\Pi^N_{LB} = AS_N(gm_E - \frac{(1 - gm_E)r}{ITR_E}) - AS_E(do_E + io_E + k_E)$$

$$= 4.78(.2135 - \frac{(1 - .2135).0784}{13.66}) - 5.50(.10 + .0763 + .0335)$$

$$= - .154947$$

$- \Pi^N_{LB}$ as % of AS_N = 3.24156%

Looking first at our calculations of Π^E, we find that Π^E was positive in 1970 and 1971, negative in 1972 and 1973, and very close to zero in 1974, 1975, and 1976. It is interesting to note that even though established supermarkets, on average, were making negative or zero profits between 1972 and 1976 inclusive, new supermarkets were still being opened. This result might be explained by the fact that some local markets were growing, and new supermarkets were being established in these markets, while other local markets were declining, and established supermarkets in these local markets were being closed due to their unprofitability.

When we compare our calculations of Π^N with our calculations of Π^E, we find that our upper and lower bound estimates of Π^N are always negative and less than Π^E.

We can only speculate about which estimate of Π^N, Π^N_{UB} or Π^N_{LB}, would be closer to the true net profits of our representative new supermarket. One of the most critical determinants would be the shape of the long run average cost curve. If both AS_N and AS_E appear on a flat portion of the average cost curve, then do_E and io_E would constitute good estimators of do_N and io_N. This would then imply that Π^N_{UB} would be a good estimator of the true Π^N. On the other hand, suppose that AS_N was on the declining portion of an L-shaped short run average cost curve, while AS_E was on the flat portion of that curve. Then, Π^N_{LB} might be a better estimator of the true Π^N. Support for this conclusion is obtained when one considers that many of the component elements of io would be incurred by a firm when operating a supermarket, regardless of the absolute level of AS. This would then imply that $AS_E(io_E)$ would be a fairly accurate estimator of IO_N. However, since DO would be expected to vary with AS, we would expect

$do_E(AS_E)$ to overestimate DO_N. Thus, whether or not Π^N_{LB} is a better estimator of Π^N than Π^N_{UB} depends upon the shape of the short run average cost curve and also the extent to which $do_E(AS_E)$ and $io_E(AS_E)$ are accurate estimators of DO_N and IO_N.

Regardless, however, of whether Π^N_{LB} or Π^N_{UB} is closer to the true Π^N, we have shown that our estimates of Π^N are more than just marginally negative and that they are substantially less than Π^E. The driving force of these results is as follows: First, for the years 1970-1976, AS_N is less than AS_E. Second, since we have maintained that the capital costs per square foot of selling area per week of new supermarkets would not differ significantly from the capital costs per square foot of selling area per week of established supermarkets, then

$$K_N \doteq AS_E(k_E) = K_E. \tag{4.16}$$

Thus, in comparing equations (4.8) and (4.14), we find that $AS_N < AS_E$ and $K_N = K_E$ imply that $\Pi^N_{UB} < \Pi^E$. In comparing equations (4.8) and (4.15) we find that $AS_N < AS_E$, $K_N = K_E$ and $O_N = O_E$ imply that $\Pi^N_{LB} < \Pi^N_{UB} < \Pi^E$. Finally, AS_N is small relative to AS_E. Thus, not only are Π^N_{LB} and Π^N_{UB} less than Π^E, but they are also less than zero. Hence, our calculations support the null hypothesis that the average profits of new supermarkets in the United States and Canada are negative in the first twelve months of operation of these supermarkets. In the next section, we interpret the significance of these results and make some concluding remarks.

4.6 Interpretation of Results and Concluding Remarks

In this chapter of the thesis, we have examined the null hypothesis of negative initial profits. Our calculations of Π^N provided evidence in support of the null hypothesis. However, we should note some of the limitations of our testing procedure. One of the most serious limitations was our inability to do a proper statistical test of the null hypothesis due to the absence of sufficient information on the variance and distributions of cost and revenue variables. A second limitation was our inability to calculate Π^N using data drawn strictly from a sample of new supermarkets. That is, to obtain estimates of Π^N, we had to adapt ORFC cost data using several restrictive assumptions (especially with respect to capital costs, operating costs and the gross margin). We were unable to check the accuracy of these assumptions with the limited data at our disposal. The most serious limitation of the analysis is that we were only able to obtain evidence in support of an hypothesis regarding the average profits of new supermarkets, and not an hypothesis regarding the profits of individual new supermarkets.

Apart from the limitations of the analysis, we should make a few comments regarding the significance of our results. In particular, are there other reasons why our estimates of Π^N might be negative apart from the explanation that firms have engaged in preemptive location strategies? One explanation that comes to mind is that start-up costs for new supermarkets might be appreciable. Since, however, we use ORFC cost data in order to estimate the cost components of Π^N, start-up costs have not been included in our net profit calculations. Thus start-up costs do not provide an explanation for negative Π^N_{UB} or Π^N_{LB}.

One might be tempted to assert that our estimates of Π^N are negative because it takes time for consumers to realize that a new supermarket has been established in their neighborhood or because it takes time for consumers to change their shopping habits. We do not attach much importance to these as explanations for our results for the following reasons: First, while some consumers may not realize that a new supermarket has been established in their neighborhood during the first few weeks that it is in operation, we would not expect such a lack of awareness to last for an extended period of time. Second, economic theory and empirical studies suggest that consumers are responsive to price, and we would not expect a large number of consumers to forego the cost savings to be obtained by shopping at a closer new supermarket in order to shop at a more distant, but familiar, older supermarket. However, the relative importance of these alternative explanations for our estimates of Π^N are ultimately matters for empirical investigation.

We conclude that insufficient consumer density provides the best explanation for our estimates of Π^N. That is, our empirical evidence is consistent with firms establishing new supermarkets in the market such that these new supermarkets represent excess capacity at the time in which they are opened. This explanation, in turn, is consistent with the hypothesis of preemptive firm behavior. In the next chapter, we consider the locational implications of preemption. We devise tests to determine simultaneously if preemption has occurred in particular markets and, if so, which firm is the preemptor.

FOOTNOTES TO CHAPTER 4

1. The Super Market Industry Speaks, 1976, conducted by Research Division, Super Market Institute, Inc. In 1976, 40 percent of the Institute's U.S. and Canadian member companies participated in the survey, and these companies operated 10,278 food stores. (We should also note that in 1977, the Super Market Institute changed its name to the Food Marketing Institute.)

2. For example, in 1976, a total of 384 companies replied to the Food Marketing Institute survey, and of these, 103 companies had either opened or closed supermarkets during the previous year. See Facts About New Supermarkets Opened in 1976, conducted by Research Division, Super Market Institute, Inc.

3. In 1976, the operating results data reported in ORFC were based on surveys of 58 companies operating 5831 stores, with aggregate sales of 24.4 billion dollars for the fiscal year May, 1975, to April, 1976.

4. While ORFC does report sales data, the sales data are not in a form which is useful for our profit calculations.

5. Our estimate of the net profits of established supermarkets is based on ORFC and SMIS data. This data includes the operating results of new supermarkets as well as that of older supermarkets.

6. ORFC, 1975-76, p.93.

7. The costs of warehouse operations include the costs of receiving, checking, storing, selecting, and loading of merchandise and supplies

for distribution to the stores, and exclude employee benefits and occupancy costs. ORFC, 1975-76, p.93.

8. The costs of transportation operations include the costs of operating a fleet of vehicles for the delivery of merchandise to stores. Hired hauling is included in this cost category, but employee benefits and garage occupancy are excluded. ORFC, 1975-76, p.93.

9. Merchandising and buying costs include all of the costs (excluding employee benefits and occupancy) of developing merchandise and pricing policies and the procurement of all items sold or consumed in the stores. This cost category also includes the costs of all buyers, merchandising managers, and clerical and administrative assistants. ORFC, 1975-76, p.93.

10. Advertising and sales promotion costs include all of the costs (excluding employee benefits and occupancy) relating to advertising and display, sales promotion, customer relations, and public relations, and all other costs incurred to attract and retain customers. ORFC, 1975-76, p.93.

11. Accounting and office services costs include all costs (excluding employee benefits and occupancy) of accounting and bookkeeping activities including tabulating, internal auditing, store inventory taking and processing, budgeting, and all similar activities usually performed by the controller's office. Also included are the costs of office services such as mail room, telephone switchboard, general office supplies, etc. ORFC, 1975-76, p.93.

12. General administration costs include the costs of all central office activities not provided for in other cost categories. Included here are the costs and expenses of corporate officers, staff, personnel administration, insurance administration, real estate management, design and construction, research and development, legal and financial, etc. ORFC, 1975-76, p.93.

13. Field supervision costs include all of the costs (excluding employee benefits and occupancy) of the employees engaged in the supervision and administration of the stores. Included here are the costs of the superintendent of stores, regional, divisional, or district managers and supervisors, field merchandisers and specialists, and the clerical and administrative assistants of such employees, whether stationed in the field or at the home office. ORFC, 1975-76, p.93.

14. Employee benefits include the costs for fringe benefits of employees which arise from management policy, from negotiations with labor unions, or as a result of governmental requirements, including vacations, sick leaves, payroll taxes, personnel insurance premiums and similar payments. ORFC, 1975-76, p. 93.

15. Non-store occupancy costs include all of the non-capitalized costs relating to real estate, buildings and fixtures, and equipment, other than for store properties. ORFC, 1975-76, p.93.

16. For example, the opening of a new store by a supermarket chain firm would result in an increase in the quantity of goods which must pass through the firm's distribution network. This increase in goods is

certain to have some impact on the costs of warehouse operations, transportation operations, merchandising and buying, and accounting and office services. The opening of a new store would also necessitate an increase in labor costs and fringe benefits, and would be likely to increase the costs of field supervision and general administration. Advertising and sales promotion costs also would be expected to increase with the opening of a new store in a new area, especially if one considers the additional costs to the firm of sending out weekly advertisements to residents in the neighborhood of the new store.

17. ORFC, 1975-76, p.93. ORFC does not provide us with a definition of "non-capitalized costs." We presume that each firm reports the same figures on non-capitalized costs of store real estate, buildings, fixtures and equipment to ORFC as it reports for tax purposes.

18. "Net cost of merchandise sold is the billed or invoice cost of merchandise sold, less trade discounts (except cash discounts earned) and less returns and allowances received from manufacturers or wholesalers, plus processing expense (for such operations as produce prepackaging at the warehouse, bakery, coffee roasting, egg handling, banana ripening, etc.), and plus transportation charges." ORFC, 1975-76, p.92.

19. ORFC defines the inventory turnover rate, or stockturns, as follows: "Stockturns is the number of times the average merchandise inventory was sold during the year. The stockturns figures are

based on beginning and ending inventories (in warehouse as well as in stores) and are computed by dividing net cost of merchandise sold (as defined under gross margin) by the average inventory at cost." ORFC, 1975-76, p.92.

20. Mallen and Haberman [1975; 163-166].

21. "One, store size has little effect on store operating expenses; two, store utilization as measured in sales per square foot does have a significant effect on store costs in so far as high costs are associated with low rates of utilization and as utilization rates increase cost levels begin to decline at first and then appear to level out. These results are similar to other studies using much the same techniques (National Commission, 1967; Dooley, 1968)." Savitt [1975; 227]. Also see the National Commission on Food Marketing [1967] and Dooley [1968; 145-150].

22. If new supermarkets are primarily opened by established firms and charge the joint profit maximizing prices, while gm_E is based on competitive prices, then we would expect $gm_N > gm_E$. If new supermarkets were primarily opened by new entrants and if established firms charge joint profit maximizing prices, then we would expect $gm_N < gm_E$. We do not regard these cases as likely since 1) we would not expect new supermarkets opened by established firms to charge prices significantly different from other established firms, 2) we would not expect most new supermarkets to be opened by new entrants in any time period.

23. Profit calculations for years prior to 1970 would have been possible given further assumptions. The main difficulty is that for years prior to 1970, ORFC does not calculate costs as percentage of sales for all supermarket firms, but rather for firms with sales below $20 million, with sales between $20 million and $100 million, and with sales above $100 million. However, given the results of profit calculations for the years 1970-1976, further calculations for years prior to 1970 seemed unnecessary.

Chapter 5

THE LOCATION TEST OF PREEMPTION

5.1 Introduction

In Chapter 3 of this thesis, we developed the theory of market preemption within a nonstochastic framework. We derived the implication that if there is an anticipated increase in density in a market such that a new store (or plant) could be profitably established in that market, and if the new store would have as its neighbors other stores that an existing firm owns, then the existing firm will have an incentive to preempt the market. In addition, given the assumptions of our theory, the existing firm will act on that incentive with probability equal to one.

In this chapter of the thesis, we wish to test the locational implications of the theory of preemption. To do so, we must view preemption as a probabilistic process taking place in a stochastic world. That is, while an existing firm, under the conditions specified above, will still have an incentive to preempt the market, it may sometimes fail to act upon this incentive for a variety of reasons, i.e. unanticipated growth in the market, management miscalculation, capital constraints, etc. If existing firms frequently failed to act upon the incentive to preempt, then it might appear that the allocation of firm ownership to stores in the market is essentially random. In other words, there may not be a discernible pattern to the spatial allocation of firm ownership of stores in the market, suggesting that the probability that a store is owned by a particular firm does not depend upon neighbor relations or the sequence of past store openings. However, a preempting firm would not establish its new stores in the market in a random fashion, but rather would take account of the ex post state of neighbour relations that would exist if it established a new store in the market. Thus, preemption in a stochastic world should be viewed as a state dependent probabilistic process, meaning a process over time such that the probability that a given store is owned by a given firm depends upon the neighbor relations with other stores in the market.

There are two types of tests which we shall use in order to ascertain the nature and extent of preemption in a given market. The first type of test utilizes cross section data on store ownership and the neighbor relations between stores in a given market. We devise tests to determine if our data were generated by an independent stochastic process. The second type of test utilizes time series data on the date at which each store was established in the market, where that store was located, and which firm owned it. We devise tests to determine if our data were generated by a state dependent stochastic process.

We shall perform the cross section tests first in order to see if we may reject the hypothesis that our data were generated by an independent stochastic process. The cross section data are more readily accessible than the time series data, and the cross section test will perform a screening function for us. That is, if we cannot reject the hypothesis that our data were generated by an independent stochastic process, then there is really no need to proceed further and test for the existence of state dependence. If we may reject the hypothesis of randomness, then we shall proceed and test the hypothesis that our data were generated by a state dependent stochastic process.

The data base for all of our tests will consist of supermarket location data from the Greater Vancouver Regional District of the province of British Columbia. In the next section, we shall discuss our reasons for selecting the Greater Vancouver Regional District as the basis for our empirical work. We shall also define what we mean by a supermarket, distinguish between potential preemptors and competitive fringe firms, and provide descriptions of the supermarket firms operating within the Greater Vancouver Regional District.

5.2 The Market

5.2.1 Reasons for Selecting the Greater Vancouver Regional District as the Basis for the Empirical Work

The supermarket industry in the province of British Columbia has been chosen as the basis for testing the locational implications of the preemption hypothesis. The choice was not an arbitrary one, but rather was based on the need to have easy access to supermarket location data.[1]

The province of British Columbia may be broken down into a number of geographically distinct "sub-markets". A sub-market is assumed to contain consumers who mainly patronize stores in their sub-market, either because the distance (transportation costs) or time costs would make the patronizing of stores in other sub-markets too costly from the point of view of utility maximizing consumers. In order to conduct tests for randomness or state dependence, a set of sub-markets of British Columbia had to be chosen which conformed reasonably well to the criterion of containing consumers who mainly patronize stores in their sub-market. The four sub-markets comprising the Greater Vancouver Regional District (GVRD) were judged to be sufficiently geographically distinct to satisfy our criterion. Each sub-market is separated from its neighboring sub-market by bodies of water, and there is a small number of bridges which allow only limited access between sub-markets. In Table II, the Greater

Vancouver Regional District member municipalities are listed by sub-market.

TABLE II

MEMBER MUNICIPALITIES OF THE GVRD BY SUB-MARKET

I. Vancouver Sub-market

1) Vancouver 2) New Westminster 3) Port Coquitlam 4) Burnaby

5) Coquitlam 6) Port Moody

II. Richmond Sub-market

1) Richmond

III. North Shore Sub-market

1) North Vancouver 2) West Vancouver 3) Lions Bay

IV. Delta-Surrey Sub-market

1) Delta 2) Surrey 3) White Rock

5.2.2 Defining a Supermarket and Distinguishing Between Potential Preemptors and Competitive Fringe Firms

Our next task is to establish criteria for determining which retail food stores belong to the supermarket industry. Not all stores which sell food would automatically be classified as supermarkets. Many retail food stores would be classified as convenience stores, and hence would be excluded from our analysis. There are several competing definitions of what constitutes a supermarket. For example, the Super Market Institute in 1976 defined a supermarket as "... a departmentalized food store doing at least $1 million a year, or about $20,000 weekly."[2] Statistics Canada calls supermarkets "combination stores", and uses the following detailed definition:

> Retail businesses in which the sales of a balanced line of groceries, bakery products, dairy products, canned and/or frozen foods, prepared meats, fresh meats, fish and poultry, fresh fruits and vegetables, beer (Newfoundland and Quebec), and other food lines form the dominant business activity. Fresh meat, fish and poultry must account for at least 20% (but less than 60%) of total sales. In addition, limited lines of newspapers, magazines, paper products, soft drinks, tobacco items, health and beauty aids, housewares and other non-food articles may also be carried. However, no one commodity line, excepting beer, can account for more than 60% of total sales.[3]

(Note that the Statistics Canada definition does not insist on a given level of sales in order for a store to be classified as a combination store.) Still other definitions of a supermarket were offered by location analysts in the supermarket industry itself. Since we do not have access to individual store sales data, any definition requiring that a grocery store be classified as a supermarket only if it does a certain level of sales cannot be used. We have therefore chosen to proceed by classifying retail food stores as supermarkets on the basis of a definition which combines elements of the Super Market Institute and Statistics Canada definitions. Since we do have access to individual store size data, and since store size will be assumed to be a good proxy for sales volume, the following definition of a supermarket will be used initially for purposes of classifying data:

<u>Definition 1</u>. A firm's stores will be designated as supermarkets if the average (mean) ground floor area of all stores owned by that firm exceeds 10,000 square feet, and if they are capable of being the destination of a consumer's weekly grocery shopping trip in that they stock the goods listed in the Statistics Canada combination store definition.[4]

Having defined the criteria which will be used in determining whether a firm is a member of the supermarket industry, we must now establish the basis for identifying those firms which are the potential market preemptors. The theory of market preemption suggests that in order for a firm to be a preemptor, it should construct new stores in the market at locations which maximize the joint profits of the firm, and it should construct these stores at points in time when it would not be profitable for a new entrant to enter. Thus, potential market preempting firms may be identified by the extent to which they have opened new stores in the market over the period of time when the market was expanding, or by the number of stores which they own relative to the total number of stores comprising the industry over a given market or sub-market. On the other hand, firms belonging to the "competitive fringe" may be identified by the extent to which they have not opened new stores in the market over the period of time when the market was expanding, by the fact that it seems unreasonable to believe that the firm selected the locations of its stores in order to maximize the joint profits over all of its stores, or by the number of stores which the firm owns relative to the total number of stores comprising the industry over a given market or sub-market. For example, we would immediately classify all supermarkets which are independently owned and controlled as belonging to the competitive fringe.

5.2.3 Supermarket Firms Operating in the GVRD

On the basis of the aforementioned criteria, we may identify three supermarket firms which may be regarded as capable of pursuing a preemptive location strategy in some sub-market of British Columbia. The first such firm is Canada Safeway, Ltd., a wholly owned subsidiary of Safeway Stores, Inc., which is based in the United States. Canada Safeway, Ltd., is broken up into geographic divisions and each division is responsible for conducting its own location analysis and for making recommendations regarding new store construction.[5] Final decisions on the construction of new stores are made by Safeway Stores, Inc., the U.S. parent company. As of March, 1978, Canada Safeway owned and operated 87 stores in British Columbia, 46 of which were in the four sub-markets comprising the GVRD. Canada Safeway also owns and operates its own warehousing and procurement agent, Macdonalds Consolidated.

The second firm is Overwaitea, a subsidiary of Neonex, Ltd. Overwaitea is a provincially based supermarket chain firm, and as of March, 1978, it owned and operated 40 Overwaitea stores and 6 Your Mark-it Food Stores throughout British Columbia. Of these, 3 Overwaitea stores and 3 Your Mark-it Food Stores were located in the four sub-markets comprising the GVRD.[6] Overwaitea also handles its own warehousing and distribution.

The third firm capable of pursuing a preemptive location strategy in British Columbia is Kelly Douglas & Company, Ltd., a subsidiary of George Weston, Ltd. Kelly Douglas not only owns and operates its own supermarkets under the Super Valu, Shop Easy, and Economart names, but it also grants franchises to independent supermarket operators under the Super Valu and Shop Easy names. We have chosen to regard all of the Kelly Douglas owned and franchised stores as having been located according to a joint profit maximizing location strategy. The reasons are as follows: Most of the Kelly Douglas franchise stores are offered to independents on the basis of locations which are pre-selected by Kelly Douglas, although occasionally an independent in possession of an existing store will approach Kelly Douglas for a franchise. The only major difference between franchise stores and corporate owned stores, besides ownership, is size. The franchise stores tend to be smaller, since few independent operators can meet the capital requirements of owning and operating the larger stores.[7] Thus, there is little basis for classifying the franchise stores as belonging to firms which are members of the competitive fringe, given that Kelly Douglas uses the same site selection procedure for most of its franchise stores as it does for its corporate owned stores, and given that the decision to franchise a store is made on the basis of its size and not its location. Kelly Douglas store ownership figures appear in Table III and Table IV.

All other supermarket firms which operate in British Columbia will be designated as belonging to the competitive fringe, and we shall briefly describe the competitive fringe firms which have stores located in the GVRD. The largest competitive fringe firm is represented by the H. Y. Louie Company, Ltd. H. Y. Louie itself is predominantly a service organization, acting as distributor and consultant to independently owned IGA (Independent Grocers Association) supermarkets. H. Y. Louie grants IGA franchises to independent operators in British Columbia for IGA Canada, Ltd., provided the potential franchisee meets certain minimum standards. Some of the IGA stores are owned by the H. Y. Louie Company, these stores consisting mainly of those taken over by the corporation from franchisees who could not meet their contractual obligations. H. Y. Louie does not view itself as a supermarket chain firm and does not engage in location analysis.[8]

The second largest competitive fringe firm operating in the GVRD is Woodward's. Woodward's is primarily a department store chain firm, but it does operate a number of "food floors", all but one of which are attached to its department stores. Hence, it seems reasonable to presume that Woodward's has located its food floors in order to increase its department store revenues and profits by taking advantage of the demand externalities created by having the two operations located next to each other.

The remaining two competitive fringe firms are Stong's, which owns five stores in the GVRD, and High-Low, which owns four. Both firm's stores are widely scattered throughout the GVRD, and hence neither firm can be regarded as a potential preemptor of any sub-market of the GVRD. Store ownership figures by firm for British Columbia and the sub-markets comprising the GVRD appear in Table III and Table IV.

TABLE III

STORE OWNERSHIP BY FIRM--BRITISH COLUMBIA (B.C.)

Firm	Number of Stores in B.C.
Canada Safeway (Firm F_s)	87
Overwaitea (Firm F_o)	46
Kelly Douglas (Firm F_k)	
Super Valu (Corporate)	35
Super Valu (Franchise)	47
Shop Easy (Corporate)	7
Shop Easy (Franchise)	22
Economart (Corporate)	3
Total:	247

TABLE IV

STORE OWNERSHIP BY FIRM--GVRD SUB-MARKETS

Firm	Sub-markets: Vancouver	Delta-Surrey	North Shore	Richmond
Canada Safeway (Firm F_s)	30	7	4	5
Overwaitea (Firm F_o)	3	2	0	1
Kelly Douglas (Firm F_k)	22	9	6	2
Competitive Fringe (cf)				
IGA	16	3	2	2
Woodward's	4	1	1	1
Stong's	2	0	3	0
High-Low	2	2	0	0
Total:	79	24	16	11

Before proceeding further, it should be noted that Table III does not contain a figure for the number of stores comprising the competitive fringe in B.C. In order to determine the precise number of competitive fringe stores in B.C., it would be necessary to visit personally every town and city in B.C. in order to assess whether or not a given retail food store was a supermarket. Such a procedure was deemed impractical, and we have therefore chosen to estimate the number of competitive fringe stores in B.C. in the following manner: We make the assumption that the number of competitive fringe stores in B.C. is proportional to population. The population of the GVRD in 1976 was 1,085,242, while the population of B.C. was 2,466,608. Thus, approximately 44% of the people living in B.C. resided in the GVRD in 1976, and it is assumed that the observed number of competitive fringe stores in the GVRD, 39, is 44% of the total number of competitive fringe stores in B.C. We have therefore assumed that there are 89 competitive fringe stores in B.C.

In the next section, we discuss the testing procedure, test statistics, and test results of the null hypothesis that our observations on store ownership were generated by an independent stochastic process. We shall conduct the tests for each sub-market of the GVRD separately, as well as for all sub-markets combined. Thus, when we refer to the test results for the GVRD, we shall be referring to tests based on our observations of the spatial allocation of firm ownership throughout the GVRD, disregarding sub-market boundaries.

5.3 The Test of Random Firm Ownership

5.3.1 Motivation for the Test

In this section and the next, we shall devise tests in order to determine whether our observations on firm ownership and neighbor relations were generated by an independent stochastic process. In order to facilitate our discussion, we shall utilize the following framework: Assume that there are j firms which own and operate stores in some spatially extended market, A. These j firms will be defined as constituting an industry because they sell the same vector of goods. The market A is assumed to be made up of U geographically distinct sub-markets, indexed A_u $(u = 1,2,\ldots,U)$, where (as stated earlier) each sub-market is assumed to contain consumers who mainly patronize stores in their sub-market, either because the distance (transportation costs) or time costs would make the patronizing of stores in other sub-markets too costly from the point of view of utility maximizing consumers. We may now define the relative frequency f_i as being the number of stores that firm F_i $(i = 1,2,\ldots,j)$ owns in market A (n_i) divided by the number of stores in market A $(\sum_{i=1}^{j} n_i)$ or

$$(5.1) \qquad f_i = \frac{n_i}{\sum_{i=1}^{j} n_i} \qquad\qquad i = 1,2,\ldots,j, \quad \sum_{i=1}^{j} n_i = n \; .$$

Using this framework, we may be a bit more precise about what we mean by random firm ownership. Consider first what might be deemed the antithesis of random firm ownership, perfect preemption. If some firm has perfectly preempted some sub-market A_u of A, then unless that firm owns all of the stores in market A, there must necessarily be some divergence between the relative frequency of the preempting firm's stores in A_u and the relative frequency of the preempting firm's stores in A. The magnitude of this discrepancy will of course depend upon the extent to which the preempting firm has preempted other sub-markets in A. Now consider a more realistic situation where market A is dominated by the stores of several large firms, and no firm has perfectly preempted any sub-market. If the spatial allocation of firm ownership of these stores was completely random over all sub-markets of A, then we would expect the relative frequency of any firm's stores in a given sub-market to be insignificantly different from the relative frequency of that firm's stores in A. In other words, we would observe the complete absence of a given firm's stores being concentrated in any particular sub-market of A. This is what we mean by random firm ownership of stores, and the hypothesis of random firm ownership that will be tested in this section is formalized next.

5.3.2 Statement of the Null Hypothesis of Random Firm Ownership of Stores

The null hypothesis of random firm ownership which we shall test is as follows: Each firm's stores in some market A are randomly distributed over any arbitrarily chosen, but well defined, sub-markets of A. This random distribution of store ownership was generated by a stochastic process such that the probabilities that any given store in A is owned by firm $F_1, F_2, \ldots, F_j$ are equal to the relative frequencies $f_1, f_2, \ldots, f_j$. Thus, the probabilities that any given store is owned by firm $F_1, F_2, \ldots, F_j$ are constant and invariant with respect to which firm or firms own neighboring stores. Henceforth, these probabilities will be referred to as the set of state independent probabilities. The null hypothesis implies that firms neither collude in order to divide up the market rationally among themselves or consciously pursue a strategy of preempting the store locations in any particular sub-market.

The alternative hypothesis is that the distribution of firm ownership of stores in any arbitrarily chosen sub-market of A was generated by a state dependent probabilistic process such that the probabilities that a given store in any sub-market of A is owned by firm $F_1, F_2, \ldots, F_j$ depend upon the neighbor relations of that store with other stores in the sub-market.

Rejection of the null hypothesis will be interpreted to imply that some form of state dependence was responsible for generating our observations, although the structure of the null hypothesis prevents us from being precise about the specific nature of the dependence. While a preemptive process is necessarily a state dependent process, a state dependent process need not be preemptive, and thus rejection of the null hypothesis does not permit us to conclude that preemption exists.

Rejection of the null hypothesis for a given sub-market A_u of A also implies that the observed relative frequencies of each firm's stores in that sub-market are significantly different from the relative frequencies f_i of each firm's stores in market A. This must mean that one or more firms are relatively over-represented in A_u while one or more firms are relatively under-represented in A_u vis-a-vis the distribution of firm ownership of stores that would be generated by a random process based on the f_i. Thus, rejection of the null hypothesis would allow us to conclude that one or more firms' stores are relatively concentrated in A_u, but it would not allow us to conclude that a preemptive state dependent process was responsible for this concentration.

We shall now proceed to a discussion of the testing procedure of the null hypothesis of random firm ownership of stores.

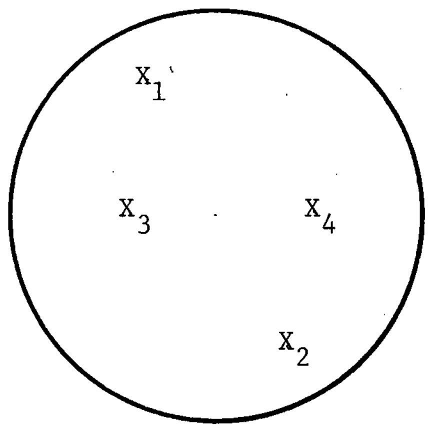
5.3.3. Testing Procedure for the Null Hypothesis When the Number of Stores in the Sub-market Is Small

In this sub-section, we shall use an example in order to illustrate the concepts and rationale behind the procedures employed to test the null hypothesis of random firm ownership of stores. Our example will utilize the following framework: Assume that there are two firms, F_1 and F_2, which own and operate stores in some spatially extended market A. These two firms will be assumed to sell the same vector of goods at the same prices. The market A is assumed to be made up of U geographically distinct sub-markets, A_u. Both firm F_1 and firm F_2 will be assumed to own one half of the stores in market A, and thus $f_1 = f_2 = \frac{1}{2}$.

If each firm's stores are randomly distributed over all sub-markets of A, then we would expect the relative frequency of stores owned by firm F_1 and firm F_2 in any given sub-market to be insignificantly different from 1/2. On the other hand, if firm F_1 or firm F_2 has preempted a given sub-market, then we would expect the relative frequency of stores owned by F_1 or F_2 in that sub-market to be significantly different from 1/2, and we would expect the preempting firm to have stores relatively concentrated in the sub-market vis-a-vis the f_i.

Now let us focus on how we might test the null hypothesis that the distribution of firm ownership of stores in a particular sub-market of A was generated by a random process based on the f_i. Consider the sub-market depicted in Figure 8, where the X_i represent store locations.

Figure 8



Our first step is to generate the random distribution of firm ownership for this sub-market that is implied by a random process based on the state independent probabilities, f_1 and f_2. This random distribution is generated by finding all of the possible permutations of firm ownership of the four stores in the sub-market and the respective probability of occurrence of each permutation. Since the probability is ½ that any given store will be owned by firm F_1 or firm F_2, each permutation will have an equal probability of occurring. There are sixteen possible permutations of firm ownership of the four stores, and these are listed in Table V.

TABLE V

PERMUTATIONS OF FIRM OWNERSHIP

	X_1	X_2	X_3	X_4		X_1	X_2	X_3	X_4
1)	F_1	F_1	F_1	F_1	9)	F_2	F_1	F_1	F_1
2)	F_1	F_1	F_1	F_2	10)	F_2	F_1	F_2	F_1
3)	F_1	F_1	F_2	F_1	11)	F_2	F_2	F_1	F_1
4)	F_1	F_2	F_1	F_1	12)	F_2	F_1	F_1	F_2
5)	F_1	F_1	F_2	F_2	13)	F_2	F_2	F_2	F_1
6)	F_1	F_2	F_1	F_2	14)	F_2	F_2	F_1	F_2
7)	F_1	F_2	F_2	F_1	15)	F_2	F_1	F_2	F_2
8)	F_1	F_2	F_2	F_2	16)	F_2	F_2	F_2	F_2

In Table VI, we provide a summary of the probabilities that given numbers of stores will be owned by firm F_1 and firm F_2. The table was constructed on the basis of the fact that each permutation has a probability .0625 of occurring.

TABLE VI

SUMMARY OF PROBABILITIES

$Pr(n_1 = 4 \text{ and } n_2 = 0) = .0625$

$Pr(n_1 = 3 \text{ and } n_2 = 1) = .2500$

$Pr(n_1 = 2 \text{ and } n_2 = 2) = .3750$

$Pr(n_1 = 1 \text{ and } n_2 = 3) = .2500$

$Pr(n_1 = 0 \text{ and } n_2 = 4) = .0625$

(Note that n_i in Table VI represents the number of stores owned by firm f_i in the sub-market of Figure 8. The subscript representing the sub-market has been suppressed for expositional clarity.)

We now wish to single out those observations which would lead us to reject the null hypothesis. If our criterion for rejection is that an observation have less than a ten percent probability of occurring, then we find that there are two observations which would lead us to reject the null hypothesis: a) if firm F_1 owns four stores and firm F_2 owns zero stores; b) if firm F_1 owns zero stores and firm F_2 owns four stores. Thus, in this example, only perfect preemption would lead us to reject the null hypothesis that our observations were generated by a random process based on the f_i.

Before proceeding further, we should note that the distribution described in Table VI is binomial. That is

$$(5.2) \qquad g(n_1) = \left\{ (n_1 + n_2)!/n_1!n_2! \right\} (f_1)^{n_1} (f_2)^{n_2}$$

where n_i = the number of stores owned by firm F_i in the sub-market of Figure 8. The binomial distribution has the following moments:

$$(5.3)\qquad \begin{aligned} E(n_i) &= \mu_i = (n_1 + n_2)f_i \\ V(n_i) &= \sigma_i^2 = (n_1 + n_2)f_1f_2. \end{aligned}$$

If more than two firms were assumed to own stores in market A, then the random distribution of firm ownership for the sub-market depicted in Figure 8 would have been multinomial.

(5.4)

$$g(n_1,n_2,\ldots,n_j) = [(\Sigma n_i)!/n_1!n_2!\ldots n_j!]\ (f_1)^{n_1}(f_2)^{n_2}\ldots(f_j)^{n_j}.$$

When there are only two firms which own stores in market A, we may use the binomial distribution in order to calculate the probabilities that given numbers of stores will be owned by each firm. We may then do a one-tailed test of the null hypothesis of random firm ownership. This test would involve determining if the probability of observing either an $N_1 > n_1$ or an $N_2 > n_2$ was less than .10. When the number of firms which own stores in market A is greater than two, it would still be possible to calculate the probability that $N_1 = n_1$, $N_2 = n_2,\ldots,N_j=n_j$ for different values of the n_i. However, when the number of stores in a given sub-market is large, it would be impractical to calculate the exact multinomial distribution corresponding to the f_i. More importantly, even if we only wished to calculate the density in that part of the multinomial distribution which represented values of the n_i more "extreme" than our observations, it is unclear what the proper critical region should be and what significance level we should choose. In the next sub-section, we discuss two procedures for testing the null hypothesis of random firm ownership which do not require knowledge of the exact shape of the multinomial distribution. The first testing procedure may be used when the number of stores in the sub-market is large, and only requires that we know the observed n_i and the set of state independent probabilities. The second testing procedure will be based on generating an approximation to the exact random distribution of firm ownership which does not rely on the calculation of all of the multinomial probabilities. The second testing procedure may be used when the number of stores in the sub-market is too small to use the first testing procedure.

5.3.4 Testing Procedure and Test Statistics for the Null Hypothesis When the Number of Stores in the Sub-market Is Large

In the previous sub-section, our procedure for finding the exact random distribution of firm ownership was based on listing all of the possible permutations of firm ownership when there are only two firms which own stores in market A. However, as $\sum_{i=1}^{j} n_{iu}$, the number of stores in sub-market A_u, becomes large, and with more than two firms in A, the number of possible permutations of firm ownership rapidly escalates and it would not be practical to find the exact shape of the multinomial distribution corresponding to the null hypothesis. In addition, as pointed out at the end of the last sub-section it is unclear what the critical region of this distribution should be or what significance level we should choose.

There are two related approaches we may take in order to test the null hypothesis when $\sum_{i=1}^{j} n_{iu}$ is large and when there are more than two firms in the market. The first approach is to do a chi-square test for goodness of fit of the null hypothesis. Given the way we have stated the null hypothesis, we are really interested in testing whether our observations on firm ownership of stores in a given sub-market, $n_{1u}, n_{2u}, \ldots, n_{ju}$, are compatible with the expected values, $e_{1u}, e_{2u}, \ldots, e_{ju}$. The expected values are formed by taking the products of the number of stores in sub-market A_u and the probabilities that a given store is owned by firm

$F_1, F_2, \ldots, F_j$, or

$$(5.5) \qquad e_{iu} = \left(\sum_{i=1}^{j} n_{iu}\right) f_i \quad .$$

"Theorem. If $n_{1u}, n_{2u}, \ldots, n_{ju}$ and $e_{1u}, e_{2u}, \ldots, e_{ju}$ represent the observed and expected frequencies, respectively, for the j possible outcomes of an experiment that is to be performed n times, then as n becomes infinite, the distribution of the random variable

$$(5.6) \qquad \sum_{i=1}^{j} (n_{iu} - e_{iu})^2 / e_{iu}$$

will approach that of a chi-square variable with j=1 degrees of of freedom."[9]

Thus, given n_{iu} and e_{iu}, we need only calculate (5.6) and then determine whether this value exceeds the critical value of chi-square that is obtained from a table of critical values of the chi-square distribution. If it does, then we would reject the null hypothesis that our observations on the firm ownership of stores in sub-market A_u were generated by a random process based on the f_i. The upper tail of the chi-square distribution is the accepted critical region for purposes of hypothesis testing, and Kendall and Stuart justify this choice from the point of view of its asymptotic power.[10]

According to Hoel and others, as long as $j \geq 5$ and $e_{iu} \geq 5$, the chi-square distribution will provide a satisfactory approximation to the exact distribution of the quantity given by (5.6). If $j < 5$, then the e_{iu} should be slightly larger than 5.[11] Walker and Lev have stated additional guidelines to insure that the approximation is good.

> "If there are 2 or more degrees of freedom and the expectation in each cell is more than 5, the chi-square table assures a good approximation to the exact probabilities. If there are 2 or more degrees of freedom and roughly approximate probabilities are acceptable for the test of significance, an expectation of only 2 in a cell is sufficient. If there are more than 2 degrees of freedom and the expectation in all the cells but one is 5 or more, then an expectation of only one in the remaining cell is sufficient to provide a fair approximation to the exact probabilities."[12]

Looking back at the data in Table IV, it is clear that the expected frequencies for the Richmond, North Shore, and Surrey-Delta sub-markets will not all exceed 5. In addition, it seems unreasonable to regard the f_i for B.C. as being approximately equal. Thus, we cannot do the chi-square test of the null hypothesis for these sub-markets since the expected frequencies for these sub-markets violate the criteria which insure that the chi-square distribution will provide a satisfactory approximation to the exact distribution of the quantity given by (5.6). However, there is an alternative procedure which may be used to test the null hypothesis when $\sum_{i=1}^{j} n_{iu}$ is too large to find the exact shape of the random distribution, yet too small to do the chi-square test, and when the number of firms in the market is greater than two. This alternative procedure entails generating an approximation to the shape of the true distribution, converting the generated distribution into the distribution of the quantity given by (5.6), and then finding where our observations lie within this distribution. We shall call this alternative testing procedure the X^2 test, and we shall now proceed to discuss it in more detail.

Let us define a draw as consisting of the assignment of firm ownership to one store in some sub-market A_u. Define a permutation as consisting of one complete assignment of firm ownership to all of the stores in some sub-market A_u, or the set of draws of the $\sum_{i=1}^{j} n_{iu}$ stores in A_u. Using the computer, we may generate a "large" number of random permutations of firm ownership, where the draws for each permutation are made on the basis of a set of fixed probabilities equal to the f_i of market A. From the list of permutations so generated, we may easily calculate the number of stores drawn for each firm in each permutation. The joint distribution of the numbers of stores drawn for each firm in each permutation will constitute our estimate of the true distribution.

Our next step is to convert our estimate of the true distribution into the distribution of the quantity given by (5.6). We do so by calculating $\sum_{i=1}^{j} (\tilde{n}_{iu} - \bar{n}_{iu})^2/\bar{n}_{iu}$ for each randomly generated permutation, where $\tilde{n}_{iu}$ = the randomly generated number of stores owned by firm F_i in sub-market A_u, and $\bar{n}_{iu}$ = the mean number of stores generated for firm F_i in sub-market A_u, or

$$(5.7) \qquad \bar{n}_{iu} = \sum_{\text{permutations}} \tilde{n}_{iu}/\text{number of permutations} .$$

That is, suppose Table VII represents the first three permutations of firm ownership in some sub-market A_u.

TABLE VII

THREE RANDOM PERMUTATIONS OF FIRM OWNERSHIP

	$\tilde{n}_{1u}$	$\tilde{n}_{2u}$	$\tilde{n}_{3u}$	$\tilde{n}_{4u}$
(1)	7	10	8	12
(2)	8	11	13	5
(3)	10	8	6	13

For each row of Table VII, we may compute the quantity $\sum_{i=1}^{4} (\tilde{n}_{iu} - \bar{n}_{iu})^2/\bar{n}_{iu}$, given that we have already computed $\bar{n}_{iu}$ for each firm. We may then plot the distribution of this quantity. Finally, we calculate $\sum_{i=1}^{4} (n_{iu} - \bar{n}_{iu})^2/\bar{n}_{iu}$, where n_{iu} = the observed number of stores owned by firm F_i in sub-market A_u, and we find where this statistic lies in the distribution of $\sum_{i=1}^{4} (\tilde{n}_{iu} - \bar{n}_{iu})^2/\bar{n}_{iu}$. If, for example, the statistic lies in the 10% right tail of the distribution, we would reject the null hypothesis that our observations were generated by a random process based on the f_i. By choosing the 10% right tail of the distribution as the critical region, we are choosing to let the type I error equal 10%. There is a well known trade off between the type I error, the probability of rejecting the null hypothesis when it is actually true, and the type II error, the probability of accepting the null hypothesis when the alternative hypothesis is true, such that the size of the type II error increases as the size of the type I error decreases. By tolerating a relatively small type I error, we therefore bias the test towards accepting the null hypothesis. From the point of view of our hypothesis testing, this is desirable since we wish to be confident that we are rejecting a false null hypothesis.[13]

What is the intuitive interpretation behind using the X^2 test as a test of the null hypothesis? First, we note that the chi-square statistic is essentially a measure of the discrepancy between observed and expected values.[14] The larger is the discrepancy between observed and expected values in relation to the expected values, the larger will be the contribution of the term $(n_{iu} - e_{iu})^2/e_{iu}$ to the chi-square statistic. This interpretation also holds for the X^2 test. Thus, we may focus on the individual terms making up the observed X^2 statistic, $\sum_{i=1}^{j} (n_{iu} - \bar{n}_{iu})^2/\bar{n}_{iu}$, in order to assess the nature of the discrepancies between observed and mean number of stores owned by each firm which are leading us to either accept or reject the null hypothesis. This sort of analysis will give us a feel for the positions of firms in sub-market A_u relative to the f_i and relative to each other.

One final comment regarding the X^2 test is in order. We have noted that we cannot do the standard chi-square test for the Richmond, North Shore, and Delta-Surrey sub-markets because the expected frequencies are too small. However, the expected frequencies for the GVRD and the Vancouver sub-market are large enough to insure that the chi-square distribution will provide a good approximation to the quantity given by (5.6). We may therefore use the results from the chi-square test as a check against the results of the X^2 test in the Vancouver sub-market and the GVRD in order to insure that our computer program is providing an accurate estimate of the true distribution. In other words, since the chi-square distribution is an approximation to the distribution of the X^2 statistics which we generate, and since this approximation should be a good one provided the number of stores in the sub-market and the number of randomly generated permutations is large, the chi-square test and the X^2 test should yield approximately the same results. Finally, we should note that while generating the distributions of the X^2 statistics is not a necessity for the GVRD and the Vancouver sub-market in order to test the null hypothesis of random firm ownership, these distributions will be necessary in order to test a related hypothesis in a later section of this chapter.

One question which must be confronted before reporting the results from the X^2 tests is as follows: How many random permutations of firm ownership are necessary to insure that the approximation of the generated distribution to the true distribution is a good one? One way of approaching this question is to compare the results of the chi-square test and the X^2 test for the GVRD for different numbers of permutations. As stated above, if the approximation is good, both tests should yield nearly the same results. In Table VIII, we report the results of the standard chi-square test and the results of the X^2 test for varying numbers of permutations for the GVRD. Each sum in Table VIII is over j firms, and, henceforth, the jth firm will represent the competitive fringe.

As we can see, the results from the chi-square test and the X^2 tests based on different numbers of permutations of firm ownership are virtually identical. We may conclude from this that as few as 250 permutations of firm ownership will provide a good approximation to the true shape of the random distribution of firm ownership.[15] However, we shall use 1000 permutations in order to generate our random distributions of firm ownership, in part because the accuracy of the estimate to the

TABLE VIII

RESULTS OF THE CHI-SQUARE TEST AND THE X^2 TEST FOR

THE GVRD--PERMUTATIONS = 250, 500, 750, 1000

Chi-square Test

$$\sum_{i=1}^{4} (n_i - e_i)^2/e_i = (46 - 33.661)^2/33.661 + (6 - 17.798)^2/17.798$$

$$+ (39 - 44.107)^2/44.107 + (39 - 34.434)^2/34.434$$

$$= 13.540549$$ lies in the 1% tail of the chi-square distribution with three degrees of freedom.

X^2 Tests

250 Permutations

$$\sum_{i=1}^{4} (n_i - \bar{n}_i)^2/\bar{n}_i = (46 - 34.044)^2/34.044 + (6 - 17.924)^2/17.924$$

$$+ (39 - 43.512)^2/43.512 + (39 - 34.520)^2/34.520$$

$$= 13.1806266$$

% of $\sum_{i=1}^{4} (\tilde{n}_i - \bar{n}_i)^2/\bar{n}_i$ distribution to right of 13.1806266 = .4%.

500 Permutations

$$\sum_{i=1}^{4} (n_i - \bar{n}_i)^2/\bar{n}_i = (46 - 33.914)^2/33.914 + (6 - 17.606)^2/17.606$$

$$+ (39 - 44.016)^2/44.016 + (39 - 34.464)^2/34.464$$

$$= 13.1264939$$

% of $\sum_{i=1}^{4} (\tilde{n}_i - \bar{n}_i)^2/\bar{n}_i$ distribution to right of 13.1264939 = .8% .

Table VIII (continued)

750 Permutations

$$\sum_{i=1}^{4} (n_i - \bar{n}_i)^2/\bar{n}_i = (46 - 33.543)^2/33.543 + (6 - 17.737)^2/17.737$$
$$+ (39 - 44.095)^2/44.095 + (39 - 34.625)^2/34.625$$
$$= 13.5343668$$

% of $\sum_{i=1}^{4} (\tilde{n}_i - \bar{n}_i)^2/\bar{n}_i$ distribution to right of 13.5343668 = .4% .

1000 Permutations

$$\sum_{i=1}^{4} (n_i - \bar{n}_i)^2/\bar{n}_i = (46 - 33.49)^2/33.49 + (6 - 17.761)^2/17.761$$
$$+ (39 - 44.433)^2/44.433 + (39 - 34.316)^2/34.316$$
$$= 13.764613$$

% of $\sum_{i=1}^{4} (\tilde{n}_i - \bar{n}_i)^2/\bar{n}_i$ distribution to right of 13.764613 = .4% .

true distribution increases as we increase the number of permutations, and in part because we shall need the larger number of permutations for a related test of randomness, to be discussed in a later section of this chapter.

5.3.5 Test Results of the Null Hypothesis for the GVRD and Constituent Sub-markets

In this sub-section, we report the results obtained from testing the null hypothesis that our observations on firm ownership of stores were generated by a random process based on the f_i. Our observations on firm ownership in each sub-market were reported in Table IV, and the f_i used to generate the random distributions are listed in Table IX.

TABLE IX

RELATIVE FREQUENCIES OF EACH FIRM'S STORES IN B.C.

Firm	Relative Frequency
Canada Safeway (Firm F_s)	87/336 ≈ .2589285
Overwaitea (Firm F_o)	46/336 ≈ .1369048
Kelly Douglas (Firm F_k)	114/336 ≈ .3392858
Competitive Fringe (c.f)	89/336 ≈ .2648809

In Table X, we provide descriptive measures for the marginal distributions of firm ownership generated for each sub-market and for the GVRD. (In the two firm case, the marginal distribution, $f(n_1)$, bears the following relation to the joint distribution, $f(n_1,n_2)$: $f(n_1) = \sum_{n_2} f(n_1,n_2)$. The function $f(n_1,n_2)$ gives the probabilities that N_1 will assume the value

n_1 while at the same time N_2 will assume the value n_2.)[16] We note once again that the random distribution for the GVRD was generated separately from the distribution of firm ownership for the individual sub-markets.

TABLE X

MARGINAL DISTRIBUTION DESCRIPTIVE MEASURES BY FIRM FOR THE GVRD AND CONSTITUENT SUB-MARKETS

		Firm F_s	Firm F_o	Firm F_k	Competitive Fringe
GVRD	$\bar{n}_i$	33.490	17.761	44.433	34.316
	σ	4.7172	3.9425	5.3977	5.2090
Vancouver	$\bar{n}_i$	20.363	10.895	26.553	21.189
	σ	3.5261	3.0808	4.1649	3.7743
Delta-Surrey	$\bar{n}_i$	6.111	3.258	8.302	6.329
	σ	2.1427	1.6650	2.4014	2.2449
North Shore	$\bar{n}_i$	4.058	2.270	5.524	4.148
	σ	1.7748	1.3620	1.8770	1.7283
Richmond	$\bar{n}_i$	2.858	1.496	3.722	2.924
	σ	1.4268	1.1105	1.5294	1.4527

After translating our randomly generated distributions of firm ownership into distributions of the quantity $\sum_{i=1}^{j} (\tilde{n}_{iu} - \bar{n}_{iu})^2/\bar{n}_{iu}$, and using the information contained in Tables IV and X, we obtain the following results from doing the X^2 test of the null hypothesis.

TABLE XI

RESULTS OF THE X^2 TESTS OF THE NULL HYPOTHESIS OF RANDOM FIRM OWNERSHIP BY GVRD AND SUB-MARKETS

GVRD

Firm F_s	Firm F_o	Firm F_k	cf
$\frac{(46 - 33.49)^2}{33.49}$	$\frac{(6 - 17.761)^2}{17.761}$	$\frac{(39 - 44.433)^2}{44.433}$	$\frac{(39 - 34.316)^2}{34.316}$
4.6730397	7.7879128	.6643145	.6393477

$$\sum_{i=1}^{j} (n_i - \bar{n}_i)^2/\bar{n}_i = 13.764613$$

(13.540544)*

% of $\sum_{i=1}^{j} (\tilde{n}_i - \bar{n}_i)^2/\bar{n}_i$ distribution to right of 13.764613 = .4%

Vancouver

Firm F_s	Firm F_o	Firm F_k	cf
$\frac{(30 - 20.363)^2}{20.363}$	$\frac{(3 - 10.895)^2}{10.895}$	$\frac{(22 - 26.553)^2}{26.553}$	$\frac{(24 - 21.189)^2}{21.189}$
4.5608091	5.721067	.7806955	.3729161

$$\sum_{i=1}^{j} (n_i - \bar{n}_i)^2/\bar{n}_i = 11.435487$$

(11.413771)

% of $\sum_{i=1}^{j} (\tilde{n}_i - \bar{n}_i)^2/\bar{n}_i$ distribution to right of 11.435487 = .9%

* The figure in parentheses is the result obtained by calculating the chi-square statistic, $\sum_{i=1}^{j} (n_i - e_i)^2/e_i$.

Table XI (continued)

Delta-Surrey

Firm F_s	Firm F_o	Firm F_k	cf
$\frac{(7 - 6.111)^2}{6.111}$	$\frac{(2 - 3.258)^2}{3.258}$	$\frac{(9 - 8.302)^2}{8.302}$	$\frac{(6 - 6.329)^2}{6.329}$
.1293276	.485747	.0586851	.0171023

$$\sum_{i=1}^{j} (n_i - \bar{n}_i)^2/\bar{n}_i = .690862$$

(.7129479)

% of $\sum_{i=1}^{j} (\tilde{n}_i - \bar{n}_i)^2/\bar{n}_i$ distribution to right of .690862 = 87.3%

North Shore

Firm F_s	Firm F_o	Firm F_k	cf
$\frac{(4 - 4.058)^2}{4.058}$	$\frac{(0 - 2.27)^2}{2.27}$	$\frac{(6 - 5.524)^2}{5.524}$	$\frac{(6 - 4.148)^2}{4.148}$
.0008289	2.27	.0410166	.8268813

$$\sum_{i=1}^{j} (n_i - \bar{n}_i)^2/\bar{n}_i = 3.1387268$$

(2.987564)

% of $\sum_{i=1}^{j} (\tilde{n}_i - \bar{n}_i)^2/\bar{n}_i$ distribution to right of 3.1387268 = 38.6%

Table XI (continued)

Richmond			
Firm F_s	Firm F_o	Firm F_k	cf
$\frac{(5 - 2.858)^2}{2.858}$	$\frac{(1 - 1.496)^2}{1.496}$	$\frac{(2 - 3.722)^2}{3.722}$	$\frac{(3 - 2.924)^2}{2.924}$
1.6053757	.1644491	.796691	.0019753

$$\sum_{i=1}^{j} (n_i - \bar{n}_i)^2/\bar{n}_i = 2.5684911$$

(2.6024497)

% of $\sum_{i=1}^{j} (\tilde{n}_i - \bar{n}_i)^2/\bar{n}_i$ distribution to right of 2.5684911 = 48%

In Table XI, we report the individual components of the X^2 statistics $\sum_{i=1}^{j} (n_i - \bar{n}_i)^2/\bar{n}_i$ in order that the reader may easily ascertain the sign of each discrepancy and its relative contribution to the X^2 statistic. We also indicate the percentage of the generated random distribution lying to the right of the X^2 statistic, and the figures in parentheses represent our calculations of the chi-square statistic, $\sum_{i=1}^{j} (n_i - e_i)^2/e_i$. (It will be recalled that we report the results of the chi-square test in order to check the accuracy of the computer program which generates the random distributions. The reader may easily verify that the results from the chi-square test and the X^2 test are in close agreement with each other, indicating that our estimates of the true distributions are accurate.)

Looking at the results in Table XI, we see that we would reject the null hypothesis that our observations were generated by a random process based on the f_i for the Vancouver sub-market and the GVRD. These results are significant at the 1% level. We cannot reject the null hypothesis for the Richmond, North Shore, or Delta-Surrey sub-markets.

We shall delay our interpretation of these results for the time being. We wish first to test a related hypothesis that our observations on the neighbor relations in the GVRD and its constituent sub-markets were generated by an independent stochastic process. This we do in the next section.

5.4 The Test of Random Neighbor Relations

5.4.1 Motivation for the Test

In the previous section, our focus was on testing the null hypothesis that our observations on firm ownership of stores in the GVRD and constituent sub-markets were generated by an independent stochastic process based on the f_i. Note in particular that this hypothesis was concerned with the number of stores that each firm owned in each sub-market, and not with where these stores were located within the sub-market in relation to each other. However, the theory of market preemption has definite implications about the neighbor relations which should exist in a sub-market if it has been preempted by one or more firms.

Consider once again the case of perfect preemption. If some firm has perfectly preempted some sub-market A_u of A, then we would observe all of the stores in A_u having as their neighbors only other stores that the preempting firm owns. If we assume that market A is dominated by the stores of several large firms, then we would expect a significant divergence between the observed neighbor relations in sub-market A_u and the set of neighbor relations that would be generated by a random distribution of firm ownership of stores based on the f_i. However, we would not expect to observe perfect preemption in any sub-market, given the stochastic nature of the world, whence we must devise a formal test to determine the extent to which our observations on neighbor relations within given sub-markets are consistent with a random process based on the f_i. In the next sub-section, we formalize the null hypothesis of random neighbor relations that will be tested in this section.

5.4.2 Statement of the Null Hypothesis of Random Neighbor Relations

The null hypothesis of random neighbor relations which we shall test in this section is as follows: The observed set of neighbor relations in a given sub-market was generated by a random distribution of firm ownership of stores in the sub-market. This random distribution was produced by a stochastic process such that the probabilities that any given store in A is owned by firm $F_1, F_2, \ldots, F_j$ are equal to the relative frequencies $f_1, f_2, \ldots, f_j$. These probabilities are constant and invariant with respect to which firm or firms own neighboring stores.

The alternative hypothesis is that the set of observed neighbor relations in any arbitrarily chosen sub-market of A was generated by a state dependent probabilistic process such that the probabilities that a given store in any sub-market of A is owned by firm $F_1, F_2, \ldots, F_j$ depend upon the neighbor relations of the store with other stores in the sub-market.

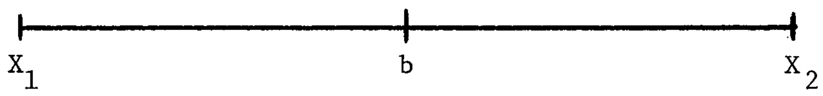
Rejection of the null hypothesis will once again be interpreted to imply that some form of state dependence was responsible for generating our observations, although the structure of the null hypothesis prevents us from being precise about the specific nature of the dependence. Rejection of the null hypothesis for a given sub-market A_u of A will also be interpreted to imply that at least one firm's stores are "clustered" in sub-market A_u. That is, at least one firm's stores are located more in proximity to each other than would be expected on the basis of a random distribution of firm ownership of stores produced by a random process based on the f_i. This interpretation will become clearer after we have operationalized the concept of neighbor relations in the next sub-section.

5.4.3 Testing Procedure for the Null Hypothesis When the Number of Stores in the Sub-market Is Small

In this sub-section, we shall extend the example of sub-section 5.3.3 in order to illustrate the concepts and rationale behind the procedures employed to test the null hypothesis of random neighbor relations. However, before doing so, we need to devise a measure of neighbor relations in order to facilitate testing of the null hypothesis.

In a one-dimensional market, the concept of neighbor relations translates into the concept of market area boundary. Consider the market described in Figure 9:

Figure 9



It is assumed that the firms located at X_1 and X_2 sell the same commodity at a common price. Then, the market area boundary between the firms located at X_1 and X_2 will be the perpendicular bisector of the market segment, X_1, X_2, represented by point b. In order to implement our tests of the null hypothesis, we shall generalize this concept of market area boundary to two dimensions with the following definitions:

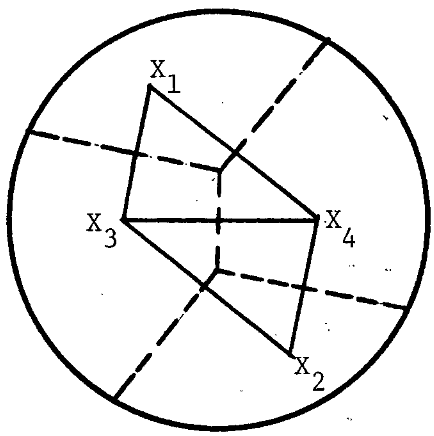
Definition 2. A boundary exists between two stores, store 1 and store 2, if some part of the perpendicular bisector of a line drawn between the locations of store 1 and store 2 lies closer to these locations than the perpendicular bisector of a line drawn between the location of store 1 and the location of any other store ℓ, and between the location of store 2, and the location of any other store ℓ.

Definition 3. A common boundary exists between two stores if a boundary exists between them, and if these two stores are owned by the same firm.

In defining market area boundary as we have in Definition 2, we have implicitly assumed that all firms charge the same vector of prices for the same vector of goods. This simplifying assumption is necessary in order to operationalize the concept of market area boundary for the purpose of generating the random distribution of market area boundaries. While we recognize that stores owned by different firms probably charge slightly different prices, small price differences would not be expected to seriously affect the quantitative results.

Let us now focus on how we might test the null hypothesis that the set of observed neighbor relations in a particular sub-market of A was generated by an independent stochastic process based on the f_i. In Figure 10, we reproduce the sub-market which appeared in Figure 8. The dashed lines are the market area boundaries of the stores located at X_1, X_2, X_3, X_4, and have been drawn in accordance with Definition 2.

Figure 10



We shall call this method of finding market area boundaries the perpendicular bisector - least distance method.

We may summarize the information about market boundaries contained in Figure 10 by constructing a boundary matrix:

$$
(5.8) \quad \begin{array}{c} \\ X_1 \\ X_2 \\ X_3 \\ X_4 \end{array}
\begin{array}{c}
\begin{array}{cccc} X_1 & X_2 & X_3 & X_4 \end{array} \\
\begin{bmatrix}
0 & & & \\
0 & 0 & & \\
1 & 1 & 0 & \\
1 & 1 & 1 & 0
\end{bmatrix}
\end{array}
$$

If two stores have a boundary with each other, then a 1 will appear in the boundary matrix. A store cannot have a boundary with itself, so 0 entries appear along the main diagonal. Since the matrix is symmetric around the main diagonal, we need not fill in the upper half of the matrix.

Our next step is to generate the random distribution of common boundaries for this sub-market that is implied by a random process based on the state independent probabilities, $f_1 = f_2 = \frac{1}{2}$. Since we have already listed all the random permutations of firm ownership of stores 1-4 in Table V, we need only use the boundary matrix in conjunction with this list of permutations in order to construct the "common boundary distribution". The common boundary distribution attaches probabilities to the occurrence of various numbers of common boundaries for each firm, given the probabilities of occurrence of the different permutations of firm ownership. For example, suppose we wished to find the probability that firm F_1 will have three common boundaries while firm F_2 will have zero. Looking at permutation (4) in Table V, we see that stores 1, 2, and 4 are all owned by firm F_1, and looking at the common boundary matrix (5.8), we see that stores 1 and 3, 1 and 4, and 3 and 4 have boundaries with each other. Thus, we have found one permutation where firm F_1 has three common boundaries, while firm F_2 has zero. This result, however, also occurs in permutation (9). Since each permutation has a .0625 probability of occurring, the probability of observing three common boundaries for firm F_1 and zero common boundaries for firm F_2 equals .125. In Table XII, we summarize our calculations of the probabilities that firms F_1 and F_2 will have various numbers of common boundaries:

TABLE XII

JOINT COMMON BOUNDARY DISTRIBUTION

$Pr(B_{11} = 5$ and $B_{22} = 0) = .0625$

$Pr(B_{11} = 3$ and $B_{22} = 0) = .1250$

$Pr(B_{11} = 2$ and $B_{22} = 0) = .1250$

$Pr(B_{11} = 1$ and $B_{22} = 1) = .2500$

$Pr(B_{11} = 1$ and $B_{22} = 0) = .0625$

$Pr(B_{11} = 0$ and $B_{22} = 1) = .0625$

$Pr(B_{11} = 0$ and $B_{22} = 2) = .1250$

$Pr(B_{11} = 0$ and $B_{22} = 3) = .1250$

$Pr(B_{11} = 0$ and $B_{22} = 5) = .0625$

B_{ii} = the number of common boundaries for firm F_i

In Table XIII, we have calculated the marginal distributions corresponding to the joint distribution of Table XII.

TABLE XIII

MARGINAL COMMON BOUNDARY DISTRIBUTIONS

$Pr(B_{11} = 5) = .0625$	$Pr(B_{22} = 5) = .0625$
$Pr(B_{11} = 3) = .1250$	$Pr(B_{22} = 3) = .1250$
$Pr(B_{11} = 2) = .1250$	$Pr(B_{22} = 2) = .1250$
$Pr(B_{11} = 1) = .3125$	$Pr(B_{22} = 1) = .3125$
$Pr(B_{11} = 0) = .3750$	$Pr(B_{22} = 0) = .3750$

Again, we wish to single out those events which, if they occurred, would lead us to reject the null hypothesis. If our criterion for rejection is that an observation on common boundaries for a firm have less than a ten percent probability of occurring, then there are two observations which would lead us to reject the null hypothesis: a) if firm F_1 has five common boundaries while firm F_2 has zero common boundaries: b) if firm F_2 has five common boundaries and firm F_1 has zero common boundaries. These results could only occur if firm F_1 and firm F_2 owned all four stores in the market, respectively, and we have already seen in sub-section 5.3.3 that such observations on firm ownership would lead us to reject the null hypothesis of random firm ownership. Thus, we have found that the same set of observations on firm ownership of stores in the sub-market depicted in Figure 10 will lead us to reject both the null hypothesis of random firm ownership and the null hypothesis of random neighbor relations.

Sometimes it may be true that the set of observations on firm ownership that will lead to rejection of the null hypothesis of random firm ownership will perfectly coincide with the set of observations on firm ownership that will lead to rejection of the null hypothesis of random neighbor relations. However, this will not always be the case.[17]

It is important to note that the random variables B_{11} and B_{22} are not independent of each other. The probability that stores 1 and 4 have a common boundary is not independent of whether or not stores 4 and 2 have a common boundary. Thus, whereas the distribution of firm ownership of stores was binomial or multinomial because the probabilities that a store is owned by firm F_1 or firm F_2 are independent, the distribution of common boundaries is not multinomial because such independence of the B_{ii} does not exist. This fact will become important in our discussion of the proper testing procedure and test statistics of the null hypothesis of random neighbor relations when the number of stores in a sub-market is large, a discussion to which we now turn.

5.4.4 Testing Procedure and Test Statistics for the Null Hypothesis When the Number of Stores in the Sub-market Is Large

In the previous sub-section, our procedure for generating the exact random common boundary distribution entailed listing all of the possible permutations of firm ownership of stores, and then finding the number of common boundaries for each firm in each permutation by using the boundary matrix. However, if $\sum_{i=1}^{j} n_{iu}$ is large, such a procedure would be impractical. In addition, since the common boundary distribution is not multinomial, we cannot use the multinomial distribution to generate the probabilities that firms F_1, F_2, ..., F_j will have given numbers of common boundaries, and we cannot do a chi-square test of the null hypothesis.

Therefore, once again the best test of the null hypothesis is the X^2 test.

The procedure for doing the X^2 test of the null hypothesis of random neighbor relations is essentially the same as that for doing the X^2 test of the null hypothesis of random firm ownership, and we may briefly describe the procedure as follows: First, we take the random permutations of firm ownership which we generated in order to find the random distribution of firm ownership, and we use the boundary matrix to find the number of common boundaries which each firm has in each permutation. The joint distribution of the number of common boundaries which each firm has in each permutation will constitute our estimate of the true common boundary distribution. Next, we convert our estimate of the true distribution into the distribution of the following quantity:

$$(5.9) \qquad \left[\sum_{i=1}^{j-1} \frac{(\tilde{B}_{ii} - \bar{B}_{ii})^2}{\bar{B}_{ii}}\right] + \frac{(\tilde{B}_{jj} - \bar{B}_{jj})^2}{\bar{B}_{jj}} + \frac{(\tilde{B}_{iI} - \bar{B}_{iI})^2}{\bar{B}_{iI}} \qquad i \neq I$$

where $\tilde{B}_{ii}$ = the number of randomly generated common boundaries which stores owned by firm F_i have with themselves, $\tilde{B}_{jj}$ = the number of randomly generated boundaries between stores owned by competitive fringe firms, and $\tilde{B}_{iI} = \sum_{i \neq I} \tilde{b}_{iI}$ = the total number of randomly generated boundaries between stores owned by different firms (including boundaries between potential preemptor firms and competitive fringe firms). Each b_{iI} represents the number of randomly generated boundaries between stores owned by firms F_i and F_I, $i \neq I$. Bars over variables indicate mean generated values. To simplify our discussion, we shall call each term in the sum given by (5.9) a "relative discrepancy".

A couple of comments regarding (5.9) are in order. First, we include the relative discrepancy between observed and mean generated boundaries between competitive fringe firms as a separate component of (5.9) because the size of this discrepancy has implications for the acceptance or rejection of randomness in a given sub-market. The theory of preemption suggests that if potential preemptor firms have been effectively preempting the market, then we should expect to observe few boundaries between stores which belong to the competitive fringe relative to the mean number of competitive fringe boundaries that would be generated by a random process based on the f_i. The reasons are as follows: In a market which has been preempted by one or more firms, we might still observe the existence of competitive fringe stores due to management miscalculation, unanticipated increases in density, etc., on the part of preempting firms. However, we would expect these stores to be primarily located such that they are bounded by established firm stores. If firm ownership were randomly distributed on the basis of the f_i, there would be no such presumption. This implies that if the relative frequency of the competitive fringe stores in a given sub-market is approximately equal to our estimate of the state independent probability, f_j, then we would expect a larger number of boundaries between competitive fringe stores when firm ownership is randomly distributed on the basis of the f_i compared to the number of competitive fringe boundaries that would exist if one or more firms have preempted the market. The larger the discrepancy between observed and mean generated competitive fringe boundaries, the less likely is it that a random process based on the f_i was responsible for generating our observations, and the better our chances may be of rejecting the null hypothesis.

Second, we include the relative discrepancy between observed and mean generated boundaries between stores owned by different firms as a separate component of (5.9) because the size of this relative discrepancy also has implications for the acceptance or rejection of randomness in a given sub-market. That is, if the distribution of firm ownership of stores in a given sub-market is completely random and based on the f_i, then we would expect fewer common boundaries between stores owned by any given firm, and consequently more boundaries between stores owned by different firms than would be the case if one or more firms have preempted the sub-market. The larger the discrepancy between observed and mean generated boundaries between stores owned by different firms, the better our chances may be of rejecting the null hypothesis.

Having converted our estimate of the true distribution into the distribution of the quantity given by (5.9), we need only find where the sum of the observed and mean generated relative discrepancies,

$$\left(\sum_{i=1}^{j} \frac{(B_{ii} - \bar{B}_{ii})^2}{\bar{B}_{ii}} \right) + \frac{(B_{iI} - \bar{B}_{iI})^2}{\bar{B}i_I}$$

, lies within this distribution. (Note that the relative discrepancy between observed and mean generated boundaries between competitive fringe stores is represented by the j-th term in the sum.) If, for example, this statistic lies within the 10% tail of the distribution, we would reject the null hypothesis that our observations on neighbor relations were generated from a random distribution of firm ownership based on the f_i.[18]

Before proceeding to report the results of the X^2 tests of the null hypothesis, we must once again confront the question of how many random permutations of firm ownership are necessary in order to insure that the approximation of the generated distribution to the true distribution is a good one. However, unlike the random distribution of firm ownership, we do not know the theoretical form of the common boundary distribution (and thus we cannot compare the results from the X^2 test with the results from some other test like the chi-square in order to determine if our approximation is good). Therefore, we propose to take the following alternative approach: First, we know that the accuracy of the estimate of the true distribution should increase as we increase the number of permutations. So, our first step would be to compare the cumulative frequencies at different points in the marginal distributions of common boundaries for different numbers of permutations in order to see if there are any "major" discrepancies. Our second step would be to subject these discrepancies to a criterion in order to determine their relative importance. The criterion we have chosen is to compare the results of X^2 tests based on the different numbers of permutations as a means of determining if the differences in cumulative frequencies at different points in the marginal distributions are small enough such that the results of the X^2 tests would be invariant with respect to the number of random permutations. In other words, if the accuracy of the estimate of the true distribution does not increase enough in going from 250 to 1000 random permutations of firm ownership to generate any fundamental changes in results, then we can be confident that any increase in accuracy of the estimate obtained by doing more than 1000 permutations will also not generate any changes in the results.

It will be recalled that in sub-section 5.3.4, we generated four random distributions of firm ownership for the GVRD based on 250, 500, 750, and 1000 permutations of firm ownership. For the experiments discussed above, we have converted these random distributions of firm ownership into the corresponding common boundary distributions by finding the number of common boundaries for each firm in each permutation. In Table XIV, we report the cumulative frequencies at different points in the marginal distributions of common boundaries for firms F_s, F_o, F_k, and the competitive fringe. (The number of boundaries between stores owned by different firms is, of course, the total number of boundaries in the GVRD minus the total number of common boundaries. In other words, it is a residual and not independent of the total number of common boundaries in the GVRD.)

TABLE XIV

CUMULATIVE FREQUENCIES FOR THE MARGINAL DISTRIBUTIONS OF THE GVRD - PERMUTATIONS = 250, 500, 750, 1000

Firm F_s

B_{ss} / # of Permutations	6	10	14	18	22	26	30	34	38	42	μ
250		4.0	15.6	35.6	56.8	74.0	87.6	92.8	98.0	99.2	22.008
500	.6	4.8	18.0	34.4	56.4	73.4	86.0	93.8	97.4	98.8	21.970
750	.3	4.4	16.9	36.7	57.2	75.9	87.9	94.7	98.5	99.3	21.611
1000	.5	4.7	18.8	39.6	61.2	78.4	88.8	94.9	98.0	99.3	21.115

Table XIV (continued)

Firm F_o

B_{oo} / # of Permutations	2	4	6	8	10	12	14	16	18	μ
250	14.1	40.2	61.4	79.1	90.0	94.8	98.4	99.6	99.6	5.9600
500	13.6	39.1	64.3	78.7	89.9	96.6	99.0	99.6	100.0	5.8060
750	15.1	39.1	63.1	81.1	90.0	95.7	98.2	99.2	99.6	5.7853
1000	13.7	35.8	58.3	77.7	88.9	94.6	97.3	98.8	99.5	6.0700

Firm F_k

B_{kk} / # of Permutations	21	25	29	33	37	41	45	49	53	57	μ
250	5.2	12.4	25.6	41.6	55.6	71.6	81.6	89.2	93.6	98.0	36.500
500	4.2	11.2	22.8	38.0	54.2	68.6	80.0	89.4	93.2	95.6	37.250
750	5.9	12.4	25.9	40.4	55.6	70.1	80.7	87.9	93.2	96.3	36.877
1000	5.7	12.9	22.9	36.9	53.2	65.4	78.3	86.8	92.5	95.6	37.569

Competitive Fringe

B_{cf} / # of Permutations	6	10	14	18	22	26	30	34	38	42	μ
250	.4	6.8	20.4	33.6	52.0	69.6	83.2	92.0	96.4	98.4	22.428
500	.2	3.4	13.8	31.2	55.8	74.8	85.8	93.4	96.8	99.2	22.230
750	.4	4.8	14.0	31.7	52.4	70.7	82.0	90.5	95.5	98.7	22.955
1000	.6	4.0	16.4	35.2	54.8	70.7	84.5	92.0	96.2	98.4	22.461

Looking at Table XIV, we note first that differences in cumulative frequencies at given points of the marginal distributions rarely exceed 5%. A plot of the marginal distributions for the various numbers of permutations would also show that the marginal common boundary distributions for a given firm have approximately the same shape. Second, we note that there is no consistent tendency for the discrepancies in cumulative frequencies at given points in the marginal distributions to decline as we increase the number of permutations.

Our next step is to see if the results of the X^2 test based on the above common boundary distributions are invariant with respect to the number of permutations. The results of these tests are reported in Table XV.

TABLE XV

RESULTS OF THE X^2 TESTS FOR THE GVRD

PERMUTATIONS = 250, 500, 750, 1000

250 Permutations

$$\left\{ \sum_{i=1}^{j} \frac{(B_{ii} - \bar{B}_{ii})^2}{\bar{B}_{ii}} \right\} + \frac{(B_{iI} - \bar{B}_{iI})^2}{\bar{B}_{iI}} = \frac{(31 - 22.008)^2}{22.008} + \frac{(0 - 5.96)^2}{5.96}$$

$$+ \frac{(25 - 36.500)^2}{36.500} + \frac{(8 - 22.428)^2}{22.428} + \frac{(244 - 221.1)^2}{221.1}$$

$$= 24.9106259$$

Table XV (continued)

% of $\left\{\sum_{i=1}^{j} \frac{(\tilde{B}_{ii} - \bar{B}_{ii})^2}{\bar{B}_{ii}}\right\} + \frac{(\tilde{B}_{iI} - \bar{B}_{iI})^2}{\bar{B}_{iI}}$ distribution to the right of 24.9106259 = 6.8%

<u>500 Permutations</u>

$$\left\{\sum_{i=1}^{j} \frac{(B_{ii} - \bar{B}_{ii})^2}{\bar{B}_{ii}}\right\} + \frac{(B_{iI} - \bar{B}_{iI})^2}{\bar{B}_{iI}} = \frac{(31 - 21.97)^2}{21.97} + \frac{(0 - 5.806)^2}{5.806}$$

$$+ \frac{(25 - 37.25)^2}{37.25} + \frac{(8 - 22.23)^2}{22.23} + \frac{(244 - 220.74)^2}{220.74}$$

$$= 25.1059537$$

% of $\left\{\sum_{i=1}^{j} \frac{(\tilde{B}_{ii} - \bar{B}_{ii})^2}{\bar{B}_{ii}}\right\} + \frac{(\tilde{B}_{iI} - \bar{B}_{iI})^2}{\bar{B}_{iI}}$ distribution to the right of 25.1059537 = 4.8%

<u>750 Permutations</u>

$$\left\{\sum_{i=1}^{j} \frac{(B_{ii} - \bar{B}_{ii})^2}{\bar{B}_{ii}}\right\} + \frac{(B_{iI} - \bar{B}_{iI})^2}{\bar{B}_{iI}} = \frac{(31 - 21.611)^2}{21.611} + \frac{(0 - 5.7853)^2}{5.7853}$$

$$+ \frac{(25 - 36.877)^2}{36.877} + \frac{(8 - 22.955)^2}{22.955} + \frac{(244 - 220.77)^2}{220.77}$$

$$= 25.8770136$$

% of $\left\{\sum_{i=1}^{j} \frac{(\tilde{B}_{ii} - \bar{B}_{ii})^2}{\bar{B}_{ii}}\right\} + \frac{(\tilde{B}_{iI} - \bar{B}_{iI})^2}{\bar{B}_{iI}}$ distribution to the right of 25.8770136 = 5.86667%

Table XV (continued)

1000 Permutations

$$\left\{ \sum_{i=1}^{j} \frac{(B_{ii} - \bar{B}_{ii})^2}{\bar{B}_{ii}} \right\} + \frac{(B_{iI} - \bar{B}_{iI})^2}{\bar{B}_{iI}} = \frac{(31 - 21.115)^2}{21.115} + \frac{(0 - 6.07)^2}{6.07}$$

$$+ \frac{(25 - 37.569)^2}{37.569} + \frac{(8 - 22.461)^2}{22.461} + \frac{(244 - 220.78)^2}{220.78}$$

$$= 26.655214$$

$$\% \text{ of } \left\{ \sum_{i=1}^{j} \frac{(\tilde{B}_{ii} - \bar{B}_{ii})^2}{\bar{B}_{ii}} \right\} + \frac{(\tilde{B}_{iI} - \bar{B}_{iI})^2}{\bar{B}_{iI}}$$ distribution to the right of 26.655214 = 5.8%

The results appearing in Table XV indicate that no fundamental changes occur as we increase the number of permutations from 250 to 1000. If our criterion for rejection is that the X^2 statistic lie within the 10% tail of the distribution, then we would reject the null hypothesis regardless of the number of permutations which we had generated for the test. However, since the accuracy of the estimate should increase as we increase the number of permutations, we shall use 1000 permutations of firm ownership as the basis for our tests of the null hypothesis of random neighbor relations. The results of these tests appear in the next sub-section.

5.4.5 Test Results of the Null Hypothesis of Random Neighbor Relations for the GVRD and Constituent Sub-markets

In this sub-section, we report the results obtained from testing the null hypothesis that our observations on neighbor relations were generated by a random process based on the f_i of B.C. Our observations on neighbor relations were obtained by using the perpendicular bisector - least distance method of finding common boundaries, and these observations appear in Table XVI.

TABLE XVI

COMMON BOUNDARIES AND BOUNDARIES BY FIRM - GVRD AND SUB-MARKETS

Boundary	GVRD	Vancouver	Delta-Surrey	North Shore	Richmond
B_{ss}	31	20	4	2	5
B_{oo}	0	0	0	0	0
B_{kk}	25	8	13	4	0
B_{cf}	8	7	1	0	0
B_{iI}	244	162	45	22	15
Total	308	197	63	28	20

In Table XVII, we provide descriptive measures for the marginal distributions of common boundaries generated for each sub-market and for the GVRD. These distributions are based on the random distributions of firm ownership which were generated for the tests in section 5.3 and were obtained by using the boundary matrix for the GVRD to find the number of common boundaries which each firm has in each random permutation of firm ownership.

TABLE XVII

MARGINAL COMMON BOUNDARY DISTRIBUTION DESCRIPTIVE MEASURES

BY FIRM FOR THE GVRD AND SUB-MARKETS

		B_{ss}	B_{oo}	B_{kk}	B_{cf}	B_{iI}
GVRD	$\bar{B}_{ii}$	21.115	6.07	37.569	22.461	220.78
	σ	7.3977	3.6175	10.709	8.1837	8.4637
Vancouver	$\bar{B}_{ii}$	13.145	3.793	22.312	14.057	143.69
	σ	5.5779	2.7647	8.0844	6.1184	6.9433
Delta-Surrey	$\bar{B}_{ii}$	4.8820	1.3430	9.1500	5.2490	42.376
	σ	4.0470	1.7806	5.8674	4.2411	4.5501
North Shore	$\bar{B}_{ii}$	1.8110	.56800	3.2860	1.8960	20.439
	σ	1.9583	.99517	2.6783	1.9258	2.4063
Richmond	$\bar{B}_{ii}$	1.3470	.35900	2.2590	1.4220	14.613
	σ	1.6066	.75279	2.2572	1.7581	2.0336

After translating our randomly generated distributions of common boundaries into distributions of the quantity

(5.10) $$\left\{ \sum_{i=1}^{j} \frac{(\tilde{B}_{ii} - \bar{B}_{ii})^2}{\bar{B}_{ii}} \right\} + \frac{(\tilde{B}_{iI} - \bar{B}_{iI})^2}{\bar{B}_{iI}}$$

and using the information contained in Table XVI and Table XVII, we obtain the following results from doing the X^2 test of the null hypothesis:

TABLE XVIII

RESULTS OF THE X^2 TESTS OF THE NULL HYPOTHESIS

OF RANDOM NEIGHBOR RELATIONS BY GVRD AND SUB-MARKETS

GVRD

$\frac{(B_{ss} - \bar{B}_{ss})^2}{\bar{B}_{ss}}$	$\frac{(B_{oo} - \bar{B}_{oo})^2}{\bar{B}_{oo}}$	$\frac{(B_{kk} - \bar{B}_{kk})^2}{\bar{B}_{kk}}$	$\frac{(B_{cf} - \bar{B}_{cf})^2}{\bar{B}_{cf}}$	$\frac{(B_{iI} - \bar{B}_{iI})^2}{\bar{B}_{iI}}$
$\frac{(31 - 21.115)^2}{21.115}$	$\frac{(0 - 6.07)^2}{6.07}$	$\frac{(25 - 37.569)^2}{37.569}$	$\frac{(8 - 22.461)^2}{22.461}$	$\frac{(244 - 220.78)^2}{220.78}$
4.6276687	6.07	4.2050562	9.3103833	2.442107

$$\left\{ \sum_{i=1}^{j} \frac{(B_{ii} - \bar{B}_{ii})^2}{\bar{B}_{ii}} \right\} + \frac{(B_{iI} - \bar{B}_{iI})^2}{\bar{B}_{iI}} = 26.655214$$

% of $\left\{ \sum_{i=1}^{j} \frac{(\tilde{B}_{ii} - \bar{B}_{ii})^2}{\bar{B}_{ii}} \right\} + \frac{(\tilde{B}_{iI} - \bar{B}_{iI})^2}{\bar{B}_{iI}}$ distribution to right of 26.655214 = 5.8%

Table XVIII (continued)

Vancouver

$\frac{(B_{ss}-\bar{B}_{ss})^2}{\bar{B}_{ss}}$	$\frac{(B_{oo}-\bar{B}_{oo})^2}{\bar{B}_{oo}}$	$\frac{(B_{kk}-\bar{B}_{kk})^2}{\bar{B}_{kk}}$	$\frac{(B_{cf}-\bar{B}_{cf})^2}{\bar{B}_{cf}}$	$\frac{(B_{iI}-\bar{B}_{iI})^2}{\bar{B}_{iI}}$
$\frac{(20-13.145)^2}{13.145}$	$\frac{(0-3.793)^2}{3.793}$	$\frac{(8-22.312)^2}{22.312}$	$\frac{(7-14.057)^2}{14.057}$	$\frac{(162-143.69)^2}{143.69}$
3.5748212	3.793	9.1804114	3.5425077	2.3331902

$$\left\{\sum_{i=1}^{j}\frac{(B_{ii}-\bar{B}_{ii})^2}{\bar{B}_{ii}}\right\}+\frac{(B_{iI}-\bar{B}_{iI})^2}{\bar{B}_{iI}} = 22.424229$$

% of $\left\{\sum_{i=1}^{j}\frac{(\tilde{B}_{ii}-\bar{B}_{ii})^2}{\bar{B}_{ii}}\right\}+\frac{(\tilde{B}_{iI}-\bar{B}_{iI})^2}{\bar{B}_{iI}}$ distribution to right of 22.424229 = 7.7%

Surrey-Delta

$\frac{(B_{ss}-\bar{B}_{ss})^2}{\bar{B}_{ss}}$	$\frac{(B_{oo}-\bar{B}_{oo})^2}{\bar{B}_{oo}}$	$\frac{(B_{kk}-\bar{B}_{kk})^2}{\bar{B}_{kk}}$	$\frac{(B_{cf}-\bar{B}_{cf})^2}{\bar{B}_{cf}}$	$\frac{(B_{iI}-\bar{B}_{iI})^2}{\bar{B}_{iI}}$
$\frac{(4-4.882)^2}{4.882}$	$\frac{(0-1.343)^2}{1.343}$	$\frac{(13-9.15)^2}{9.15}$	$\frac{(1-5.249)^2}{5.249}$	$\frac{(45-42.376)^2}{42.376}$
.1593453	1.343	1.6199453	3.4395124	.1624829

$$\left\{\sum_{i=1}^{j}\frac{(B_{ii}-\bar{B}_{ii})^2}{\bar{B}_{ii}}\right\}+\frac{(B_{iI}-\bar{B}_{iI})^2}{\bar{B}_{iI}} = 6.7242859$$

% of $\left\{\sum_{i=1}^{j}\frac{(\tilde{B}_{ii}-\bar{B}_{ii})^2}{\bar{B}_{ii}}\right\}+\frac{(\tilde{B}_{iI}-\bar{B}_{iI})^2}{\bar{B}_{iI}}$ distribution to right of 6.7242859 = 63%

Table XVIII (continued)

North Shore

$\frac{(B_{ss} - \bar{B}_{ss})^2}{\bar{B}_{ss}}$	$\frac{(B_{oo} - \bar{B}_{oo})^2}{\bar{B}_{oo}}$	$\frac{(B_{kk} - \bar{B}_{kk})^2}{\bar{B}_{kk}}$	$\frac{(B_{cf} - \bar{B}_{cf})^2}{\bar{B}_{cf}}$	$\frac{(B_{iI} - \bar{B}_{iI})^2}{\bar{B}_{iI}}$
$\frac{(2 - 1.811)^2}{1.811}$ .0197244	$\frac{(0 - .568)^2}{.568}$ .568	$\frac{(4 - 3.286)^2}{3.286}$ .1551418	$\frac{(0 - 1.896)^2}{1.896}$ 1.896	$\frac{(22 - 20.439)^2}{20.439}$ .1192191

$$\left\{ \sum_{i=1}^{j} \frac{(B_{ii} - \bar{B}_{ii})^2}{\bar{B}_{ii}} \right\} + \frac{(B_{iI} - \bar{B}_{iI})^2}{\bar{B}_{iI}} = 2.7580853$$

% of $\left\{ \sum_{i=1}^{j} \frac{(\tilde{B}_{ii} - \bar{B}_{ii})^2}{\bar{B}_{ii}} \right\} + \frac{(\tilde{B}_{iI} - \bar{B}_{iI})^2}{\bar{B}_{iI}}$ distribution to right of 2.7580853 = 79%

Richmond

$\frac{(B_{ss} - \bar{B}_{ss})^2}{\bar{B}_{ss}}$	$\frac{(B_{oo} - \bar{B}_{oo})^2}{\bar{B}_{oo}}$	$\frac{(B_{kk} - \bar{B}_{kk})^2}{\bar{B}_{kk}}$	$\frac{(B_{cf} - \bar{B}_{cf})^2}{\bar{B}_{cf}}$	$\frac{(B_{iI} - \bar{B}_{iI})^2}{\bar{B}_{iI}}$
$\frac{(5 - 1.347)^2}{1.347}$ 9.9067624	$\frac{(0 - .359)^2}{.359}$ .359	$\frac{(0 - 2.259)^2}{2.259}$ 2.259	$\frac{(0 - 1.422)^2}{1.422}$ 1.422	$\frac{(15 - 14.613)^2}{14.613}$ .0102490

$$\left\{ \sum_{i=1}^{j} \frac{(B_{ii} - \bar{B}_{ii})^2}{\bar{B}_{ii}} \right\} + \frac{(B_{iI} - \bar{B}_{iI})^2}{\bar{B}_{iI}} = 13.9570114$$

% of $\left\{ \sum_{i=1}^{j} \frac{(\tilde{B}_{ii} - \bar{B}_{ii})^2}{\bar{B}_{ii}} \right\} + \frac{(\tilde{B}_{iI} - \bar{B}_{iI})^2}{\bar{B}_{iI}}$ distribution to right of 13.9570114 = 14.1%

Looking at the results in Table XVIII, we see that we would reject the null hypothesis that our observations on neighbor relations were generated by a random process based on the f_i for the Vancouver sub-market and the GVRD. These results are significant at the 10% level. We cannot reject the null hypothesis for the Richmond, Delta-Surrey, and North Shore sub-markets. In the next section, we shall analyze these results more closely.

5.5 Interpretation of the Test Results of Randomness

In the previous two sections, we found that we could reject the null hypothesis of random firm ownership and the null hypothesis of random neighbor relations for the GVRD and the Vancouver sub-market. We shall now interpret these results.

Let us focus on the GVRD results first. In order to facilitate our discussion, we shall once again call each term of the sum of the $(n_i - \bar{n}_i)^2/\bar{n}_i$ and the $(B_{ii} - \bar{B}_{ii})^2/\bar{B}_{ii}$ a "relative discrepancy". In Table XI, we see that the largest relative discrepancy between observed and mean generated firm ownership occurs for firm F_o, while the second largest relative discrepancy occurs for firm F_s. Given the signs of these discrepancies before squaring we may conclude that firm F_s's stores are relatively concentrated in the GVRD and firm F_o's stores are relatively unconcentrated or under represented in the GVRD vis-a-vis the relative frequencies f_i. Firm F_k is also relatively under represented in the GVRD, although the discrepancy between observed and mean generated firm ownership is not large relative to the sizes of the other discrepancies. In Table XVIII, we find that the results for common boundaries do not show a perfect correspondence to those just reported for firm ownership. In Table XVIII, the largest relative discrepancy between observed and mean generated common boundaries occurs for competitive fringe stores, and the sign of this discrepancy before squaring indicates the absence of clustering of competitive fringe stores in the GVRD. If we exclude this relative discrepancy, we see that the ordering of relative discrepancies by their magnitude is the same in Table XVIII as it is in Table XI: firm F_o has the largest relative discrepancy between observed and mean generated common boundaries, while firm F_s has the second largest, and firm F_k has the third largest. Given the signs of these discrepancies before squaring it appears that firm F_s's stores are relatively clustered in the GVRD, while the stores of firm F_o and firm F_k are not.

When we look at the Vancouver results, we find that the ordering of the relative discrepancies in firm ownership in Vancouver is the same as that for the GVRD. Again, firm F_s's stores are relatively concentrated and firm F_o's stores are relatively unconcentrated, and the discrepancy between observed and mean generated firm ownership for firm F_k is not large relative to the sizes of the other discrepancies. However, the ordering of the relative discrepancies in observed and mean generated common boundaries by their magnitude is not the same in Vancouver as it is in the GVRD. In particular, the largest relative discrepancy occurs for firm F_k, while the relative discrepancies for firm F_s, firm F_o, and the competitive fringe are approximately of equal size. Again, firm F_s's stores are the only ones which are candidates for being clustered, while firm F_o's and firm F_k's are not.

It is interesting to note that we rejected the null hypothesis of random firm ownership and the null hypothesis of random neighbor relations for the GVRD, but not for three of its constituent sub-markets, Richmond, Delta-Surrey, and the North Shore. This result appears to be due to the fact that we rejected the null hypothesis for the Vancouver sub-market, and the Vancouver sub-market accounts for 60.77% of the stores in the GVRD. Thus, in some sense, the Vancouver sub-market has dominated the GVRD in terms of the results obtained from our tests of randomness.

Rejection of the null hypothesis of randomness for the GVRD and Vancouver sub-market was earlier said to imply the existence of some sort of state dependence. It is therefore appropriate at this point to test for the existence of state dependence in the Vancouver sub-market. This we do in the next section.

5.6 The Test of State Dependence

5.6.1 Motivation for the Test

In the previous two sections of this chapter, we tested the hypothesis that the stochastic process which was responsible for generating our observations on firm ownership and neighbor relations was an independent stochastic process based on a set of fixed state independent probabilities. These state independent probabilities were defined to mean that the probabilities that a store is owned by firm $F_1, F_2, \ldots, F_j$ do not depend on the state of neighbor relations prior to the point in time when the store is established. We found that we could reject these hypotheses for the GVRD and the Vancouver sub-market. However, these tests, based as they were on a set of cross section observations on store locations, only permitted us to reject the hypotheses of randomness, and they did not allow us to be precise about the nature of the process which actually gave rise to our observations. Such precision requires knowledge of the process itself or observations on the outcomes of the process over time.

In this section, we shall utilize time series data on the date at which each store was established in the Vancouver sub-market in order to test the hypothesis that the stochastic process which gave rise to our observations on the sequence of store openings is a state dependent process. A state will be defined over the set of neighbor relations that a given store will have with other stores in the sub-market if that store is established.

The theory of preemption suggests that potential neighbor relations are key considerations in a preempting firm's location strategy. By establishing new stores in a given market at locations which are only bounded by other stores that it owns, and at points in time when it would not be profitable for other firms to establish stores, a preempting firm maximizes the present value of its profits. It does so by avoiding costly price competition with other firms, and by selecting the prices and locations which maximize the joint profits over all of its stores. Thus, in order to identify a particular firm as having preempted in a given sub-market, we must first determine if the states of neighbor relations have had an impact on the outcomes of the stochastic process. Once we have established that the process which gave rise to our observations is a state dependent one, we may begin to analyze the process more closely with the aim of determining whether the underlying probabilities which generated the process are consistent with the existence of preemptive firm behavior in the market.

In the next sub-section, we formally state the null hypothesis of state dependence, and we discuss the implications of rejecting or accepting the hypothesis. In order to test the null hypothesis of state dependence, we must first obtain estimates of state dependent probabilities, and our procedure for constructing these estimates is explained in sub-section 5.6.3. We then go on to discuss how we may use our estimates of state dependent and state independent probabilities in order to conduct a test of state dependence. As noted above, even if we accept the hypothesis of state dependence, we must still determine if our estimates of the state dependent probabilities are consistent with one or more firms having preempted in the market. In sub-section 5.6.4, we establish two related sets of criteria based on comparisons of state dependent probabilities and relative frequencies which will enable us to make this determination. In sub-section 5.6.5, we conduct a test for state dependence using Vancouver sub-market data, and in sub-section 5.6.6, we subject our estimates of state dependent probabilities to the two sets of criteria established in sub-section 5.6.4. Finally, in sub-section 5.6.7, we provide an interpretation of our results.

5.6.2 Statement of the Null Hypothesis of State Dependence

The null hypothesis that we shall test in this section may be stated as follows: The observed set of neighbor relations and distribution of firm ownership in a given sub-market A_u of A were generated by a state dependent probabilistic process over time. This process may be characterized by a set of $M \times j$ probabilities, where j equals the number of firms (including the competitive fringe) which have established stores in the sub-market A_u, and M equals the number of possible states of neighbor relations which any given store might have with other stores if it were established in the sub-market. (As in the previous section, "neighbor relation" should be thought of in the context of a store owned by a given firm having a boundary with a store owned by itself or with a store owned by a different firm.) Each probability, π_{mi} ($m=1,2,\ldots,M$; $i=1,2,\ldots,j$), represents the probability that a particular firm F_i will establish a store in the sub-market, given that that store would have as its neighbors stores owned by firms represented by state m.

The alternative hypothesis is that the observed set of neighbor relations and distribution of firm ownership in a given sub-market A_u of A were generated by a random process based on a set of state independent probabilities.

One implication of the null hypothesis is that if the M x j state dependent probabilities π_{mi} ($m=1,2,\ldots,M$; $i=1,2,\ldots,j$) are truly the probabilities of a state dependent process, then they should be significantly different from the probabilities of a state independent process. If these probabilities are not significantly different from the state independent probabilities, then all of the M states may be collapsed into one state, with the consequence that the probabilities of a store being owned by given firms do not depend upon the specific set of neighbor relations that that store would have with other stores in the sub-market if it was established. Another interpretation would be that if our estimates of the state dependent probabilities are insignificantly different from the state independent probabilities, then the explanatory power of the null hypothesis of state dependence would be nil since the process from which estimates of the π_{mi} are obtained would be observationally equivalent to an independent stochastic process based on the state independent probabilities.

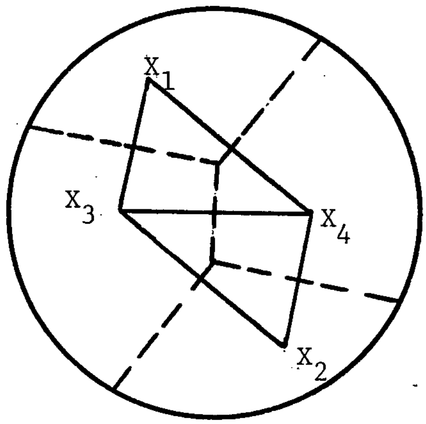
Finally, we should like to note once again that while acceptance of the null hypothesis means that the process which gave rise to our observations on firm ownership and neighbor relations is consistent with a state dependent probabilistic process, it does not necessarily mean that the process was a preemptive one. Whether or not the process was a preemptive one must be inferred from a careful analysis of the state dependent probabilities themselves. In the next sub-section, we discuss the procedure which we use to obtain estimates of state dependent probabilities, and we devise a test of the null hypothesis of state dependence.

5.6.3 Testing Procedure for State Dependence

In this sub-section, we devise a testing procedure for the null hypothesis of state dependence. As in the previous sections, we shall use an example to illustrate the procedure for obtaining estimates of the state dependent probabilities π_{mi} and the testing procedure for the null hypothesis.

Consider once again the sub-market represented by Figure 10, which we reproduce below as Figure 11.

Figure 11



In section 5.4.3, we assumed that Figure 10 represented a snapshot of the sub-market at one point in time and that we did not know the sequence in which the stores were established. Now, however, let us assume that we know the sequence, and that store 1 located at X_1 was established at time t_1, store 2 located at X_2 was established at time t_2, and so forth, where $t_1 < t_2 < t_3 < t_4$. Since store 1 located at X_1 was the first store to be opened in this sub-market, we shall define it as representing the initial condition.

There are a finite number of states of neighbor relations which a firm might be faced with when it considers opening either store 2, store 3, or store 4 in the sub-market at time t_2, t_3 and t_4 respectively. For example, the new store might have one, two or three boundaries with the stores owned by firm F_1 or firm F_2 depending on when the new store is established in the sub-market and whether firm F_1 or firm F_2 owns the stores that are established in the sub-market prior to the new store. Or, the new store might have one or two boundaries with stores owned by firm

F_1 (firm F_2) and one boundary with a store owned by firm F_2 (firm F_1), again depending on when the new store is established and which firm or firms owned the existing stores. As the number of firms and the number of store locations in a sub-market increase, the total number of possible states of neighbor relations increases rapidly. We shall find it necessary to assume that what matters to the firm is whether its new store would only have boundaries with other stores that it owns or if it would have boundaries with stores owned by other firms, and that the firm is not concerned with the absolute number of boundaries which its new store would have with its own stores or the stores of other firms. This assumption means that in our example, there are only three possible states of neighbor relations which a firm might be faced with when it considers opening a new store at some time t, and these three states are represented by the B_i on the left hand side of the following contingency table:

TABLE XIX

CONTINGENCY TABLE OF STATE DEPENDENT FREQUENCIES

	F_1	F_2
B_1	a_{11}	a_{12}
B_2	a_{21}	a_{22}
B_1, B_2	a_{31}	a_{32}

Given that there are only two firms which constitute the industry in our example, a firm which establishes a new store in the sub-market may find that its store has boundaries only with stores owned by firm $F_1(B_1)$, boundaries only with stores owned by firm $F_2(B_2)$, or boundaries with stores owned by both firm F_1 and firm $F_2(B_1,B_2)$. The F_i at the top of the table symbolize a store owned by firm F_i being established in the sub-market. Thus, contingency table element a_{11} represents the number of times that firm F_1 established a store in the sub-market from time t_2 to time t_4 such that it only had boundaries with stores owned by firm F_1. Contingency table element a_{31} represents the number of times that firm F_1 established a store in the sub-market from time t_2 to time t_4 such that it had at least one boundary with a store owned by firm F_1 and at least one boundary with a store owned by firm F_2. The rest of the entries in the table may be interpreted in a similar fashion.

Next, we convert the contingency table into a matrix of relative frequencies.

(5.11)

$$\begin{array}{cc} & \begin{array}{cc} F_1 & \quad F_2 \end{array} \\ \begin{array}{c} B_1 \\[2em] B_2 \\[2em] B_1,B_2 \end{array} & \begin{pmatrix} \dfrac{a_{11}}{a_{11}+a_{12}} & \dfrac{a_{12}}{a_{11}+a_{12}} \\[1em] \dfrac{a_{21}}{a_{21}+a_{22}} & \dfrac{a_{22}}{a_{21}+a_{22}} \\[1em] \dfrac{a_{31}}{a_{31}+a_{32}} & \dfrac{a_{32}}{a_{31}+a_{32}} \end{pmatrix} \end{array}$$

We shall regard the relative frequencies in matrix (5.11) as constituting our best estimates of the state dependent probabilities π_{mi}. Our reasons for this conclusion are as follows: The state dependent probabilities are state dependent in the sense that the probabilities that a given store is owned by firm F_1, F_2, ..., F_j depend upon the state of neighbor relations that that store would have with other stores in the market if it was established. Thus, the state dependent probabilities may be interpreted as being conditional probabilities, where

$$(5.12) \qquad \pi_{mi} = \Pr(F_i \mid m) = \frac{\Pr(F_i \cap m)}{\Pr(m)}$$

$$\Pr(m) > 0 \qquad (i = 1,2,\ldots,j\,; \;\; m = 1,2,\ldots,M)$$

Equation (5.12) says that the probability that firm F_i will own a given store in A_u, given that that store would have boundaries with stores owned by the firms represented by state m, is equal to the probability that firm F_i establishes a store in A_u and state m occurs, divided by the probability that state m occurs. These conditional probabilities may be estimated as follows:

$$(5.13) \qquad \pi_{mi} = \Pr(F_i \mid m) = \frac{a_{mi}}{\sum_{m=1}^{M} \sum_{i=1}^{j} a_{mi}} \div \frac{\sum_{i=1}^{j} a_{mi}}{\sum_{m=1}^{M} \sum_{i=1}^{j} a_{mi}} .$$

The numerator of (5.13) constitutes our estimate of $\Pr(F_i \cap m)$. That is, the probability that firm F_i establishes a store in A_u and state m occurs may be estimated by the number of times that firm F_i established a store in

A_u given that the store had boundaries with stores owned by the firms represented by state m, divided by the total number of stores which are established in the sub-market. The denominator of (5.13) constitutes our estimate of Pr(m). That is, the probability that state m occurs may be estimated by the number of times when the opportunity to establish a store in A_u, such that the store would only have boundaries with stores owned by the firms represented by state m, presented itself, divided by the total number of stores which are established in the sub-market. We may rewrite (5.13) as follows:

$$\pi_{mi} = \frac{a_{mi}}{\sum_{i=1}^{j} a_{mi}} .$$

Note that implicit in this interpretation of the state dependent probabilities is the assumption that what matters to a firm is simply the state of neighbor relations in the immediate vicinity of where it plans to open a new store, and not, for example, the state of neighbor relations throughout the sub-market at the time when it wishes to establish a new store. Also implicit in this interpretation of the state dependent probabilities is that whenever firms are faced with a given state of neighbor relations, the same set of probabilities determine which firm will actually establish the new store. (We also wish to note that $\sum_{i=1}^{j} \pi_{mi} = \sum_{i=1}^{j} Pr(F_i \mid m) = 1$, but that $\sum_{m=1}^{M} \pi_{mi}$ would not equal one in general.)

Having obtained estimates of the state dependent probabilities, we must determine if they are significantly different from some set of state independent probabilities. As in sections 5.3 and 5.4, we shall let the relative frequencies of each firm's stores in market A be our estimates of the state independent probabilities. We do not use sub-market relative frequencies as our estimates of state independent probabilities in order to conduct a test of state dependence for the following reasons: Suppose that a given sub-market's relative frequencies f_{iu} are the result of one firm having preempted the market. If our test of state dependence involved determining if the f_{iu} were significantly different from the π_{mi}, then we might find that the f_{iu} are not significantly different from the π_{mi} precisely because the f_{iu} are the result of a state dependent process. Consequently, we would reject the null hypothesis of state dependence when it is in fact true. We therefore regard the f_i from market A as the most appropriate estimates of the state independent probabilities since the f_i from market A are based on a larger number of outcomes of the process (or processes) which gave rise to them.

Returning now to our example, we shall assume that both firm F_1 and firm F_2 own half of the stores in market A, and thus our estimates of the state independent probabilities are $f_1 = f_2 = 1/2$. Testing for a significant difference between our estimates of the state dependent probabilities and the state independent probabilities involves testing for the similarity between matrix (5.11) and the following matrix of state independent probabilities:

(5.14)

$$\begin{array}{c} \\ B_1 \\ B_2 \\ B_1, B_2 \end{array} \begin{array}{c} \begin{array}{cc} F_1 & F_2 \end{array} \\ \begin{bmatrix} 1/2 & 1/2 \\ 1/2 & 1/2 \\ 1/2 & 1/2 \end{bmatrix} \end{array}$$

Once again, the most appropriate test of significance to perform here is a chi-square test since we are interested in the significance of the discrepancies between our observations a_{mi} in the contingency table and the number of cases e_{mi} which would be expected to appear in the cells of the table if our observations were generated by an independent stochastic process based on the f_i. In order to conduct a chi-square test, we would first compute

(5.15)
$$\sum_{m=1}^{M} \sum_{i=1}^{j} \frac{(a_{mi} - e_{mi})^2}{e_{mi}},$$

where $e_{mi} = f_i(\sum_{i=1}^{j} a_{mi})$. The distribution of the random variable represented by (5.15) will approach that of a chi-square variable with $(M-1)(j-1)$ degrees of freedom as the number of times the experiment is performed approaches infinity.[19] If the calculated value of (5.15) lies in the critical region of a chi-square distribution with $(M-1)(j-1)$ degrees of freedom, then we may accept the hypothesis that the a_{mi} are significantly different from the e_{mi}. This in turn implies that the process giving rise to our observations a_{mi} is consistent with a state dependent stochastic process based on the π_{mi}.

Since the sub-market of our example is so small (that is, only three observations on the process after we exclude the store representing our initial condition), it would be inappropriate to calculate (5.15) for hypothetical values of the a_{mi}. However, the example has served to illustrate what the appropriate testing procedure is when the number of stores in the sub-market is large. In the next sub-section, we proceed to a discussion of how we may use our estimates of the state dependent probabilities in order to determine if the state dependent process is consistent with preemptive firm behavior.

5.6.4 Comparative Analysis of State Dependent Probabilities and Relative Frequencies

In the previous sub-section, we discussed how we would obtain estimates of the state dependent probabilities when there are only two firms operating in a sub-market. This procedure obviously generalizes to a sub-market with j firms, where the j th firm represents the competitive fringe stores in the sub-market. We also explained how we could use our estimates of state dependent probabilities in conjunction with estimates of state independent probabilities in order to do a chi-square test of the null hypothesis of state dependence. Given that we might accept the null hypothesis of state dependence, we must establish criteria for determining whether the process is a preemptive one. We do so by examining the theoretically predicted differences between state dependent probabilities and relative frequencies. However, prior to this analysis, we shall discuss ways in which we may reduce the dimensionality of the matrix of state dependent probabilities. The chi-square test of state dependence and data limitations require that such a reduction be made.

In this sub-section, we shall consider a sub-market consisting of two firms, which are potential preemptors, and also a competitive fringe. The matrix of state dependent probabilities for this sub-market would be as follows:

$$
(5.16)\qquad
\begin{array}{r}
\\
B_1 \\ B_2 \\ B_{cf} \\ B_1, B_{cf} \\ B_2, B_{cf} \\ B_1, B_2 \\ B_1, B_2, B_{cf}
\end{array}
\begin{array}{c}
\begin{array}{ccc} F_1 & F_2 & cf \end{array} \\
\begin{bmatrix}
\pi_{11} & \pi_{12} & \pi_{13} \\
\pi_{21} & \pi_{22} & \pi_{23} \\
\pi_{31} & \pi_{32} & \pi_{33} \\
\pi_{41} & \pi_{42} & \pi_{43} \\
\pi_{51} & \pi_{52} & \pi_{53} \\
\pi_{61} & \pi_{62} & \pi_{63} \\
\pi_{71} & \pi_{72} & \pi_{73}
\end{bmatrix}
\end{array}
$$

By simply adding the competitive fringe to the sub-market, we have increased the number of state dependent probabilities which require estimates from six to twenty-one. This large increase in the number of state dependent probabilities may cause problems for our test of state dependence since, ideally, fewer than 20% of the cells of the contingency table upon which matrix (5.16) is based should have expected frequencies less than five. Thus, we must ask if there are ways in which we may combine certain states in matrix (5.16) in order to increase the expected frequencies in as many cells of the contingency table as possible, while at the same time not impairing our ability to use the state dependent probabilities to ascertain the existence of preemptive firm behavior in the sub-market.

First, we may combine state B_1 and state B_1,B_{cf}. This is because firm F_1, in its capacity as potential preemptor, would have roughly the same incentive to preempt the market if it faced a state such that it could establish a new store in the sub-market which would only have boundaries with other firm F_1 stores, or if it could establish a new store in the sub-market which would have boundaries with competitive fringe stores as well as firm F_1 stores. This same reasoning allows us to combine states B_2 and B_2,B_{cf}. Next, we may combine states B_1,B_2 and B_1,B_2,B_{cf}. The reason is because according to the theory of preemption, both firm F_1 and firm F_2 would have an incentive to preempt the market if they faced these states of neighbor relations, although the theory does not predict which firm will actually act upon that incentive first. Finally, we shall treat B_{cf} as a residual and combine it with states B_1,B_2 and B_1,B_2,B_{cf}. The reason is because if a new store would only have boundaries with stores belonging to the competitive fringe, the theory does not predict which firm will establish that store. Thus, state B_{cf} more closely resembles state B_1,B_2 and B_1,B_2,B_{cf} than it does state B_1 or state B_2.

After combining states, we obtain the following matrix of state dependent probabilities:

$$
(5.17) \qquad
\begin{array}{r c}
 & \begin{array}{ccc} F_1 & F_2 & cf \end{array} \\
\begin{array}{r} B_1 / B_1,B_{cf} \\ B_2 / B_2,B_{cf} \\ B_{cf} / B_1,B_2 / B_1,B_2,B_{cf} \end{array} &
\begin{bmatrix} \tilde{\pi}_{11} & \tilde{\pi}_{12} & \tilde{\pi}_{13} \\ \tilde{\pi}_{21} & \tilde{\pi}_{22} & \tilde{\pi}_{23} \\ \tilde{\pi}_{31} & \tilde{\pi}_{32} & \tilde{\pi}_{33} \end{bmatrix}
\end{array}
$$

Now, let us assume that we have conducted a test of the null hypothesis of state dependence for this sub-market, and that we have accepted the null hypothesis. We wish to establish criteria which would permit us to say that the state dependent probabilities are consistent with preemptive firm behavior on the part of firm F_1, firm F_2, or both firm F_1 and firm F_2.

Our first set of criteria will be based upon the theoretically predicted differences between the state dependent probabilities and the relative frequencies f_i. In previous sections, we treated the f_i as our best estimates of the state independent probabilities. However, we may no longer treat the f_i as estimates of the state independent probabilities, because if all firms' stores are not randomly distributed, then the f_i will not be independent of the spatial structure of each firm's stores in the sub-markets comprising market A. Nonetheless if firm F_1 has engaged in preemptive behavior in a sub-market, we would expect $\tilde{\pi}_{11} > f_1$ for the following reasons: First, recall that our estimate of $\tilde{\pi}_{11}$ is obtained by finding the number of cases from t_1 (the initial condition) to the present in which firm F_1 has established stores in the sub-market such that they only had boundaries with other firm F_1 stores. The relative frequency f_1 is a weighted average of the sub-market relative frequencies of firm F_1's stores, where the weights represent the relative importance of each sub-market in market A. Provided firm F_1 has not preempted all sub-markets to the same extent, there is a tendency for $\tilde{\pi}_{11}$ to exceed f_1 if firm F_1 has preempted the sub-market represented by matrix (5.17). This same reasoning leads us to expect that $\tilde{\pi}_{22} > f_2$ if firm F_2 has preempted the sub-market.

Let us now consider the implications of discrepancies between $\tilde{\pi}_{12}$ and f_2 and $\tilde{\pi}_{13}$ and f_3. If firm F_1 has engaged in preemptive behavior in the sub-market, then the opportunity for firm F_2 or the competitive fringe to establish a store in the sub-market when faced with states B_1 or B_1, B_{cf} will not often present itself. Thus, there is a tendency, which depends upon the weights of sub-markets which f_2 and f_3 are based on, for $\tilde{\pi}_{12} < f_2$ and $\tilde{\pi}_{13} < f_3$ in a sub-market which has been actively preempted by firm F_1. (It must be kept in mind that f_2 and f_3 are weighted averages of all of the sub-market relative frequencies. In particular, f_2 may be based on some sub-market relative frequencies where firm F_2 has preempted, and f_3 may be based on some sub-market relative frequencies where neither firm F_1 or firm F_2 has preempted.) This same reasoning leads us to expect $\tilde{\pi}_{21} < f_1$ and $\tilde{\pi}_{23} < f_3$ in a sub-market which has been actively preempted by firm F_2.

Finally, we should note that the theory of preemption does not lead to any particular predictions about what the discrepancies between $\tilde{\pi}_{31}$ and f_1, $\tilde{\pi}_{32}$ and f_2, and $\tilde{\pi}_{33}$ and f_3 should be if either firm F_1, firm F_2, or both firm F_1 and firm F_2 have engaged in preemptive behavior within some sub-market.

We may summarize the above discussion briefly as follows: 1) if $\tilde{\pi}_{11} > f_1$, $\tilde{\pi}_{12} < f_2$, $\tilde{\pi}_{13} < f_3$, firm F_1 will be said to have engaged in the preemption of the sub-market; 2) if $\tilde{\pi}_{22} > f_2$, $\tilde{\pi}_{21} < f_1$, $\tilde{\pi}_{23} < f_3$, firm F_2 will be said to have engaged in the preemption of the sub-market. Note once again that $\tilde{\pi}_{mi}$ and f_i are based upon the complete set of outcomes of the process in the sub-market and market A, respectively, from t_1 to the present. However, the theory of preemption also makes predictions about what the differences between state dependent probabilities and the relative frequencies of each firm's stores in the sub-market should be in each time period between t_1 and the present if a given firm has preempted in the market. These predictions will constitute a second set of criteria for determining if the state dependent probabilities are consistent with one or more firms having engaged in preemption in the sub-market. (We should note that this second set of criteria is not independent of the first set.) We shall regard the second set of criteria as providing us with an additional check on the consistency of our estimates of the state dependent probabilities with the predictions of the theory, and as providing us with valuable insights into the nature of the process over time.

Consider first the implications of a positive discrepancy between $\tilde{\pi}_{11}(t)$ and $f_{1u}(t)$ in each time period between t_1 and the present, where $\tilde{\pi}_{11}(t)$ represents our estimate of the state dependent probability based on the outcomes of the state dependent process between t_1 (the initial condition) and some point in time t, and $f_{1u}(t)$ represents the relative frequency of firm F_1's stores in sub-market A_u at time t. Let us assume that our initial condition consists of a firm F_1 store and a competitive fringe store. If firm F_1 established a store in the sub-market at time t_2 such that state B_1 prevailed, then our estimate of $\tilde{\pi}_{11}$ at time t_2 would be 1 and $f_{1u}(t_2) = 2/3$. Thus, $\tilde{\pi}_{11}(t_2) > f_{1u}(t_2)$. Suppose that at time t_3, firm F_1 and firm F_2 establish stores in the sub-market such that state B_1 prevailed. Then, $\tilde{\pi}_{11}(t_3) = 2/3 > 3/5 = f_{1u}(t_3)$. If firm F_1 continues to act upon the incentive to preempt by establishing stores in the sub-market when a profitable opportunity exists and when it is faced with state B_1, then there will be a tendency for $\tilde{\pi}_{11}(t)$ to exceed $f_{1u}(t)$ in every time period. Thus, $\tilde{\pi}_{11}(t) > f_{1u}(t)$ for all t will be consistent with firm F_1 having preempted in the sub-market. However, we will not require this inequality to hold for <u>all</u> t in order to claim that the state dependent probabilities are consistent with a preemptive process. Due to the small number of observations on the process in the first few time periods, the inequality may initially be in the opposite direction for the first several time periods, and then change over to the theoretically predicted direction for the remaining time periods. We shall therefore only require that the inequality hold for "almost all t". For the same reasons, $\tilde{\pi}_{22}(t) > f_{2u}(t)$ for almost all t will be consistent with firm F_2 having preempted in the sub-market.

Consider next the implications of discrepancies between $\tilde{\pi}_{12}(t)$ and $f_{2u}(t)$ and $\tilde{\pi}_{13}(t)$ and $f_{3u}(t)$. Due to the fact that we have not assumed that all firms are identical and due to the unpredictable behavior of competitive fringe firms, our predictions regarding the expected signs of these discrepancies must be weak. All that we are able to say is that if firm F_1 is a strong preemptor in the sub-market, then the opportunity for firm F_2 or the competitive fringe to establish stores in the sub-market, such that they would be faced with state B_1, will not often present itself. Hence, $\tilde{\pi}_{12}(t) < f_{2u}(t)$ and $\tilde{\pi}_{13}(t) < f_{3u}(t)$ for almost all t would be consistent with firm F_1 having preempted in the sub-market. However, we will not regard $\tilde{\pi}_{12}(t) > f_{2u}(t)$ or $\tilde{\pi}_{13}(t) > f_{3u}(t)$ for almost all t as implying that firm F_1 has not preempted in the sub-market, provided that $\tilde{\pi}_{11}(t) > f_{1u}(t)$ for almost all t. These same considerations will apply to our interpretation of the discrepancies between $\tilde{\pi}_{21}(t)$ and $f_{1u}(t)$ and $\tilde{\pi}_{23}(t)$ and $f_{3u}(t)$.

Finally, we note that the theory of preemption does not make predictions about what the discrepancies between $\tilde{\pi}_{31}(t)$ and $f_{1u}(t)$, $\tilde{\pi}_{32}(t)$

and $f_{2u}(t)$, and $\tilde{\pi}_{33}(t)$ and $f_{3u}(t)$ should be if either firm F_1, firm F_2, or both firm F_1 and firm F_2 have preempted in the sub-market.

Having now discussed the testing procedure for state dependence, and what we shall regard as evidence of preemptive behavior, we may now proceed to a test of state dependence in the Vancouver sub-market.

5.6.5 Testing for State Dependence in the Vancouver Sub-market

Our test for the existence of state dependence in a given sub-market is largely based upon estimates of the state dependent probabilities. As pointed out in the previous sub-sections, in order to obtain such estimates, it is necessary to know the sequence in which the stores were established in the sub-market. Hence, in order to conduct the test for state dependence in the Vancouver sub-market, we had to reconstruct the sequential development of the supermarket industry in Vancouver in the following way: Our initial set of observations consisted of the cross sectional location pattern of supermarkets in the Vancouver sub-market as of the first quarter of 1978. Using the Vancouver, Lower Fraser Valley, and B.C. city directories we were able to look up our list of supermarket addresses, year by year, until we found the opening date for each store. We were essentially interested in plotting the history of the stores themselves. Thus, if a store was opened at some time t by firm F_s, and if that store changed ownership at some future time, then the history of that store was interpreted as representing two observations on the stochastic process. (It is for this reason that the number of observations on the stochastic process in Vancouver exceeds the number of stores in operation in Vancouver in 1978.) We traced the sequential development of the supermarket industry as far back as 1940. There were two supermarkets in operation in 1940 which are still in operation today, and these two supermarkets will represent our initial condition. After 1940, 89 stores were established, and therefore we have 89 observations on the stochastic process which gave rise to the current configuration of supermarkets in the Vancouver sub-market. Finally, we note that the population in the Vancouver sub-market in 1941 was 338,648, which compares to a Vancouver sub-market population of 674,731 in 1976.

It is important to point out that our reconstructed history of the supermarket industry in the Vancouver sub-market excludes all those stores which opened and closed prior to the first quarter of 1978. The reason for this is that many of these stores would probably fall into the convenience store or neighborhood grocer category, even though they bore the name of a firm which is today considered to be a supermarket chain firm. Supermarkets as we know them today, and as represented by the Statistics Canada combination store definition, are a fairly recent phenomenon, dating back to the 1940's.[20] In order to avoid biasing our sequential data by including the history of a large number of stores which are not supermarkets, and in the absence of size data on these stores, we chose to exclude all stores opened and closed prior to the first quarter of 1978 from our analysis.

After obtaining the opening date information on each supermarket in the Vancouver sub-market, we utilize the procedure for estimating the state dependent probabilities discussed in sub-section 5.6.3. That is, we plot each store in the sequence in which it was opened, noting as we go along the stores which the plotted store had boundaries with. This information is then summarized in a contingency table, Table XX, and, in turn, translated into a matrix of state dependent probabilities, matrix (5.18).

TABLE XX

CONTINGENCY TABLE OF STATE DEPENDENT FREQUENCIES

	F_s	F_k	cf
B_s	7	2	1
B_k	0	3	1
B_{cf}	1	0	0
B_s, B_{cf}	4	5	4
B_k, B_{cf}	1	1	2
B_s, B_k	5	4	4
B_s, B_k, B_{cf}	14	13	16

Note: Only 88 (instead of 89) observations appear in Table XX since one firm F_k store was established such that it had boundaries with no other firm's stores.

(5.18)

$$\begin{array}{l} \\ B_s \\ B_k \\ B_{cf} \\ B_s, B_{cf} \\ B_k, B_{cf} \\ B_s, B_k \\ B_s, B_k, B_{cf} \end{array}
\begin{array}{c} \begin{array}{ccc} F_s & F_k & cf \end{array} \\ \left[\begin{array}{ccc} .700 & .200 & .100 \\ .000 & .750 & .250 \\ 1.000 & .000 & .000 \\ .308 & .384 & .308 \\ .250 & .250 & .500 \\ .384 & .308 & .308 \\ .326 & .302 & .372 \end{array}\right] \end{array}$$

The first thing to note is that firm F_o's stores have been placed in the competitive fringe category. This decision was made, in part, on the basis of the very small number of firm F_o's stores which were established in the Vancouver sub-market (i.e. three). In addition, the dimensionality of both the contingency table and state dependent probability matrix would have been drastically increased had we not combined the firm F_o and competitive fringe categories. Second, it is clear that we cannot use the contingency table XX as presently constructed in order to do a chi-square test of the null hypothesis of state dependence. The reason is that only five of the twenty-one cells of table XX would have expected frequencies greater than five. We must therefore combine various states in order to increase the expected frequencies in as many cells of the contingency table as possible. Since we have already discussed our reasons for combining particular states of neighbor relations in sub-section 5.6.4, we shall refrain from reproducing that discussion here, and instead provide a summary of our calculations in the form of a revised contingency table and revised state dependent probability matrix.

TABLE XXI

REVISED CONTINGENCY TABLE OF STATE DEPENDENT FREQUENCIES

	F_s	F_k	cf
B_s / B_s,B_{cf}	11	7	5
B_k / B_k,B_{cf}	1	4	3
B_{cf} / B_s,B_k / B_s,B_k,B_{cf}	20	17	20

$$
(5.19) \qquad \begin{array}{r c}
 & \begin{array}{ccc} F_s & F_k & cf \end{array} \\
B_s / B_s,B_{cf} & \\
B_k / B_k,B_{cf} & \\
B_{cf} / B_s,B_k / B_s,B_k,B_{cf} &
\end{array}
\begin{pmatrix} .478 & .305 & .217 \\ .125 & .500 & .375 \\ .351 & .298 & .351 \end{pmatrix}
$$

We shall now use the information contained in Table XXI in order to conduct the chi-square test of the null hypothesis of state dependence. The expected frequencies for each cell of Table XXI are calculated on the basis of the relative frequency of each firm's stores in B.C. These relative frequencies, which again are our estimates of the state independent probabilities for this test, are listed in Table XXII.

TABLE XXII

RELATIVE FREQUENCIES OF EACH FIRM'S STORES IN B.C.

Firm	Relative Frequency
Canada Safeway (Firm F_s)	87/336 ≈ .2589285
Kelly Douglas (Firm F_k)	114/336 ≈ .3392858
Competitive Fringe (cf.)	135/336 ≈ .4017857

The calculation of the chi-square statistic yields the following:

$$\sum_{m=1}^{M} \sum_{i=1}^{j} \frac{(a_{mi} - e_{mi})^2}{e_{mi}} = \frac{(11 - 5.9554)^2}{5.9554} + \frac{(7 - 7.8036)^2}{7.8036} + \frac{(5 - 9.2410)^2}{9.2410}$$

$$+ \frac{(1 - 2.0714)^2}{2.0714} + \frac{(4 - 2.7143)^2}{2.7143} + \frac{(3 - 3.2143)^2}{3.2143}$$

$$+ \frac{(20 - 14.7589)^2}{14.7589} + \frac{(17 - 19.3393)^2}{19.3393} + \frac{(20 - 22.9018)^2}{22.9018}$$

$$= 4.2730948 + .0827532 + 1.9463349 + .5541652$$

$$+ .6090057 + .0142875 + 1.8611908 + .2829639$$

$$+ .367676$$

$$= 9.991472.$$

This result is significant at the 5% level since it lies in the 5% tail of a chi-square distribution with four degrees of freedom. Hence, we may accept the hypothesis that the a_{mi} are significantly different from the e_{mi}. This implies that the process giving rise to our observations a_{mi} is consistent with a state dependent probabilistic process based on the $\tilde{\pi}_{mi}$. Our next task is to determine if our estimates of the state dependent probabilities are consistent with one or more firms having engaged in preemptive behavior in the Vancouver sub-market.

5.6.6 Comparative Analysis of State Dependent Probabilities and Relative Frequencies for the Vancouver Sub-market

Our first set of criteria for determining if the state dependent probabilities are consistent with one or more firms having engaged in preemptive behavior in the Vancouver sub-market involves comparisons between our estimates of the state dependent probabilities in matrix (5.19) and the relative frequencies in Table XXII. Looking at the first row of matrix (5.19), we discover the following:

$$\tilde{\pi}_{11} = .478 > .2589285 = f_s$$
$$\tilde{\pi}_{12} = .305 < .3392858 = f_k$$
$$\tilde{\pi}_{13} = .217 < .4017857 = f_{cf} .$$

All three of these inequalities are consistent with firm F_s having preempted in the Vancouver sub-market (see sub-section 5.6.4). Looking at the second row of matrix (5.19), we also find that

$$\tilde{\pi}_{22} = .500 > .3392858 = f_k$$
$$\tilde{\pi}_{21} = .125 < .2589285 = f_s$$
$$\tilde{\pi}_{23} = .375 < .4017857 = f_{cf} .$$

Again, all three of these inequalities are consistent with firm F_k having preempted in the Vancouver sub-market. Thus, on the basis of these criteria, it would appear that two firms have engaged in preemptive behavior in the Vancouver sub-market, firm F_s and firm F_k. We shall delay the further interpretation of these results until after we have determined if the state dependent probabilities satisfy our second set of criteria for designating a given firm as a preemptor.

In sub-section 5.6.4, we established that if firm F_s is to be designated as a preemptor, then $\tilde{\pi}_{11}(t)$ should exceed $f_s(t)$ for almost all t, where $f_s(t)$ represents the relative frequency of firm F_s's stores in the Vancouver sub-market at some time t. In addition, we noted that $\tilde{\pi}_{12}(t) < f_k(t)$ and $\tilde{\pi}_{13}(t) < f_{cf}(t)$ for almost all t would be consistent with firm F_s having preempted in the sub-market. A similar set of criteria was established for being able to designate firm F_k as a preemptor, most importantly $\tilde{\pi}_{22}(t) > f_k(t)$ for almost all t. In Table XXIII, we compare the annual estimates of the state dependent probabilities with the annual relative frequencies.

TABLE XXIII

ANNUAL COMPARISONS OF $\tilde{\pi}_{mi}$ AND f_{iu} FOR THE VANCOUVER SUB-MARKET

	$\tilde{\pi}_{11}$		f_s	$\tilde{\pi}_{12}$		f_k	$\tilde{\pi}_{13}$		f_{cf}
1941	1/1	>	2/3	0		0	0	<	1/3
1942	2/2	>	3/4	0		0	0	<	1/4
1947	3/3	>	4/5	0		0	0	<	1/5
1949	6/8	>	7/10	2/8	>	2/10	0	<	1/10
1954	6/8	>	7/11	2/8	>	2/11	0	<	2/11
1955	6/10	>	7/16	3/10	>	4/16	1/10	<	5/16
1956	6/10	>	9/19	3/10	>	4/19	1/10	<	6/19
1957	6/11	>	9/23	4/11	>	7/23	1/11	<	7/23
1958	6/11	>	11/27	4/11	>	9/27	1/11	<	7/27
1959	6/11	>	13/33	4/11	>	10/33	1/11	<	10/33
1960	4/12	=	13/39	4/12		13/39	2/12	<	13/39
1961	6/12	>	15/43	4/12	>	14/43	2/12	<	14/43
1962	6/12	>	16/47	4/12	<	17/47	2/12	<	14/47
1963	8/15	>	20/55	4/15	<	18/55	3/15	<	17/55
1964	9/17	>	21/59	5/17	<	21/59	3/17	<	17/59
1965	9/19	>	23/65	6/19	<	22/65	4/19	<	20/65
1966	9/20	>	24/67	7/20	>	23/67	4/20	<	20/67
1967	9/20	>	24/69	7/20	>	23/69	4/20	<	22/69
1968	9/20	>	26/72	7/20	>	24/72	4/20	<	22/72
1969	10/21	>	27/75	7/21	>	25/75	4/21	<	23/75
1970	10/21	>	28/78	7/21	>	26/78	4/21	<	24/78
1971	11/22	>	30/81	7/22	<	27/81	4/22	<	24/81
1973	11/22	>	31/83	7/22	<	27/83	4/22	<	25/83
1974	11/22	>	32/85	7/22	<	28/85	4/22	<	25/85
1975	11/22	>	33/87	7/22	<	28/87	4/22	<	26/87
1976	11/22	>	33/88	7/22	=	28/88	4/22	<	27/88
1977	11/22	>	33/89	7/22	<	29/89	4/22	<	27/89
1978	11/23	>	33/91	7/23	<	29/91	5/23	<	29/91

	$\tilde{\pi}_{22}$		f_k	$\tilde{\pi}_{21}$		f_s	$\tilde{\pi}_{23}$		f_{cf}
1941	0		0	0	<	2/3	0	<	1/3
1942	0		0	0	<	3/4	0	<	1/4
1947	0		0	0	<	4/5	0	<	1/5
1949	0	<	2/10	0	<	7/10	0	<	1/10
1954	0	<	2/11	0	<	7/11	0	<	2/11
1955	0/1	<	4/16	0	<	7/16	1/1	>	5/16
1956	0/1	<	4/19	0	<	9/19	1/1	>	6/19
1957	0/1	<	7/23	0	<	9/23	1/1	>	7/23
1958	1/2	>	9/27	0	<	11/27	1/2	>	7/27
1959	2/3	>	10/33	0	<	13/33	1/3	>	10/33
1960	3/4	>	13/39	0	<	13/39	1/4	<	13/39
1961	3/4	>	14/43	0	<	15/43	1/4	<	14/43
1962	3/4	>	17/47	0	<	16/47	1/4	<	14/47
1963	3/4	>	18/55	0	<	20/55	1/4	<	17/55
1964	4/5	>	21/59	0	<	21/59	1/5	<	17/59
1965	4/6	>	22/65	0	<	23/65	2/6	>	20/65
1966	4/6	>	23/67	0	<	24/67	2/6	>	20/67
1967	4/7	>	23/69	0	<	24/69	3/7	>	22/69
1968	4/7	>	24/72	0	<	26/72	3/7	>	22/72
1969	4/7	>	25/75	0	<	27/75	3/7	>	23/75
1970	4/7	>	26/78	0	<	28/78	3/7	>	24/78
1971	4/7	>	27/81	0	<	30/81	3/7	>	24/81
1973	4/8	>	27/83	1/8	<	31/83	3/8	>	25/83
1974	4/8	>	28/85	1/8	<	32/85	3/8	>	25/85
1975	4/8	>	28/87	1/8	<	33/87	3/8	>	26/87
1976	4/8	>	28/88	1/8	<	33/88	3/8	>	27/88
1977	4/8	>	29/89	1/8	<	33/89	3/8	>	27/89
1978	4/8	>	29/91	1/8	<	33/91	3/8	>	29/91

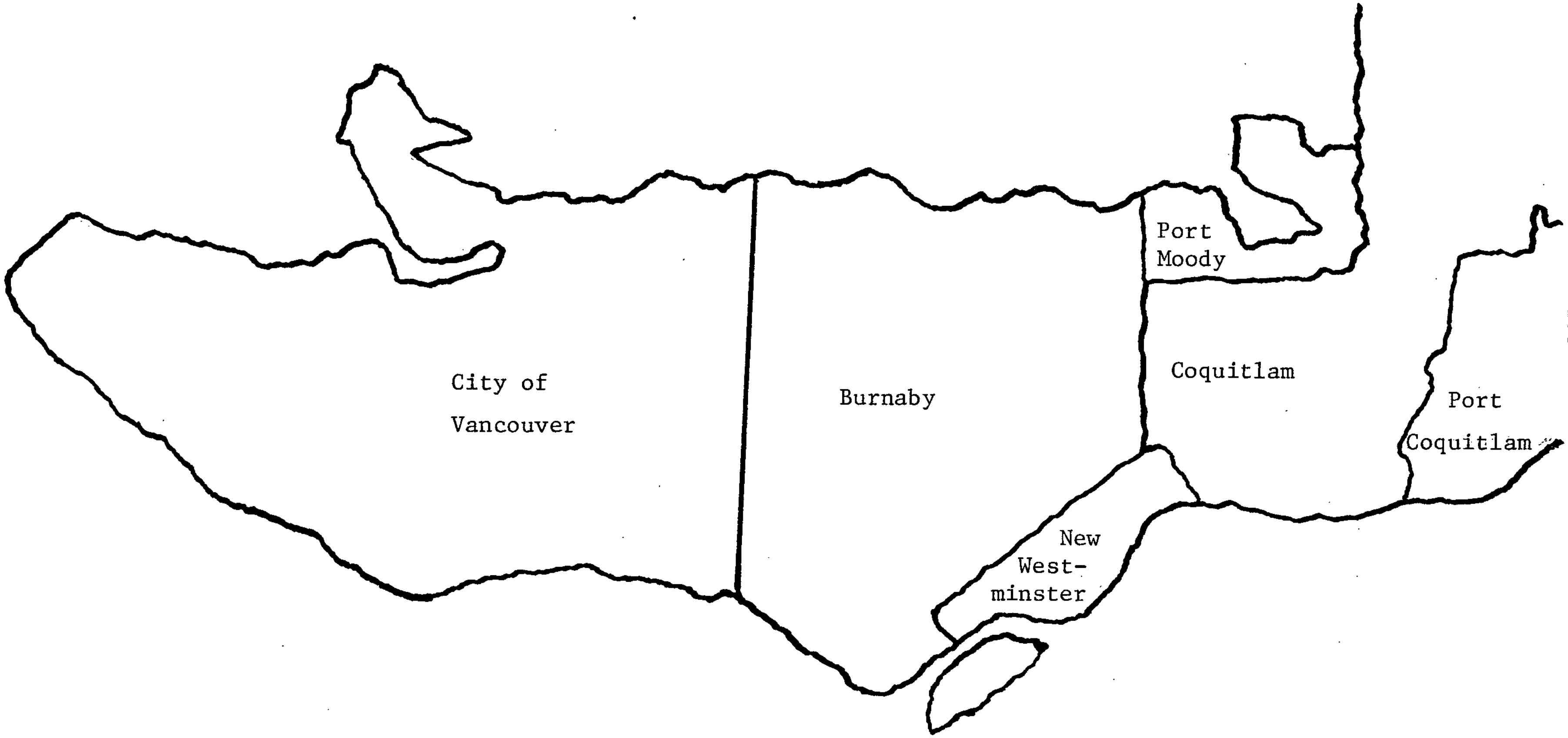
The most important result in Table XXIII is that $\tilde{\pi}_{11}(t)$ exceeds $f_s(t)$ in every time period. This clearly establishes firm F_s as a preemptor in the Vancouver sub-market. We also find that from 1958 to 1978, $\tilde{\pi}_{22}(t) > f_k(t)$. This result supports the conclusion that firm F_k began preempting in the Vancouver sub-market in 1958. Also of interest is the fact that $\tilde{\pi}_{13}(t) < f_{cf}(t)$ and $\tilde{\pi}_{21}(t) < f_s(t)$ in every time period. These results are consistent with firm F_s and firm F_k having engaged in preemptive behavior in the Vancouver sub-market respectively. Finally, we note that in 10 out of the 25 time periods listed in the table in which firm F_k had stores in the Vancouver sub-market, $\tilde{\pi}_{12} < f_k$, and in 10 out of the 28 time periods listed in the table, $\tilde{\pi}_{23} < f_{cf}$. These last results are weak, and given the tentative nature of the implications which we were able to draw regarding the signs of these discrepancies in sub-section 5.6.4, we cannot regard these results as constituting evidence against the proposition that firm F_s and firm F_k have preempted in the Vancouver sub-market.

5.6.7 Interpretation of the Comparative Analysis of State Dependent Probabilities and Relative Frequencies

We have seen in the previous sub-section that our two sets of criteria for evaluating the state dependent probabilities lend strong support to the proposition that both firm F_s and firm F_k have preempted in the Vancouver sub-market. In this sub-section, we shall consider in somewhat more detail when and where it appears that firm F_s and firm F_k established themselves as preemptors.

To facilitate our discussion, we have sketched a very rough map of the Vancouver sub-market, which appears as Figure 12 below. We shall define the western sector of the Vancouver sub-market as consisting

Figure 12


Port
Moody
City of
Vancouver
Burnaby
Coquitlam
Port
Coquitlam
New
West-
minster

of the City of Vancouver, while the eastern sector will be defined as consisting of Burnaby, Port Moody, Port Coquitlam, Coquitlam, and New Westminster.

Between the years 1941 and 1949 inclusive, firm F_s established six stores in the Vancouver sub-market, five of which were located in the western sector. These six stores represent six cases where firm F_s established stores in the Vancouver sub-market such that each store only had boundaries with other firm F_s stores. In addition, in 1949, six of the seven existing stores in the western sector were owned by firm F_s. We also find that the population in the western sector had increased from 275,353 to 344,833 between 1941 and 1951, or by 25.23%. Between 1950 and 1962 inclusive, firm F_s established nine new stores in the Vancouver sub-market, but none of these stores had boundaries only with firm F_s stores or with firm F_s and competitive fringe stores at the time when they were opened, and only four of these nine stores were opened in the western sector. (The population of the western sector increased from 344,833 to 384,522 between 1951 and 1961, or by 11.51%, while the population of the eastern sector increased from 108,190 to 175,764, or by 62.46%.) Then, between 1963 and 1971 inclusive, firm F_s established fourteen new stores in the Vancouver sub-market, and eleven of these stores were in the western sector. In addition, of these fourteen new stores, five stores had boundaries only with firm F_s stores or with firm F_s and competitive fringe stores, and all five were located in the western sector. The population of the western sector increased from 384,522 to 426,256 between 1961 and 1971, or by 10.85%. Finally, from 1972 to 1978, firm F_s only opened three new stores in the Vancouver sub-market, and all three had at least one boundary with a store owned by firm F_k.

Between the years 1958 and 1964 inclusive, firm F_k opened five of the seven stores in the Coquitlam-Port Coquitlam-Port Moody section of the eastern sector. Three of these five stores were established such that each store only had boundaries with other firm F_k stores, while one of the five stores was established such that it had boundaries with firm F_k and competitive fringe stores. These five stores represented twenty-four percent of the total number of firm F_k stores in the Vancouver sub-market in 1964, while the population of Coquitlam-Port Coquitlam-Port Moody represented only 9.53% of the total Vancouver sub-market population. In addition, between the years 1956 and 1966, the population of Coquitlam-Port Coquitlam-Port Moody had increased from 28,145 to 59,058, or by 109.83%.[21] From 1965 to 1978, firm F_k established an additional eight stores in the Vancouver sub-market, but none of these stores had boundaries only with stores owned by firm F_k or with stores owned by firm F_k and the competitive fringe.

All of this suggests that firm F_s preempted in the western sector of the Vancouver sub-market between 1941 and 1949 and between 1963 and 1971, while firm F_k preempted in the eastern sector of the Vancouver sub-market between 1958 and 1964. Further support for this conclusion is obtained when one considers that by 1971, 21 out of 30 (or 70%) of firm F_s's stores were located in the western sector, while 12 out of 21 (or 57%) of firm F_k's stores were located in the eastern sector by 1964. This breakdown gains added significance when it is realized that the eastern sector represented only 33.76% of the Vancouver sub-market population in 1966, while the western sector represented 62.85% of the Vancouver sub-market population in 1971.

In summary, the past three sections of this chapter have shown the following: 1) we may reject the null hypothesis of random firm ownership and random neighbor relations for the Vancouver sub-market; 2) we may accept the null hypothesis of state dependence for the Vancouver sub-market; 3) we accept the proposition that both firm F_s and firm F_k have preempted in the Vancouver sub-market.

In the next section of this chapter, we consider an extension of this analysis.

5.7 An Extension

5.7.1 Redefining a Supermarket

In sections 5.3 - 5.6, our analysis was based on defining all of a given firm's stores as supermarkets if the mean ground floor area of all of the stores owned by that firm exceeds 10,000 square feet, and if they are capable of being the destination of a consumer's weekly grocery shopping trip in that they stock the goods listed in the Statistics Canada combination store definition. This definition allowed for the possibility of significant variance of store size around the mean for a given firm. That is, some of a given firm's stores may be in the neighborhood of five or six thousand square feet in size, while others may be in the neighborhood of thirty-two thousand square feet in size. Should both extremes of the size distribution of stores owned by a given firm be classified as supermarkets?

There are two ways in which to approach this question. The first approach is to argue that the stores in the extremes of the size distribution of supermarkets do not really belong to the same industry and hence do not serve the same market. The stores which belong to the supermarket industry would primarily serve a market consisting of the weekly grocery shopping trips of consumers. The stores which belong to what might be called the convenience store or neighborhood grocer industry would primarily serve a market consisting of the mid-week grocery shopping trips of consumers. These mid-week shopping trips might be occasioned by consumers exhausting their inventories of particular goods before the time of the weekly shopping trip. Supermarkets and neighborhood grocers are further differentiated by the vector of goods which are sold, with supermarkets usually stocking a wider assortment of goods. By providing a wider assortment of goods, supermarkets hope to convey the image of being able to satisfy a multiplicity of consumer needs (both food and nonfood), thus providing an incentive for consumers to bypass neighborhood grocers on their way to do their weekly grocery shopping.[22]

A second approach is to argue that the stores which belong to the neighborhood grocer industry are apt to charge higher prices than supermarkets. For example, neighborhood grocers may have a lower volume of sales or lower turnover rate than supermarkets, and might charge higher prices in order to compensate for their lower profitability. Some neighborhood grocers might be faced with higher wholesale costs than supermarkets due to their inability to buy in volume or maintain their own warehouse facilities. This would be the result of the fact that most neighborhood grocers are independently owned. If we have included some neighborhood grocers in our analysis of the previous sections, and if they charge markedly higher prices than supermarkets, then we will have violated the assumption that allowed us to find the market area boundaries by the perpendicular bisector - least distance method. The simplest way of correcting for this distortion would be to eliminate the smaller stores from the analysis. (However, we would continue to maintain our assumption that the remaining stores charge the same vector of prices.)

It seems, then, that our analysis based on our earlier definition of a supermarket may be subject to a degree of measurement error. However, these errors may be of little significance if our empirical results remain fairly robust with respect to alternative definitions of a supermarket. In order to see if this is the case, we shall conduct tests of the null hypotheses of randomness and state dependence on the basis of a revised sample which conforms to the following definition of a supermarket:

Definition 4. A retail food store will be designated a supermarket if it has a ground floor area in excess of 12,000 square feet, and if it is capable of being the destination of a consumer's weekly grocery shopping trip in that it stocks the goods listed in the Statistics Canada combination store definition.

The analysis of this section will exclude the extreme tail of the size distribution of supermarkets consisting of stores less than 12,000 square feet in size. Again, we use the constituent sub-markets of the GVRD as the basis for our tests, and the procedure for testing the null hypotheses of random firm ownership, random neighbor relations, and state dependence outlined in sections 5.3 - 5.6 will be followed.

5.7.2 The Test of Random Firm Ownership

In this sub-section, we shall retest the null hypothesis of random firm ownership for the GVRD and sub-markets using a revised data set. We begin by providing lists of the revised store ownership figures for British

Columbia and the GVRD sub-markets in Tables XXIV and XXV.

TABLE XXIV

STORE OWNERSHIP BY FIRM - BRITISH COLUMBIA

(STORE SIZE > 12,000 SQUARE FEET)

Firm	Number of Stores in B.C.	
Canada Safeway (Firm F_s)	87	[87]
Overwaitea (Firm F_o)	34	[46]
Kelly Douglas (Firm F_k)		
Super Valu (Corporate)	34	[35]
Super Valu (Franchise)	21	[47]
Shop Easy (Corporate)	4	[7]
Shop Easy (Franchise)	1	[22]
Economart (Corporate)	3	[3]
Total	184	[247]

TABLE XXV

STORE OWNERSHIP BY FIRM - GVRD SUB-MARKETS

(STORE SIZE > 12,000 SQUARE FEET)

Firm	Vancouver	Delta-Surrey	North Shore	Richmond
	Sub-markets			
Canada Safeway (Firm F_s)	30 [30]	7 [7]	4 [4]	5 [5]
Overwaitea (Firm F_o)	3 [3]	2 [2]	0 [0]	1 [1]
Kelly Douglas (Firm F_k)	14 [22]	4 [9]	4 [6]	1 [2]
Competitive Fringe (cf)				
IGA	8 [16]	2 [3]	1 [2]	0 [2]
Woodward's	4 [4]	1 [1]	1 [1]	1 [1]
Stong's	1 [2]	0 [0]	3 [3]	0 [0]
High-Low	1 [2]	2 [2]	0 [0]	0 [0]
Total	61 [79]	18 [24]	13 [16]	8 [11]

The figures which appear in brackets represent the store ownership figures based on our earlier definition of a supermarket, Definition 1. Again, we make the assumption that the number of competitive fringe stores in B.C. is proportional to population. Since there are twenty-five competitive fringe stores in the GVRD which are greater than 12,000 square feet in size, and since the GVRD represents approximately 44% of the population in B.C., we have assumed that there are 57 competitive fringe stores in B.C.

Looking briefly at the revised store ownership figures, we see that Safeway's representation remains unchanged. All of their stores are greater than 12,000 square feet in size. Overwaitea's representation in the GVRD has not changed, but its representation in B.C. has been reduced by twelve. The most dramatic change has occurred in the Kelly Douglas store ownership figures. Approximately 44.7% of its stores in B.C. are less than or equal to 12,000 square feet in size, and 92% of these stores are franchises. In addition, we note that Kelly Douglas' representation in the GVRD has been reduced by 41%.

We are now prepared to test the null hypothesis that our revised observations on firm ownership were generated by an independent stochastic process based on the f_i, where the f_i are listed in Table XXVI.

TABLE XXVI

RELATIVE FREQUENCIES OF EACH FIRM'S STORES IN B.C.

(STORE SIZE > 12,000 SQUARE FEET)

Firm	Relative Frequency
Canada Safeway (Firm F_s)	87/241 $\simeq$ .3609958
Overwaitea (Firm F_o)	34/241 $\simeq$ .1410788
Kelly Douglas (Firm F_k)	63/241 $\simeq$ .2614108
Competitive Fringe (cf)	57/241 $\simeq$ .2365146

In Table XXVII, we provide descriptive measures for the marginal distributions of firm ownership generated for each sub-market and the four sub-markets combined (the GVRD).

TABLE XXVII

MARGINAL DISTRIBUTION DESCRIPTIVE MEASURES BY FIRM

FOR THE GVRD AND CONSTITUENT SUB-MARKETS

(STORE SIZE > 12,000 SQUARE FEET)

		Firm F_s	Firm F_o	Firm F_k	Competitive Fringe
GVRD	$\bar{n}_i$	36.091	14.165	26.333	23.411
	σ	4.7313	3.5767	4.5269	4.3311
Vancouver	$\bar{n}_i$	22.159	8.5400	15.897	14.404
	σ	3.7723	2.8511	3.5416	3.3514
Delta-Surrey	$\bar{n}_i$	6.5380	2.4800	4.6680	4.3140
	σ	2.021	1.460	1.8163	1.7924
North Shore	$\bar{n}_i$	4.683	1.924	3.374	3.019
	σ	1.7865	1.303	1.5769	1.5418
Richmond	$\bar{n}_i$	2.904	1.194	1.997	1.905
	σ	1.3837	1.0244	1.2388	1.2106

After translating our randomly generated distributions of firm ownership into distributions of the quantity $\sum_{i=1}^{j} (\tilde{n}_{iu} - \bar{n}_{iu})^2/\bar{n}_{iu}$, and using the information contained in Tables XXV and XXVII, we obtain the following results from doing the X^2 test of the null hypothesis.

TABLE XXVIII

RESULTS OF THE X^2 TESTS OF THE NULL HYPOTHESIS

OF RANDOM FIRM OWNERSHIP BY GVRD AND SUB-MARKETS

(STORE SIZE > 12,000 SQUARE FEET)

GVRD

Firm F_s	Firm F_o	Firm F_k	cf
$\frac{(46-36.091)^2}{36.091}$	$\frac{(6-14.165)^2}{14.165}$	$\frac{(23-26.333)^2}{26.333}$	$\frac{(25-23.411)^2}{23.411}$
2.7205752	4.7064754	.4218618	.1078519

$\sum_{i=1}^{j} (n_i - \bar{n}_i)^2/\bar{n}_i = 7.9567643 \quad (7.8290561)^*$

% of $\sum_{i=1}^{j} (\tilde{n}_i - \bar{n}_i)^2/\bar{n}_i$ distribution to right of 7.9567643 = 5.3%

Vancouver

Firm F_s	Firm F_o	Firm F_k	cf
$\frac{(30-22.159)^2}{22.159}$	$\frac{(3-8.54)^2}{8.54}$	$\frac{(14-15.897)^2}{15.897}$	$\frac{(14-14.404)^2}{14.404}$
2.7745512	3.5938641	.2263703	.0113312

$\sum_{i=1}^{j} (n_i - \bar{n}_i)^2/\bar{n}_i = 6.6060976 \quad (6.7929822)$

% of $\sum_{i=1}^{j} (\tilde{n}_i - \bar{n}_i)^2/\bar{n}_i$ distribution to right of 6.6060976 = 9.8%

* The figure in parentheses is the result obtained by calculating the chi-square statistic, $\sum_{i=1}^{j} (n_i - e_i)^2/e_i$.

Table XXVIII (continued)

Delta-Surrey

Firm F_s	Firm F_o	Firm F_k	cf
$\frac{(7-6.538)^2}{6.538}$	$\frac{(2-2.48)^2}{2.48}$	$\frac{(4-4.668)^2}{4.668}$	$\frac{(5-4.314)^2}{4.314}$
.0326466	.0929033	.0955922	.1090857

$$\sum_{i=1}^{j} (n_i - \bar{n}_i)^2/\bar{n}_i = .3302278 \quad (.3889026)$$

% of $\sum_{i=1}^{j} (\tilde{n}_i - \bar{n}_i)^2/\bar{n}_i$ distribution to right of .3302278 = 93.4%

North Shore

Firm F_s	Firm F_o	Firm F_k	cf
$\frac{(4-4.683)^2}{4.683}$	$\frac{(0-1.924)^2}{1.924}$	$\frac{(4-3.374)^2}{3.374}$	$\frac{(5-3.019)^2}{3.019}$
.0996133	1.924	.1161458	1.2998877

$$\sum_{i=1}^{j} (n_i - \bar{n}_i)^2/\bar{n}_i = 3.4396468 \quad (3.2480664)$$

% of $\sum_{i=1}^{j} (\tilde{n}_i - \bar{n}_i)^2/\bar{n}_i$ distribution to right of 3.4396468 = 35.0%

Richmond

Firm F_s	Firm F_o	Firm F_k	cf
$\frac{(5-2.904)^2}{2.904}$	$\frac{(1-1.194)^2}{1.194}$	$\frac{(1-1.997)^2}{1.997}$	$\frac{(1-1.905)^2}{1.905}$
1.5128154	.0315209	.4977511	.4299343

Table XXVIII (continued)

$$\sum_{i=1}^{j} (n_i - \bar{n}_i)^2/\bar{n}_i = 2.4720217 \quad (2.5490303)$$

% of $\sum_{i=1}^{j} (\tilde{n}_i - \bar{n}_i)^2/\bar{n}_i$ distribution to right of 2.4720217 = 55.8%

Looking at the results in Table XXVIII, we see that we may once again reject the null hypothesis that our observations were generated by an independent stochastic process based on the f_i for the Vancouver sub-market and the GVRD. These results are significant at the 10% level. We cannot reject the null hypothesis for the Richmond, North Shore, or Delta-Surrey sub-markets.

Before interpreting these results and comparing them with the results of our earlier tests, we shall test the null hypothesis that our observations on the neighbor relations in the GVRD and its constituent sub-markets were generated by an independent stochastic process based on the f_i.

5.7.3 <u>The Test of Random Neighbor Relations</u>

In this sub-section, we shall retest the null hypothesis of random neighbor relations for the GVRD and constituent sub-markets using data based on our revised definition of a supermarket. In Table XXIX, we report our calculations of common boundaries and boundaries between stores owned by different firms for the GVRD and its constituent sub-markets.

TABLE XXIX

COMMON BOUNDARIES AND BOUNDARIES BY FIRM - GVRD AND SUB-MARKETS

(STORE SIZE > 12,000 SQUARE FEET

Boundary	GVRD		Vancouver		Delta-Surrey		North Shore		Richmond	
B_{ss}	43	[31]	31	[20]	4	[4]	3	[2]	5	[5]
B_{oo}	0	[0]	0	[0]	0	[0]	0	[0]	0	[0]
B_{kk}	9	[25]	5	[8]	2	[13]	2	[4]	0	[0]
B_{cf}	15	[8]	9	[7]	3	[1]	3	[0]	0	[0]
B_{iI}	163	[244]	105	[162]	33	[45]	16	[22]	9	[15]
Total	230	[308]	150	[197]	42	[63]	24	[28]	14	[20]

The figures appearing in brackets in Table XXIX represent our earlier common boundary calculations. Some major differences in the two sets of figures are apparent. First, looking at the common boundary calculations for Vancouver, we note that firm F_s's common boundaries increase from 20 to 31 (or by 55%) while firm F_k's common boundaries decline from 8 to 5 (or by 37.5%). In Delta-Surrey sub-market, firm F_s's common boundaries remain the same, while firm F_k's common boundaries decline from 13 to 2 (or by 84.6%). In the GVRD as a whole, firm F_s's common boundaries increase from 31 to 43 (or by 38.7%), while firm F_k's decline from 25 to 9 (or by 64%). These results were not unexpected given that firm F_s's representation in the GVRD was not changed by our redefinition of a supermarket, while firm F_k's representation fell by 41%.

In Table XXX, we provide descriptive measures for the marginal distributions of common boundaries generated for each sub-market and for the GVRD. These distributions are based on the random distributions of firm ownership which were generated for the tests in the previous sub-section.

TABLE XXX

MARGINAL COMMON BOUNDARY DISTRIBUTION DESCRIPTIVE MEASURES

BY FIRM FOR THE GVRD AND SUB-MARKETS

(STORE SIZE > 12,000 SQUARE FEET)

		B_{ss}	B_{oo}	B_{kk}	B_{cf}	B_{iI}
GVRD	$\bar{B}_{ii}$	29.58	4.506	16.041	12.451	167.42
	σ	9.0098	3.0399	6.6629	5.7826	7.4842
Vancouver	$\bar{B}_{ii}$	19.771	2.971	10.338	8.434	108.49
	σ	7.9011	2.5645	5.3485	4.7439	6.3112
Delta-Surrey	$\bar{B}_{ii}$	5.583	.797	2.777	2.442	30.401
	σ	3.9926	1.198	2.7769	2.4394	3.1116
North Shore	$\bar{B}_{ii}$	3.108	.506	1.566	1.291	17.529
	σ	2.7882	.970	1.914	1.7015	2.3522
Richmond	$\bar{B}_{ii}$	1.818	.323	.925	.798	10.136
	σ	1.9992	.77283	1.3781	1.2872	1.7597

After translating our randomly generated distributions of common boundaries into distributions of the quantity

$$\left(\sum_{i=1}^{j} \frac{(\tilde{B}_{ii} - \bar{B}_{ii})^2}{\bar{B}_{ii}} \right) + \frac{(\tilde{B}_{iI} - \bar{B}_{iI})^2}{\bar{B}_{iI}}$$

and using the information contained in Table XXIX and Table XXX, we obtain the following results from doing the X^2 test of the null hypothesis:

TABLE XXXI

RESULTS OF THE X^2 TESTS OF THE NULL HYPOTHESIS

OF RANDOM NEIGHBOR RELATIONS BY GVRD AND SUB-MARKETS

(STORE SIZE > 12,000 SQUARE FEET)

GVRD

$\frac{(B_{ss} - \bar{B}_{ss})^2}{\bar{B}_{ss}}$	$\frac{(B_{oo} - \bar{B}_{oo})^2}{\bar{B}_{oo}}$	$\frac{(B_{kk} - \bar{B}_{kk})^2}{\bar{B}_{kk}}$	$\frac{(B_{cf} - \bar{B}_{cf})^2}{\bar{B}_{cf}}$	$\frac{(B_{iI} - \bar{B}_{iI})^2}{\bar{B}_{iI}}$
$\frac{(43 - 29.58)^2}{29.58}$	$\frac{(0 - 4.506)^2}{4.506}$	$\frac{(9 - 16.041)^2}{16.041}$	$\frac{(15 - 12.451)^2}{12.451}$	$\frac{(163 - 167.42)^2}{167.42}$
6.0884516	4.506	3.0905605	.5218376	.1166909

$$\left(\sum_{i=1}^{j} \frac{(B_{ii} - \bar{B}_{ii})^2}{\bar{B}_{ii}} \right) + \frac{(B_{iI} - \bar{B}_{iI})^2}{\bar{B}_{iI}} = 14.323538$$

% of $\left(\sum_{i=1}^{j} \frac{(\tilde{B}_{ii} - \bar{B}_{ii})^2}{\bar{B}_{ii}} \right) + \frac{(\tilde{B}_{iI} - \bar{B}_{iI})^2}{\bar{B}_{iI}}$ distribution to right of 14.323538 = 23.8%

Table XXXI (continued)

Vancouver

$\frac{(B_{ss}-\bar{B}_{ss})^2}{\bar{B}_{ss}}$	$\frac{(B_{oo}-\bar{B}_{oo})^2}{\bar{B}_{oo}}$	$\frac{(B_{kk}-\bar{B}_{kk})^2}{\bar{B}_{kk}}$	$\frac{(B_{cf}-\bar{B}_{cf})^2}{\bar{B}_{cf}}$	$\frac{(B_{iI}-\bar{B}_{iI})^2}{\bar{B}_{iI}}$
$\frac{(31-19.771)^2}{19.771}$	$\frac{(0-2.971)^2}{2.971}$	$\frac{(5-10.338)^2}{10.338}$	$\frac{(9-8.434)^2}{8.434}$	$\frac{(105-108.49)^2}{108.49}$
6.3775448	2.971	2.7562627	.0379838	.1122693

$$\sum_{i=1}^{j}\left[\frac{(B_{ii}-\bar{B}_{ii})^2}{\bar{B}_{ii}}\right]+\frac{(B_{iI}-\bar{B}_{iI})^2}{\bar{B}_{iI}} = 12.255059$$

% of $\left(\sum_{i=1}^{j}\frac{(\tilde{B}_{ii}-\bar{B}_{ii})^2}{\bar{B}_{ii}}\right)+\frac{(\tilde{B}_{iI}-\bar{B}_{iI})^2}{\bar{B}_{iI}}$ distribution to right of 12.255059 = 31.7%

Delta-Surrey

$\frac{(B_{ss}-\bar{B}_{ss})^2}{\bar{B}_{ss}}$	$\frac{(B_{oo}-\bar{B}_{oo})^2}{\bar{B}_{oo}}$	$\frac{(B_{kk}-\bar{B}_{kk})^2}{\bar{B}_{kk}}$	$\frac{(B_{cf}-\bar{B}_{cf})^2}{\bar{B}_{cf}}$	$\frac{(B_{iI}-\bar{B}_{iI})^2}{\bar{B}_{iI}}$
$\frac{(4-5.583)^2}{5.583}$	$\frac{(0-.797)^2}{.797}$	$\frac{(2-2.777)^2}{2.777}$	$\frac{(3-2.442)^2}{2.442}$	$\frac{(33-30.401)^2}{30.401}$
.4488427	.797	.2174034	.1275037	.22219

$$\left(\sum_{i=1}^{j}\frac{(B_{ii}-\bar{B}_{ii})^2}{\bar{B}_{ii}}\right)+\frac{(B_{iI}-\bar{B}_{iI})^2}{\bar{B}_{iI}} = 1.8129398$$

% of $\left(\sum_{i=1}^{j}\frac{(\tilde{B}_{ii}-\bar{B}_{ii})^2}{\bar{B}_{ii}}\right)+\frac{(\tilde{B}_{iI}-\bar{B}_{iI})^2}{\bar{B}_{iI}}$ distribution to right of 1.8129398 = 92.4%

North Shore

$\frac{(B_{ss}-\bar{B}_{ss})^2}{\bar{B}_{ss}}$	$\frac{(B_{oo}-\bar{B}_{oo})^2}{\bar{B}_{oo}}$	$\frac{(B_{kk}-\bar{B}_{kk})^2}{\bar{B}_{kk}}$	$\frac{(B_{cf}-\bar{B}_{cf})^2}{\bar{B}_{cf}}$	$\frac{(B_{iI}-\bar{B}_{iI})^2}{\bar{B}_{iI}}$
$\frac{(3-3.108)^2}{3.108}$	$\frac{(0-.506)^2}{.506}$	$\frac{(2-1.566)^2}{1.566}$	$\frac{(3-1.291)^2}{1.291}$	$\frac{(16-17.529)^2}{17.529}$
.0037528	.506	.1202785	2.26235	.1333699

$$\left(\sum_{i=1}^{j}\frac{(B_{ii}-\bar{B}_{ii})^2}{\bar{B}_{ii}}\right)+\frac{(B_{iI}-\bar{B}_{iI})^2}{\bar{B}_{iI}} = 3.0257413$$

% of $\left(\sum_{i=1}^{j}\frac{(\tilde{B}_{ii}-\bar{B}_{ii})^2}{\bar{B}_{ii}}\right)+\frac{(\tilde{B}_{iI}-\bar{B}_{iI})^2}{\bar{B}_{iI}}$ distribution to right of 3.0257413 = 76.0%

Table XXXI (continued)

Richmond

$\frac{(B_{ss} - \bar{B}_{ss})^2}{\bar{B}_{ss}}$	$\frac{(B_{oo} - \bar{B}_{oo})^2}{\bar{B}_{oo}}$	$\frac{(B_{kk} - \bar{B}_{kk})^2}{\bar{B}_{kk}}$	$\frac{(B_{cf} - \bar{B}_{cf})^2}{\bar{B}_{cf}}$	$\frac{(B_{iI} - \bar{B}_{iI})^2}{\bar{B}_{iI}}$
$\frac{(5 - 1.818)^2}{1.818}$	$\frac{(0 - .323)^2}{.323}$	$\frac{(0 - .925)^2}{.925}$	$\frac{(0 - .798)^2}{.798}$	$\frac{(9 - 10.136)^2}{10.136}$
5.5693752	.323	.925	.798	.127318

$$\left(\sum_{i=1}^{j} \frac{(B_{ii} - \bar{B}_{ii})^2}{\bar{B}_{ii}} \right) + \frac{(B_{iI} - \bar{B}_{iI})^2}{\bar{B}_{iI}} = 7.7426932$$

% of $\left(\sum_{i=1}^{j} \frac{(\tilde{B}_{ii} - \bar{B}_{ii})^2}{\bar{B}_{ii}} \right) + \frac{(\tilde{B}_{iI} - \bar{B}_{iI})^2}{\bar{B}_{iI}}$ distribution to right of 7.7426932 = 30.8%

Looking at the results in Table XXXI, we see that we would accept the null hypothesis that our observations on neighbor relations were generated by an independent stochastic process based on the f_i for the GVRD and all of its constituent sub-markets. Our acceptance of the null hypothesis for the GVRD and the Vancouver sub-market comes as somewhat of a surprise, and its implications will be explored in the next sub-section.

5.7.4 Interpretation of the Test Results of Randomness

In the past two sub-sections, we have shown that the null hypothesis of random firm ownership can be rejected for the GVRD and the Vancouver sub-market, but that the null hypothesis of random neighbor relations cannot be rejected for the GVRD and the Vancouver sub-market. In this sub-section, we shall interpret these results and compare them with the results of our earlier tests of random firm ownership and random neighbor relations.

Let us begin by examining the test results for the GVRD. As in our earlier tests, the largest relative discrepancy between observed and mean generated firm ownership occurs for firm F_o, while the second largest relative discrepancy occurs for firm F_s. Thus, it appears that firm F_s's stores are relatively concentrated in the GVRD, while firm F_o's stores are relatively unconcentrated, given the signs of these discrepancies before squaring. However, we do not find the ordering of relative discrepancies between observed and mean generated common boundaries to be unchanged. From Table XXXI, we see that the largest relative discrepancy occurs for firm F_s, the second largest for firm F_o, and the third largest for firm F_k. No longer does the largest relative discrepancy occur for competitive fringe stores (9.3103833 in our earlier calculations and .5218376 in our calculations based on the revised sample). When we compare the magnitude of the relative discrepancies between observed and mean generated common boundaries appearing in Tables XVIII and XXXI, we find that the total contribution of the relative discrepancies for firm F_s, firm F_o, and firm F_k is not markedly different. It seems as if the very small relative discrepancy between observed and mean generated boundaries for competitive fringe stores has been the main cause for accepting the null hypothesis of random neighbor relations for the GVRD when the test is based on the revised sample.

Let us now examine the test results for the Vancouver sub-market. Again, the ordering of relative discrepancies between observed and mean generated firm ownership is the same in Table XI as it is in Table XXVIII. Again, it appears that firm F_s's stores are relatively concentrated in the Vancouver sub-market and that firm F_o's stores are relatively unconcentrated, and these results are significant. However, the ordering of relative discrepancies between observed and mean generated common boundaries has changed considerably, as has their magnitude. The largest relative discrepancy occurs for firm F_s (6.3775448 compared to 3.5748212), the second largest for firm F_o (2.971 compared to 3.793), and the third largest for firm F_k (2.7562627 compared to 9.1804114). It seems that the large reduction in firm F_k's representation in the Vancouver sub-market caused by our redefinition of supermarket has led to a significant reduction in mean generated common boundaries for firm F_k, and hence a reduced relative discrepancy between observed and mean generated common boundaries.

What seems clear at this point is that tests based on our revised supermarket definition have not altered our conclusions regarding concentration, but have had some influence on our conclusions regarding the nature and extent of clustering. Since we have rejected the null hypothesis of random firm ownership for the Vancouver sub-market, but accepted the null hypothesis of random neighbor relations for the Vancouver sub-market, our conclusions regarding whether our observations were generated by an independent stochastic process based on the f_i of Table XXVI must necessarily be ambiguous. It is therefore appropriate to proceed with the test of state dependence for the Vancouver sub-market.

5.7.5 The Test of State Dependence

In this sub-section, we follow the procedure discussed in sub-section 5.6.3 in order to test the null hypothesis of state dependence for the Vancouver sub-market. On the basis of this procedure and our revised data set, we obtain a revised contingency table of state dependent frequencies and a new matrix of state dependent probabilities.

TABLE XXXII

CONTINGENCY TABLE OF STATE DEPENDENT FREQUENCIES

(STORE SIZE > 12,000 SQUARE FEET)

	F_s	F_k	cf
B_s	8	0	3
B_k	0	0	1
B_{cf}	1	0	0
B_s, B_{cf}	11	6	6
B_k, B_{cf}	1	2	0
B_s, B_k	1	1	0
B_s, B_k, B_{cf}	9	6	6

$$
(5.20) \qquad
\begin{array}{c|ccc|}
 & F_s & F_k & cf \\
B_s & .727 & .000 & .273 \\
B_k & .000 & .000 & 1.000 \\
B_{cf} & 1.000 & .000 & .000 \\
B_s, B_{cf} & .478 & .261 & .261 \\
B_k, B_{cf} & .333 & .667 & .000 \\
B_s, B_k & .500 & .500 & .000 \\
B_s, B_k, B_{cf} & .428 & .286 & .286
\end{array}
$$

As for our earlier test of state dependence, restrictions on the chi-square test make it necessary to combine as many states as possible. After combining states, we obtain contingency table XXXIII and state dependent probability matrix (5.21).

TABLE XXXIII

REVISED CONTINGENCY TABLE OF STATE DEPENDENT FREQUENCIES

(STORE SIZE > 12,000 SQUARE FEET)

	F_s	F_k	cf
B_s / B_s,B_{cf}	19	6	9
B_k / B_k,B_{cf}	1	2	1
B_{cf} / B_s,B_k / B_s,B_k,B_{cf}	11	7	6

$$
\begin{array}{l c}
 & \begin{array}{ccc} F_s & F_k & cf \end{array} \\
B_s / B_s, B_{cf} & \\
B_k / B_k, B_{cf} & \left(\begin{array}{ccc} .559 & .176 & .265 \\ .250 & .500 & .250 \\ .458 & .292 & .250 \end{array}\right) \\
B_{cf}, / B_s, B_k / B_s, B_k, B_{cf} &
\end{array}
\tag{5.21}
$$

In Table XXXIV, we provide a list of the relative frequencies of each firm's stores in B.C. These relative frequencies constitute our estimates of the state independent probabilities for the test of state dependence.

TABLE XXXIV

RELATIVE FREQUENCIES OF EACH FIRM'S STORES IN B.C.

(STORE SIZE > 12,000 SQUARE FEET)

Firm	Relative Frequency
Canada Safeway (Firm F_s)	87/241 ≈ .3609958
Kelly Douglas (Firm F_k)	63/241 ≈ .2614108
Competitive Fringe (cf)	91/241 ≈ .3775934

Using the information contained in contingency table XXXIII, and using our estimates of the state independent probabilities in order to calculate the expected frequencies for each cell of Table XXXIII, we are able to perform the chi-square test of state dependence.

$$\sum_{m=1}^{M} \sum_{i=1}^{j} \frac{(a_{mi} - e_{mi})^2}{e_{mi}} \doteq \frac{(19 - 12.2739)^2}{12.2739} + \frac{(6 - 8.888)^2}{8.888} + \frac{(9 - 12.8381)^2}{12.8381}$$

$$+ \frac{(1 - 1.444)^2}{1.444} + \frac{(2 - 1.0456)^2}{1.0456} + \frac{(1 - 1.5104)^2}{1.5104}$$

$$+ \frac{(11 - 8.6639)^2}{8.6639} + \frac{(7 - 6.2739)^2}{6.2739} + \frac{(6 - 9.0622)^2}{9.0622}$$

$$= 3.6859043 + .938405 + 1.1474447 + .1365207 + .8711546$$

$$+ .1724762 + .6298968 + .084034 + 1.0347452$$

$$= 8.7005815.$$

This result is significant at the 10% level since it lies in the 10% tail of a chi-square distribution with four degrees of freedom. Thus, we may accept the hypothesis that our observations a_{mi} are significantly different from the e_{mi}. This implies that the process giving rise to our observations is consistent with a state dependent probabilistic process based on the $\tilde{\pi}_{mi}$. Our next step is to determine if our estimates of the state dependent probabilities are consistent with one or more firms having preempted in the Vancouver sub-market.

5.7.6 Comparative Analysis of State Dependent Probabilities and Relative Frequencies for the Vancouver Sub-market

It will be recalled that our first set of criteria for determining if the state dependent probabilities are consistent with one or more firms having preempted in the Vancouver sub-market involves comparisons between our estimates of the state dependent probabilities in matrix (5.21) and the relative frequencies in Table XXXIV. Looking at the first row of matrix (5.21), we find that

$$\tilde{\pi}_{11} = .559 > .3609958 = f_s$$

$$\tilde{\pi}_{12} = .176 < .2614108 = f_k$$

$$\tilde{\pi}12 = .265 < .3775934 = f_{cf} .$$

All of these inequalities are consistent with firm F_s having preempted in the Vancouver sub-market (see section 5.6.4). Looking at the second row of matrix (5.21), we find that

$$\tilde{\pi}_{22} = .500 > .2614108 = f_k$$

$$\tilde{\pi}_{21} = .250 < .3609958 = f_s$$

$$\tilde{\pi}_{23} = .250 < .3775934 = f_{cf}.$$

These three inequalities are consistent with firm F_k having preempted in the Vancouver sub-market. However, given that there is only a total of four cases in the three cells of the second row of matrix (5.21), we do not attach much significance to this result. Indeed, if we look back at our initial contingency table before we combined states, we find that firm F_k never established a store in the sub-market such that it only had boundaries with other firm F_k stores. Furthermore, only two out of the fifteen firm F_k stores were established in the sub-market such that they only had boundaries with firm F_k and competitive fringe stores. We cannot regard firm F_k as being a preemptor of the Vancouver sub-market on the basis of such weak evidence. Our first set of criteria, therefore, supports the conclusion that eliminating firm F_k's smaller stores from the analysis results in eliminating firm F_k as being one of the preemptors of the Vancouver sub-market.

In sub-section 5.6.4, we established that if firm F_s is to be designated a preemptor, then $\tilde{\pi}_{11}(t)$ should exceed $f_s(t)$ for almost all t. In addition, we noted that $\tilde{\pi}_{12}(t) < f_2(t)$ and $\tilde{\pi}_{13}(t) < f_{cf}(t)$ for almost all t would be consistent with firm F_s having preempted in the sub-market. In Table XXXV, we compare the annual estimates of the state dependent probabilities with the annual relative frequencies.

TABLE XXXV

ANNUAL COMPARISONS OF $\tilde{\pi}_{mi}$ AND f_{iu} FOR THE VANCOUVER SUB-MARKET

(STORE SIZE > 12,000 SQUARE FEET)

	$\tilde{\pi}_{11}$		f_s	$\tilde{\pi}_{12}$		f_k	$\tilde{\pi}_{13}$		f_{cf}
1942	1/1	>	2/3				0	<	1/3
1947	2/2	>	3/4				0	<	1/4
1949	5/5	>	6/7				0	<	1/7
1954	5/6	>	6/8				1/6	≤	2/8
1955	5/7	>	6/9				2/7	<	3/9
1956	7/9	>	8/11				2/9	<	3/11
1957	7/10	>	8/12				3/10	≪	4/12
1958	8/12	=	10/15	1/12	>	1/15	3/12	<	4/15
1959	10/17	<	12/20	1/17	>	1/20	6/17	>	7/20
1960	10/20	>	12/25	2/20	<	3/25	8/20	=	10/25
1961	11/21	>	14/28	2/21	<	4/28	8/21	>	10/28
1962	11/21	>	15/31	2/21	<	6/31	8/21	>	10/31
1963	13/23	>	19/35	2/23	<	6/35	8/23	>	10/35
1964	14/25	>	20/38	3/25	<	8/38	8/25	>	10/38
1965	14/27	>	22/43	4/27	<	9/43	9/27	>	12/43
1966	14/28	<	23/45	5/28	≪	10/45	9/28	>	12/45
1967	14/28	=	23/46	5/28	<	10/46	9/28	>	13/46
1968	16/31	>	25/49	6/31	<	11/49	9/31	>	13/49
1969	17/32	>	26/51	6/32	<	12/51	9/32	>	13/51
1970	17/32	>	27/54	6/32	≤	13/54	9/32	>	14/54
1971	18/33	>	29/57	6/33	<	14/57	9/33	>	14/57
1973	18/33	>	30/58	6/33	<	14/58	9/33	>	14/58
1974	19/34	>	31/60	6/34	<	15/60	9/34	>	14/60
1975	19/34	>	32/62	6/34	<	15/62	9/34	>	15/62
1976	19/34	>	32/63	6/34	<	15/63	9/34	>	16/63
1978	19/34	>	32/64	6/34	<	15/64	9/34	<	17/64

When we examine the results in Table XXXV, we find that $\tilde{\pi}_{11}(t) > f_s(t)$ in all but four of the time periods listed in the table. This result confirms our conclusion, based on the first set of criteria, that firm F_s has preempted in the Vancouver sub-market. We also find that in all but two time periods, $\tilde{\pi}_{12}(t) < f_k(t)$, and this result is consistent with firm F_s having preempted in the sub-market. Finally, we note that $\tilde{\pi}_{13}(t) < f_{cf}(t)$ in nine of the twenty-six time periods listed in Table XXXV. This result is weak and we cannot regard it as constituting evidence for or against the proposition that firm F_s has preempted in the Vancouver sub-market.

When we compare Table XXXV with our earlier comparisons of $\tilde{\pi}_{mi}$ and f_{iu} in Table XXIII, some interesting observations emerge. First, between 1941 and 1949 inclusive, firm F_s established five new stores (as opposed to six in our earlier analysis) in the Vancouver sub-market such that all of these stores had boundaries only with stores owned by firm F_s or with stores owned by firm F_s and the competitive fringe. Between 1950 and 1962 inclusive, firm F_s established nine new stores in the Vancouver sub-market, six of which had boundaries only with other firm F_s stores or with firm F_s and competitive fringe stores. In our earlier analysis, none of the nine firm F_s stores opened between 1950 and 1962 had boundaries only with other firm F_s stores or with firm F_s and competitive fringe stores. Between 1963 and 1978 inclusive, firm F_s opened an additional seventeen stores in the Vancouver sub-market, eight of which had boundaries only with stores owned by firm F_s or with stores owned by firm F_s and the competitive fringe. This compares with five out of seventeen in our earlier analysis. Thus, we see that firm F_s established nineteen stores in the Vancouver sub-market such that each store had boundaries only with other firm F_s stores or with firm F_s and competitive fringe stores, and fifteen of these nineteen stores (or 78.95%) were located in the western sector. To put these last figures in perspective, we note that the western sector represented only 61.11% of the Vancouver sub-market population in 1976.

All of this suggests that firm F_s has been engaged in the continuous preemption of the Vancouver sub-market since 1941, and that it has primarily focused its preemptive location behavior in the western sector of the Vancouver sub-market.

5.7.7 Evaluation of Test Results Based on the Revised Sample

The motivation for the tests performed in this section has been to see if the empirical results based on our first definition of a supermarket remain fairly robust with respect to an alternative definition of a supermarket. By changing the number of stores which we designate as supermarkets, we not only change the relative frequencies of each firm's stores in B.C. and its constituent sub-markets, but we also change the set of spatial relationships between stores. These altered spatial relationships can have significant repercussions on our calculations of boundaries, and hence on tests based on the calculation of boundaries. In particular, under our broad definition of the supermarket industry (i.e. Definition 1), we may have included a number of stores in our sample which do not effectively compete with larger supermarkets. By including these smaller stores in our common boundary calculations based on the perpendicular bisector - least distance method, a firm which owns primarily large supermarkets will likely have its common boundaries reduced vis-a-vis the number of common boundaries it would have if the smaller stores were excluded from the sample. This reduction in common boundaries could cause us to falsely accept randomness or to falsely reject state dependence. Thus, we would expect that under a broad definition of the supermarket industry, we would be less likely to find evidence of preemptive behavior since the extent of competition would be artificially (and possibly erroneously) increased by the inclusion of stores which are not in effective competition with the larger supermarkets. That is, the more broadly we define the industry, the less likely it is that we will find one or two firms dominating it.

Having completed a series of tests based on a revised sample, it is clear that our revised supermarket definition has influenced the outcomes of the tests and the conclusions which may be derived from them. First, we have seen that the rejection of randomness was not complete for the Vancouver sub-market. While we were able to reject the hypothesis of random firm ownership, we could not reject the hypothesis of random neighbor relations. This sort of ambiguity did not exist in our first series of test results based on Definition 1 of a supermarket. Second, we found that we could still accept the hypothesis of state dependence, but with different implications for the nature of preemption in the Vancouver sub-market. In particular, while our original data set supported the proposition that firm F_s and firm F_k preempted in the Vancouver sub-market, our revised data set supports the proposition that firm F_s is the sole preemptor in the Vancouver sub-market. The inability to designate firm F_k as a preemptor is to be expected in light of the large reduction in firm F_k's representation in B.C. and the GVRD occasioned by our redefinition of supermarket. In addition, this change in results is consistent with our expectations regarding the probable effects of more narrowly defining the supermarket industry, since the redefinition of supermarket enabled us to designate only one firm as the preemptor of the Vancouver sub-market.

5.8 Concluding Remarks

In this chapter, we have sought to determine the nature and extent to which the spatial configuration of supermarkets in the Greater Vancouver Regional District is consistent with one or more firms having preempted in some sub-market of the GVRD. Our strategy has consisted of initially testing two hypotheses on the randomness of our observations on firm ownership and neighbor relations in particular sub-markets. Rejection of the null hypotheses that our observations were generated by an independent stochastic process based on the f_i was interpreted to mean that some form of state dependence was responsible for generating our observations. However, these tests would not permit us to be more precise about the specific nature of the state dependence which was responsible for generating our data. In point of fact, there are other explanations for why we might reject the hypothesis of randomness, and these explanations do not necessarily imply a preemptive location strategy on the part of any firm.

One explanation for why our observations on firm ownership and neighbor relations may be inconsistent with an independent stochastic process based on the f_i is the incentive which each firm has to economize on wholesaling or distribution costs. One of the major costs to any firm engaged in food retailing is the cost of procuring goods to sell in its stores. As the number of stores which a firm owns increases, the quantity of goods which must pass through a distribution network also increases. At some point, it may pay for a firm to vertically integrate its wholesale and retail operations in order to take advantage of the lower costs which would be incurred through such integration. (These lower costs might be due to the firm's ability to obtain quantity discounts on the purchase of large volumes of goods, to rationalize its inventory management, to coordinate product distribution to minimize transport costs, etc.) Thus, the incentive which a firm has to economize on distribution costs might lead it to concentrate its retail outlets in particular sub-markets. This concentration could lead to there being more common boundaries between stores that that firm owns than would be expected on the basis of a random allocation of firm ownership.

A second explanation for why we might reject the null hypotheses that our observations on firm ownership and neighbor relations were generated by an independent stochastic process based on the f_i has to do with the influence that marketing costs might have on a firm's location strategy. In particular, a viable marketing strategy might require a firm to have a significant presence in a particular sub-market. In addition, with only a small number of stores in a given sub-market, it may not pay for a firm to engage in a widely based marketing strategy from the point of view of the net revenues generated by such a strategy. Thus, there may be some economies to be realized in a firm's marketing costs if it concentrates its retail outlets in a given sub-market.

Both of the above explanations suggest that firms might have incentives to concentrate stores in particular sub-markets. However, they do not suggest that neighbor relations would be of much importance to a firm's location strategy. In fact, marketing considerations might lead a firm to disperse its stores throughout the sub-market instead of concentrating them in a corner of it.

Finally, we might ask if collusion is a possible explanation for observing concentration or clustering of a firm's stores in a given sub-market. On the face of it, it might seem reasonable to believe that firms would collude in order to divide up sub-markets or parts of sub-markets among themselves, and even to restrict price competition within sub-markets. The normal incentives for such behavior are entry prevention, market stability, higher profits through higher prices and reduction of competition. A major goal of collusive behavior would also be to postpone the time of entry until the profits to be derived from opening a new store in the market are greater than zero. However, due to the relatively low costs of entry into an industry such as the supermarket industry, it is likely that non-colluding firms would compete with each other for the opportunity to establish a new store in the market if the present value obtained from doing so is greater than or equal to zero. Thus, a colluding firm would not be able to postpone the time of entry or new store construction until the time when the profits attributable to a new store are greater than zero. It would still have to preempt the market if it wished to maintain its monopoly position, and it would have an incentive to locate the store such that it only had as its neighbors other stores that it owned. Apart from the fact that a colluding firm would also have to be a preempting firm if it wished to maintain its monopoly position in a given sub-market, there would be no incentive to collude if the collusive agreement would only permit the firm to do what it would do in the absence of such an agreement.

Given that there may be alternative explanations for the rejection of the null hypotheses of random firm ownership and random neighbor relations, we have chosen to regard tests of these hypotheses as performing a screening function and as providing insights into how the observed spatial configuration of stores deviates from a hypothetical random one. If we rejected these hypotheses for a particular sub-market, then we proceeded to test for the existence of the particular type of state dependence that is implied by the theory of preemption. The type of state dependence that we tested for is one that emphasizes potential neighbor relations as being a key determinant in a firm's locational choice behavior. Since the most plausible alternative explanations of rejection of randomness do not have the same implications with respect to neighbor relations that the theory of preemption has, we can eliminate these explanations as being the primary causes for acceptance of the null hypothesis of state dependence.

Now, acceptance of the null hypothesis of state dependence does not in and of itself imply that preemptive firm behavior was responsible for generating our observations. The reason is because the discrepancies between observed and expected number of stores that each firm establishes in the sub-market given different states of neighbor relations may be significant, but in the wrong direction or with the wrong sign. For example, if the state dependent probabilities were such that $\tilde{\pi}_{11} < f_1$, $\tilde{\pi}_{12} > f_2$, and $\tilde{\pi}_{13} > f_3$, then we would not say that our estimates of the state dependent probabilities are consistent with firm F_1 having preempted in the sub-market, even though we may have accepted the null hypothesis of state dependence. The fact that the discrepancies between observed and expected number of stores that each firm owns in the submarket given different states of neighbor relations have the theoretically predicted signs, and the fact that we are able to accept the null hypothesis of state dependence, together constitute evidence in support of the proposition that preemptive firm behavior is the best explanation of the observed spatial configuration of store ownership and location.

FOOTNOTES TO CHAPTER 5

1. Since we wished to have accurate, up-to-date information on supermarket locations, we found it necessary to contact personally the location analysts for several supermarket chain firms in order to obtain a list of supermarket locations throughout the province of British Columbia. Accurate and complete information on supermarket locations was not available from such obvious sources as telephone and city directories. In addition, even if it were available from these sources, it would be quite time consuming to compile the required information.

2. The Super Market Industry Speaks, 1976, conducted by Research Division, Super Market Institute, Inc. (Chicago, Illinois).

3. Census of Canada, 1971.

4. In a later section of the chapter, we report the results of a series of locational tests which utilize a revised definition of a supermarket. The revised definition will require that a retail food store be at least 12,000 square feet in total ground floor area in order to be classified as a supermarket.

5. Information regarding Canada Safeway's site selection and approval procedure, as well as a list of its supermarket locations in British Columbia, were obtained in a personal interview with the property manager of the Vancouver Division of Canada Safeway, Ltd., February, 1978.

6. A list of supermarket locations of Overwaitea and Your Mark-It Food Stores in British Columbia was provided by a location analyst for Overwaitea, March, 1978.

7. We have obtained our information regarding the Kelly Douglas franchise operation from a personal interview with a location analyst for Kelly Douglas, April, 1978. A list of the locations of all Kelly Douglas owned and franchised supermarkets was also provided.

8. Information regarding the H.Y. Louie franchise operation, as well as a list of supermarket locations in British Columbia, were supplied in a personal interview with an executive of the H.Y. Louie Company, Ltd., March, 1978.

9. Hoel [1971; 228-229].

10. Kendall and Stuart [1973; 439, 453-454].

11. Ibid.

12. Walker and Lev [1953; 107]. For a more detailed discussion and derivation of the chi-square test, see Kendall and Stuart [1963; 355-356], and Kendall and Stuart [1973; 436-440].

13. Hoel [1971; 108-112]. Choice of the upper tail of the X^2 distribution as our critical region is also suggested by the fact that the choice of the upper tail is accepted practice when performing the chi-square goodness of fit test, and the X^2 test and the chi-square test are quite similar. (In fact, the X^2 test and the chi-square test yield almost identical results when the underlying

distribution is multinomial.)

14. For a discussion of this interpretation, see Walker and Lev [1953; 107].

15. This result was not unexpected. We would expect fairly rapid convergence of the generated distribution to the exact distribution as the number of permutations increases since each assignment of firm ownership to a store is based on the same set of fixed probabilities.

16. Hoel [1971; 33-35].

17. In fact, as we shall discover in a later section of this chapter, it is quite possible that a given set of observations on firm ownership of stores will lead to rejection of the null hypothesis of random firm ownership, but will not permit the rejection of the null hypothesis of random neighbor relations.

18. Unlike our testing procedure for the null hypothesis of random firm ownership, use of the X^2 test as a test of random neighbor relations cannot be justified by its close approximation to the chi-square test. Other testing procedures based on the distributions of

$$\left[\sum_{i=1}^{j} (\tilde{B}_{ii} - \bar{B}_{ii})^2\right] + (\tilde{B}_{iI} - \bar{B}_{iI})^2 \quad \text{or} \quad \left[\sum_{i=1}^{j} \left| \tilde{B}_{ii} - \bar{B}_{ii} \right|\right] + \left| \tilde{B}_{iI} - \bar{B}_{iI} \right|$$

$$\text{or} \quad \left[\sum_{i=1}^{j} \left|\tilde{B}_{ii} - \bar{B}_{ii}\right| / \bar{B}_{ii}\right] + \left|\tilde{B}_{iI} - \bar{B}_{iI}\right| / \bar{B}_{iI} \quad \text{could have been used.}$$

However, we wished to use a consistent set of testing procedures for both null hypotheses of randomness. In addition, we did conduct tests of the null hypothesis or random neighbor relations for the GVRD using the above alternative distributions, and the results were not qualitatively affected by the choice of distribution. In fact, our observations were found to lie even further to the right in the generated distributions when we used the distributions listed above as compared to the distribution of the X^2 statistic.

19. Siegel [1956; 104-111].

20. See Markin [1968; 6-17] and Mueller and Garoian [1961; 8-15] for brief histories of the development of the supermarket industry in the United States. Another argument for excluding from our analysis stores which no longer exist today is as follows: Suppose a given firm has preempted some sub-market A_u at some time in the past. As these stores become economically and physically obsolete, the preempting firm will have an incentive to either renovate these stores or replace them with new stores at nearby locations. Thus, even if we ignore the openings and closings of stores which no longer exist in the market today, we should still be able to ascertain the existence of preemption on the basis of a more limited data set consisting of the sequential openings of stores which currently operate in the sub-market.

21. Some of the stores established in the Coquitlam-Port Coquitlam-Port Moody section of the eastern sector would also serve people residing in the Burnaby and New Westminster section of the eastern sector. The population in Burnaby-New Westminster increased from 115,410 to 150,049 between 1956 and 1966, or by 30.01%.

22. If consumers engage in multipurpose, one stop shopping, then there is a high probability that they will bypass smaller, neighborhood grocers in order to do their weekly grocery shopping at supermarkets. By shopping at the larger supermarkets with their wider assortment of goods, consumers may be maximizing the probability of finding the goods which they desire, and this may result ultimately in maximizing the consumer's utility. We do not wish to specify a formal model here, but for more details, see Baumol and Ide [1956].

Chapter 6

SUMMARY AND CONCLUSIONS

In this thesis, we have explored the conditions under which firms will engage in market preemption as a barrier to entry in a growing, spatially extended market. We developed a model of preemption in one-dimensional space, and derived the result that the established firm has an incentive to preempt the market at a point in time just prior to the earliest date at which a new entrant would find it profitable to enter. We also found that this result does not depend on the infinite competitive fringe assumption or on whether the space is one-dimensional or two-dimensional.

The major focus of the thesis has been on deriving the empirically testable implications of the theory, and testing the associated hypotheses. First, we examined the profits implication of the theory, which was stated as follows: if an existing firm and potential entrants anticipate that the market will grow at some time in the future such that a new plant could be profitably established in that market, and if the existing firm does nothing to block entry, then competition among potential entrants will lead to a new plant being established in the market at a point in time when the present value of that plant is equal to zero. Due to data limitations, we were constrained from performing a rigorous statistical test of the ideal null hypothesis associated with this implication. However, we were able to obtain indicative evidence in support of the hypothesis that the average profits of new supermarkets are negative in the first twelve months of operation of these supermarkets. The driving force of this result was that a representative new supermarket, with its lower average sales relative to a representative established supermarket, could not cover its capital costs in its first twelve months of operation. We argued that the lower average sales of new supermarkets were most likely the product of stores being established in the market at dates when the customer density was insufficient to guarantee positive profits for these stores.

We next examined the locational implication of the theory of preemption. This implication held that if there is an anticipated increase in density in a market such that a new plant could be profitably established in that market, and if the new plant would have as its neighbors other plants that an existing firm owns, then the existing firm will have an incentive to preempt the market. In order to test this implication of the theory for a particular industry and a particular spatial market, we designed two types of tests. First, we used cross section data on store ownership and neighbor relations in order to determine if our observations were generated by an independent stochastic process. Using a broad definition of what constitutes a supermarket, we were able to reject the null hypotheses that our observations were generated by an independent stochastic process based on a particular set of state independent probabilities for the Vancouver sub-market and the GVRD. We then utilized time series data on the date at which each store was established in the Vancouver sub-market, where that store was located and which firm owned it in order to determine if our data were consistent with a state dependent stochastic process. We found that we could accept the null hypothesis of state dependence for the Vancouver sub-market, and that the underlying probabilities of this process were consistent with there being two preempting firms.

Finally, we revised our definition of what constitutes a supermarket in order to see how sensitive our empirical results would be to a narrower definition of the industry. We discovered that we could only partially reject the null hypotheses of randomness for the Vancouver sub-market and the GVRD, but that our Vancouver sub-market time series data were still consistent with a state dependent probabilistic process. We also found that an analysis of the underlying probabilities of the state dependent process supported the proposition that only one firm preempted the Vancouver sub-market. We concluded that how narrowly we define the industry will have an impact on the empirical results of our tests, and that this conclusion was supported by the theory and to be expected given our testing procedure.

Our general conclusion, then, is that the theory of preemption provides a consistent and empirically acceptable explanation of the structure of the supermarket industry in the Vancouver sub-market of the GVRD. The fact that we selected the GVRD for analysis on the basis of data availability and not on the basis of any preconception as to what the locational pattern in the GVRD would be suggests that the theory of preemption should provide an explanation of supermarket industry structure and performance in many other markets as well. In addition, we would expect to find the structure of other retail industries to be consistent with preemptive behavior on the part of the dominant firms.

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APPENDIX

In this appendix, we present a series of diagrams which show the relative locations of supermarkets in the constituent sub-markets of the GVRD. The first group of diagrams represents cross sections of firm ownership in the first quarter of 1978. We have used the following symbols to indicate which firms own which stores:

Canada Safeway

Overwaitea

Kelly Douglas

Competitive Fringe

In order to ensure visual clarity, the Vancouver sub-market has been broken down into a western sector (City of Vancouver) and an eastern sector (Burnaby, New Westminster, Coquitlam, Port Coquitlam, Port Moody). We have constructed two sets of cross section diagrams, one of which is based on Definition 1 of a supermarket and the other of which is based on our revised definition of a supermarket.

The second group of diagrams portrays the sequential establishment of supermarkets in the Vancouver sub-market. Thus, associated with each symbol is a number representing the date at which that particular store was opened. We have constructed two time series diagrams portraying the sequential development of the supermarket industry, one of which is based on Definition 1 of a supermarket and the other of which is based on our revised supermarket definition. Again, for the purpose of visual clarity, we have broken down the Vancouver sub-market into a western sector and an eastern sector. However, we have numbered the stores in the western sector and eastern sector diagrams corresponding to a given supermarket definition as if the two diagrams appeared as one. In addition, it will be recalled that some of the stores in our sample changed ownership at some point in their history. Due to the limitations of the type of diagrams which we have chosen to use, change of ownership is not directly reflected in the diagrams. However, after each set of western and eastern sector diagrams, we provide a description of which stores changed firm ownership and when. For example,

$$12(F_k) \text{ --- } 27(F_s)$$

should be interpreted to mean that store number 12, owned by firm F_k, was taken over by firm F_s and became store number 27.

Finally, we should note two conventions which were employed in our calculations of boundaries for these sub-markets. First, if a perpendicular bisector boundary between a store 1 and a store 2 is only an arbitrarily small distance ε more distant than the nearest perpendicular bisector boundary between store 1 and another store, then stores 1 and 2 will be assumed to have a boundary with each other. Second, if two or more stores are within ε distance of each other, then it will be assumed that these two stores have the same market area boundaries with other stores. A cursory examination of the diagrams which follow should convince the reader of the necessity of these conventions, and also give the reader an idea of how large ε was allowed to be (in our calculations, one city block).

Figure A.1

RICHMOND SUB-MARKET CROSS SECTION

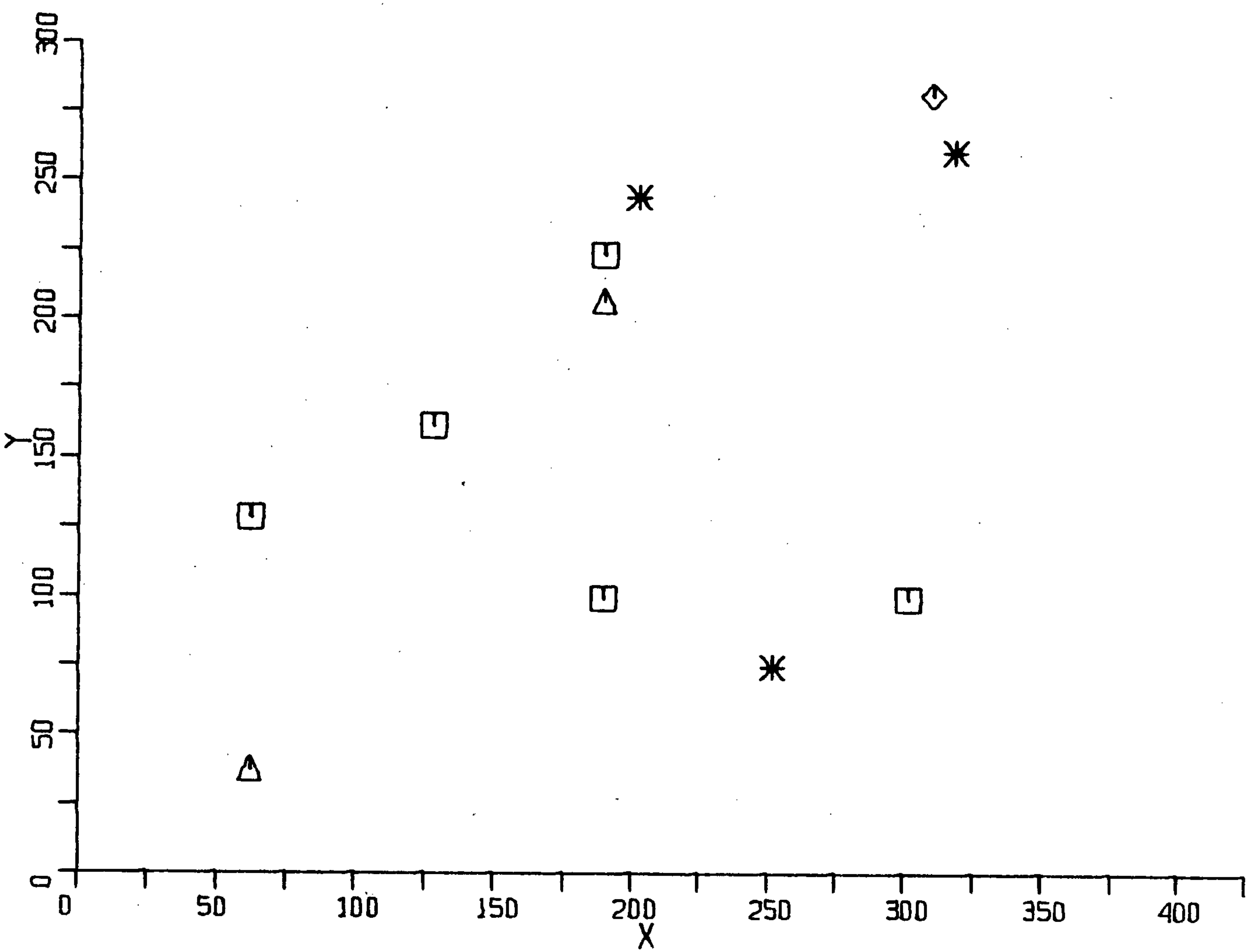


Figure A.2

NORTH SHORE SUB-MARKET CROSS SECTION

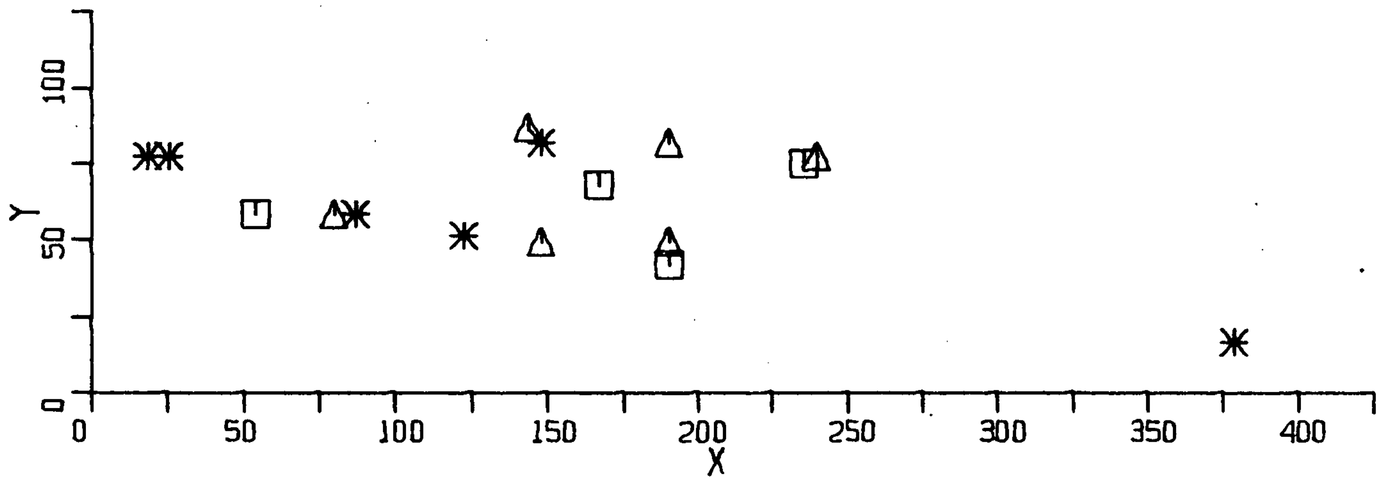


Figure A.3

DELTA-SURREY SUB-MARKET CROSS SECTION

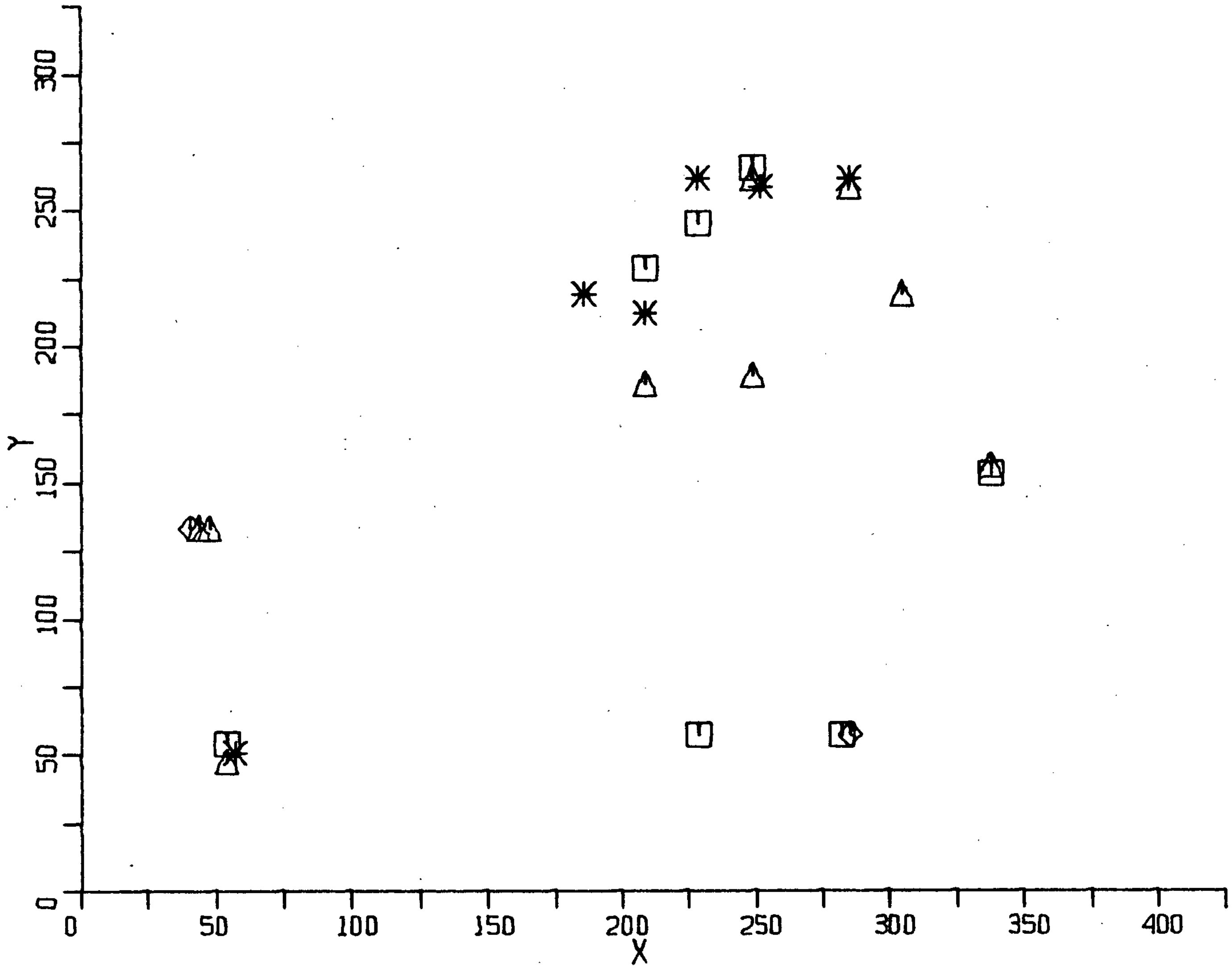


Figure A.4

VANCOUVER SUB-MARKET WESTERN SECTOR CROSS SECTION

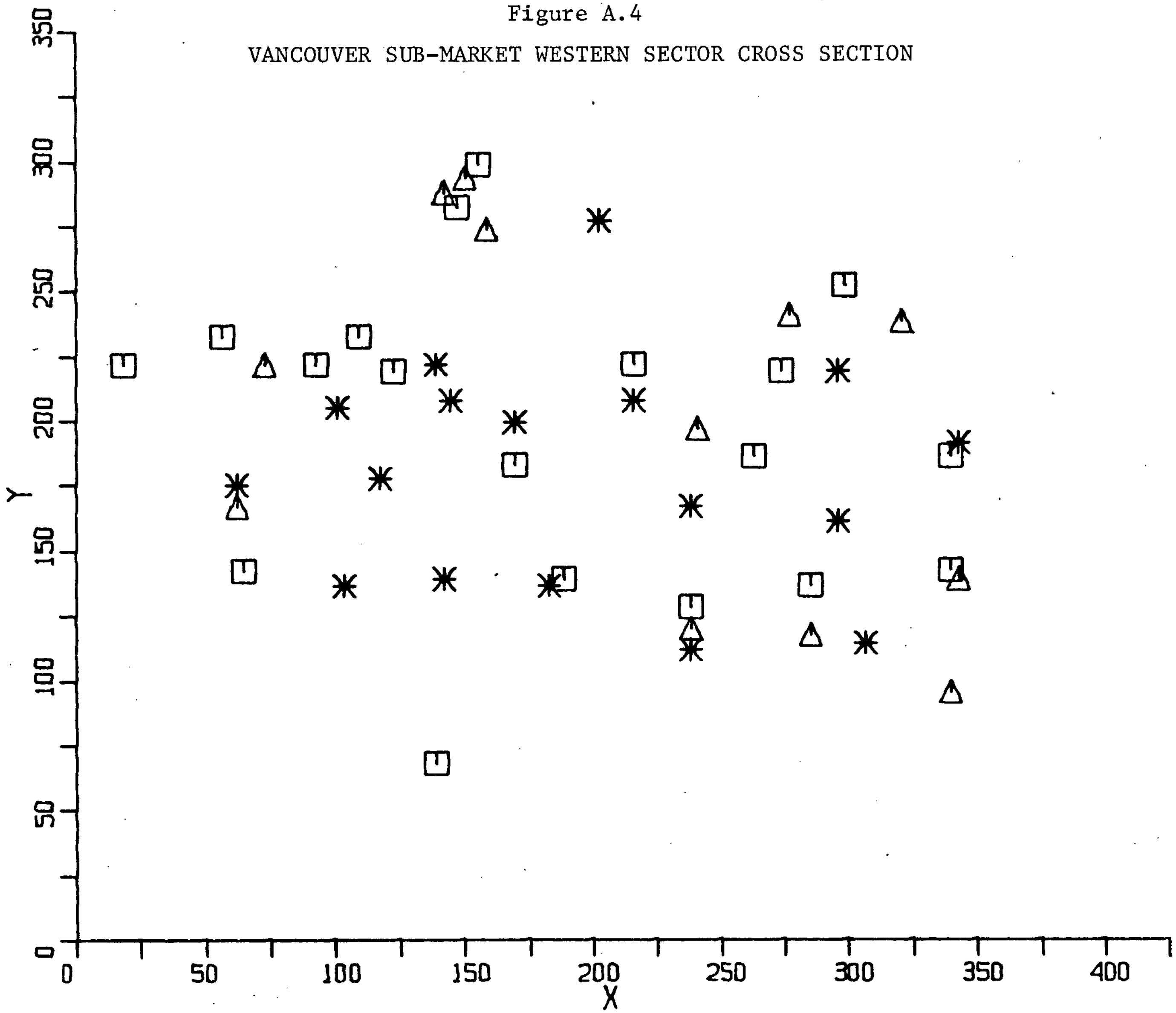


Figure A.5

VANCOUVER SUB-MARKET EASTERN SECTOR CROSS SECTION

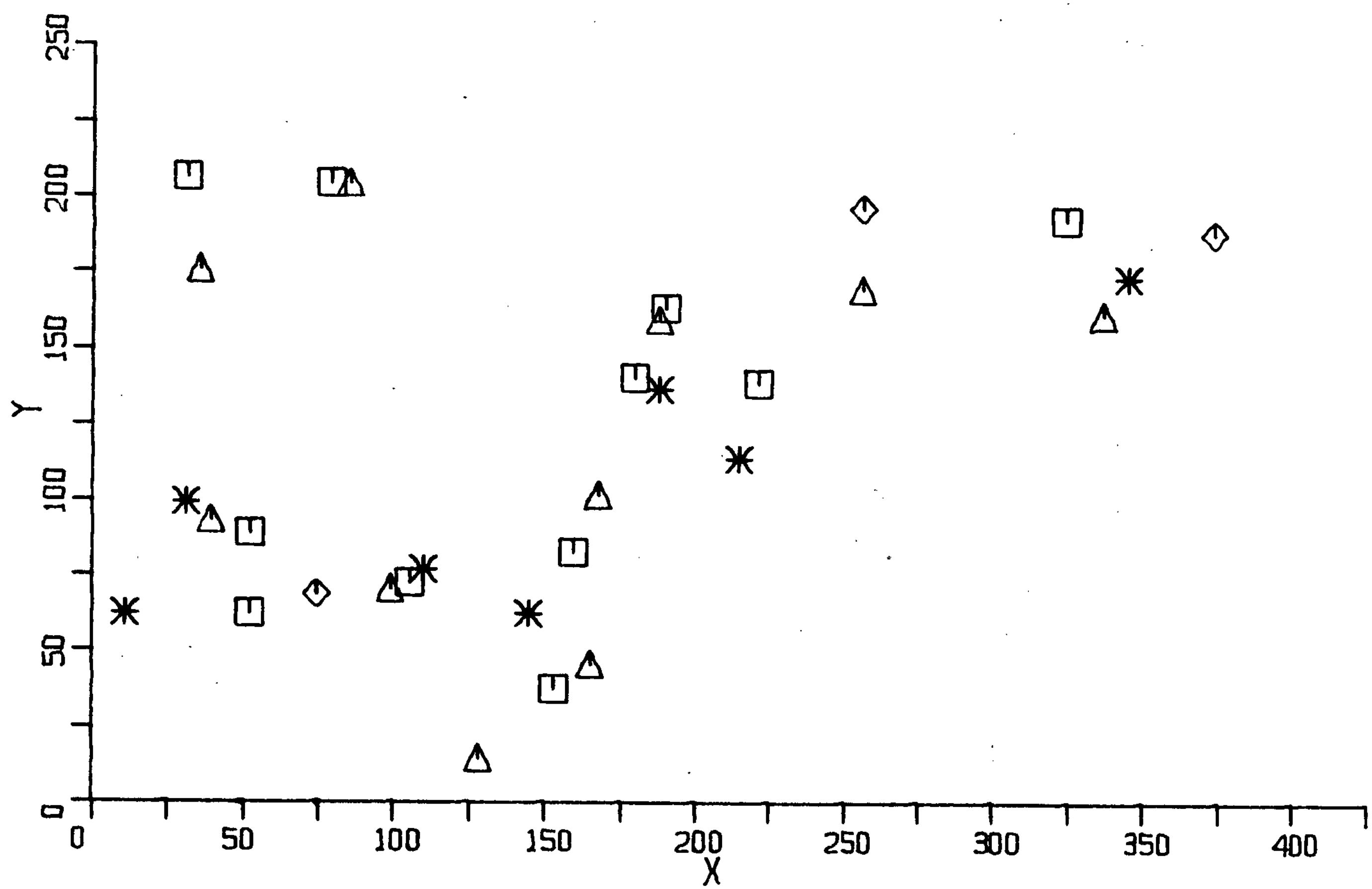


Figure A.6

RICHMOND SUB-MARKET CROSS SECTION

(STORE SIZE > 12,000 SQUARE FEET)

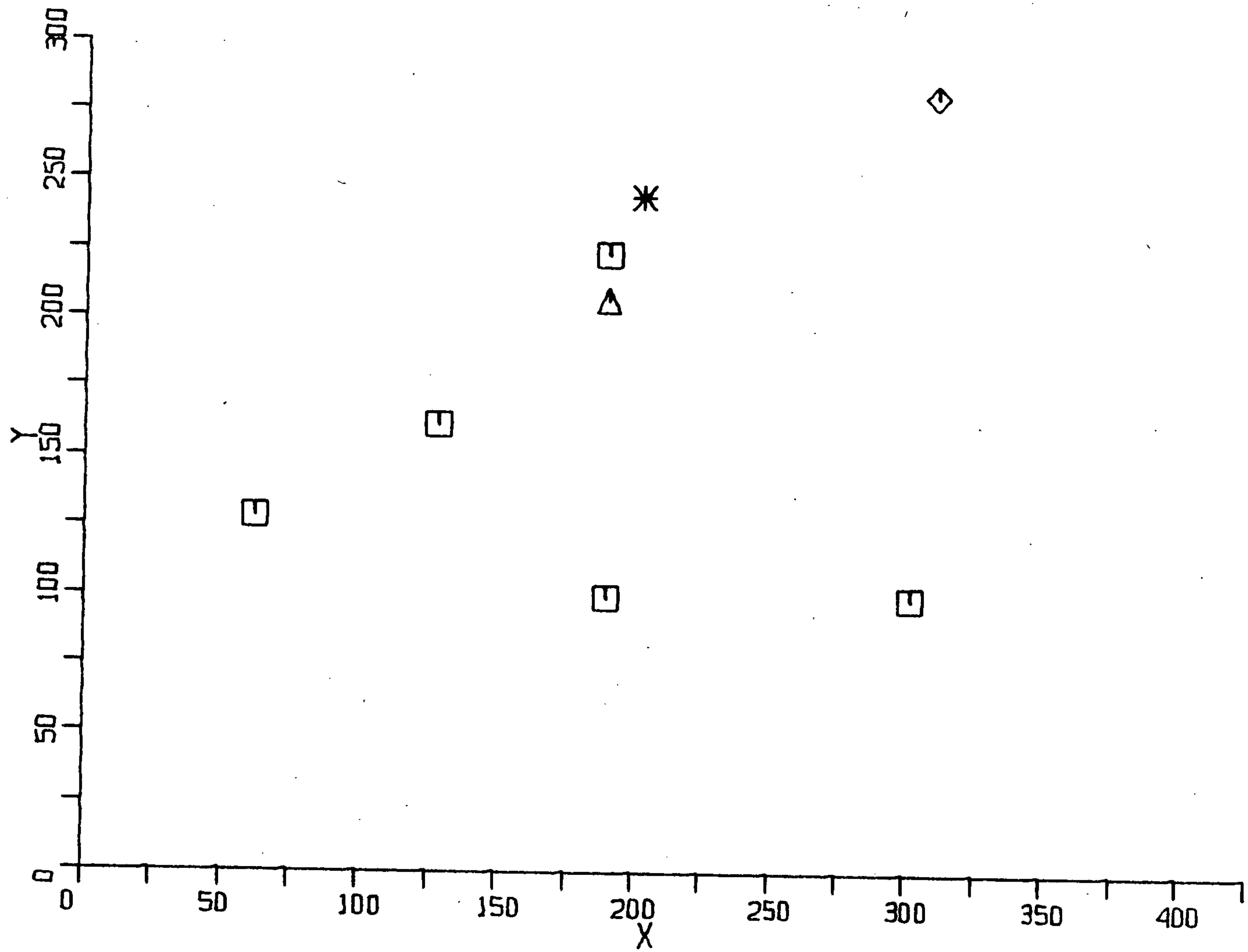


Figure A.7

NORTH SHORE SUB-MARKET CROSS SECTION

(STORE SIZE > 12,000 SQUARE FEET)

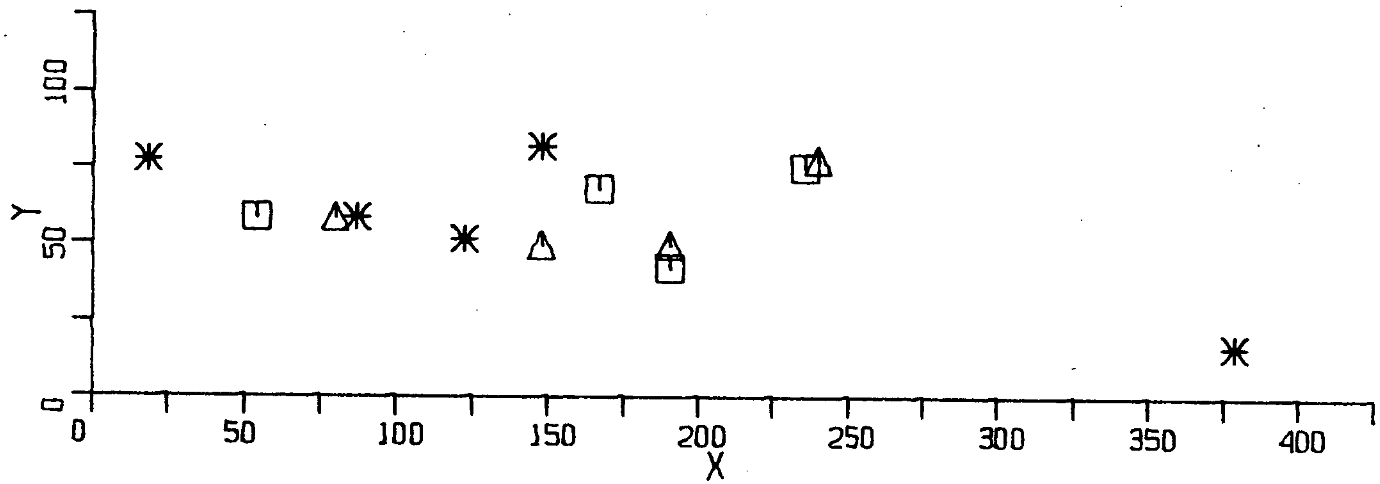


Figure A.8

DELTA-SURREY SUB-MARKET CROSS SECTION

(STORE SIZE > 12,000 SQUARE FEET)

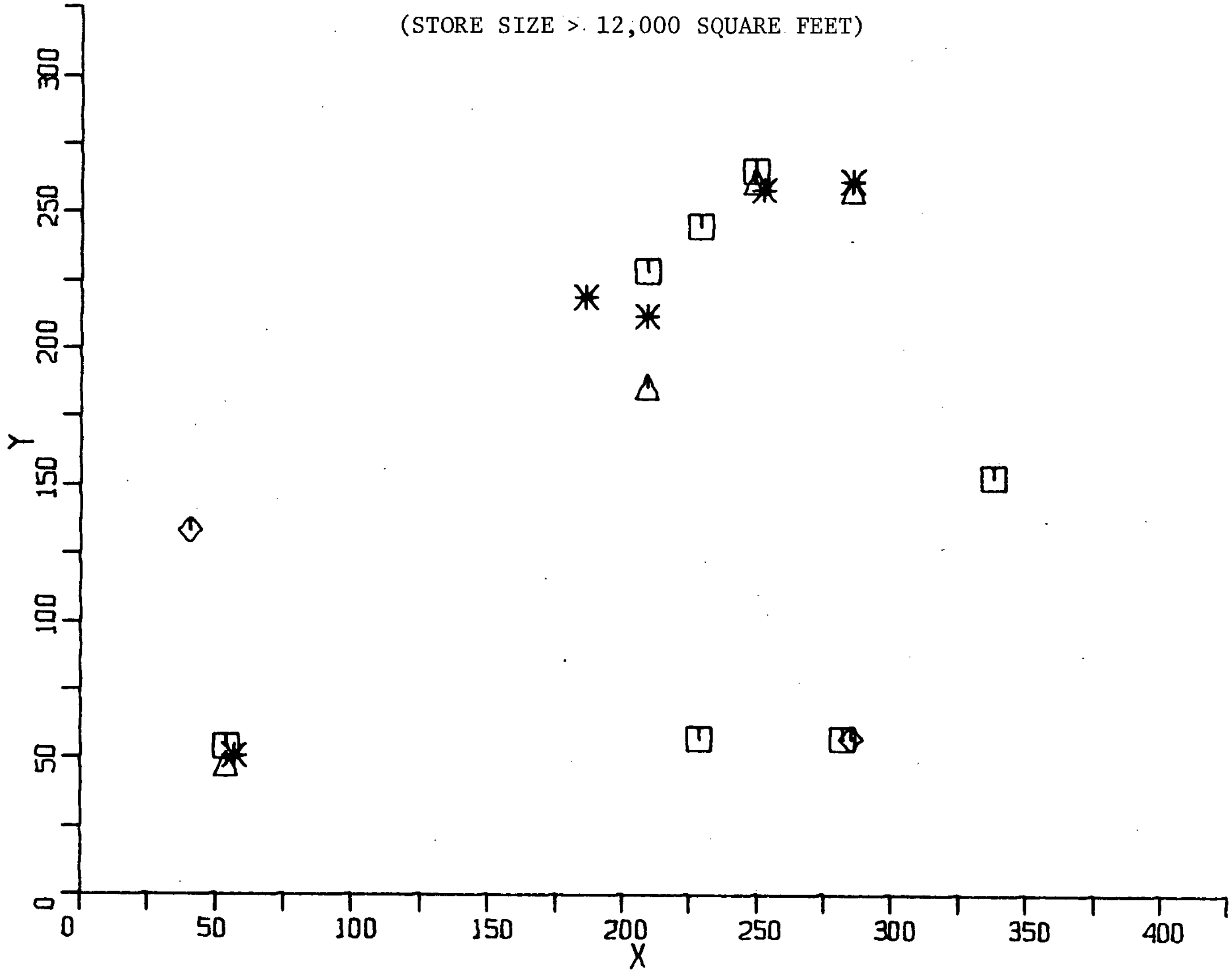


Figure A.9

VANCOUVER SUB-MARKET WESTERN SECTOR CROSS SECTION

(STORE SIZE > 12,000 SQUARE FEET)

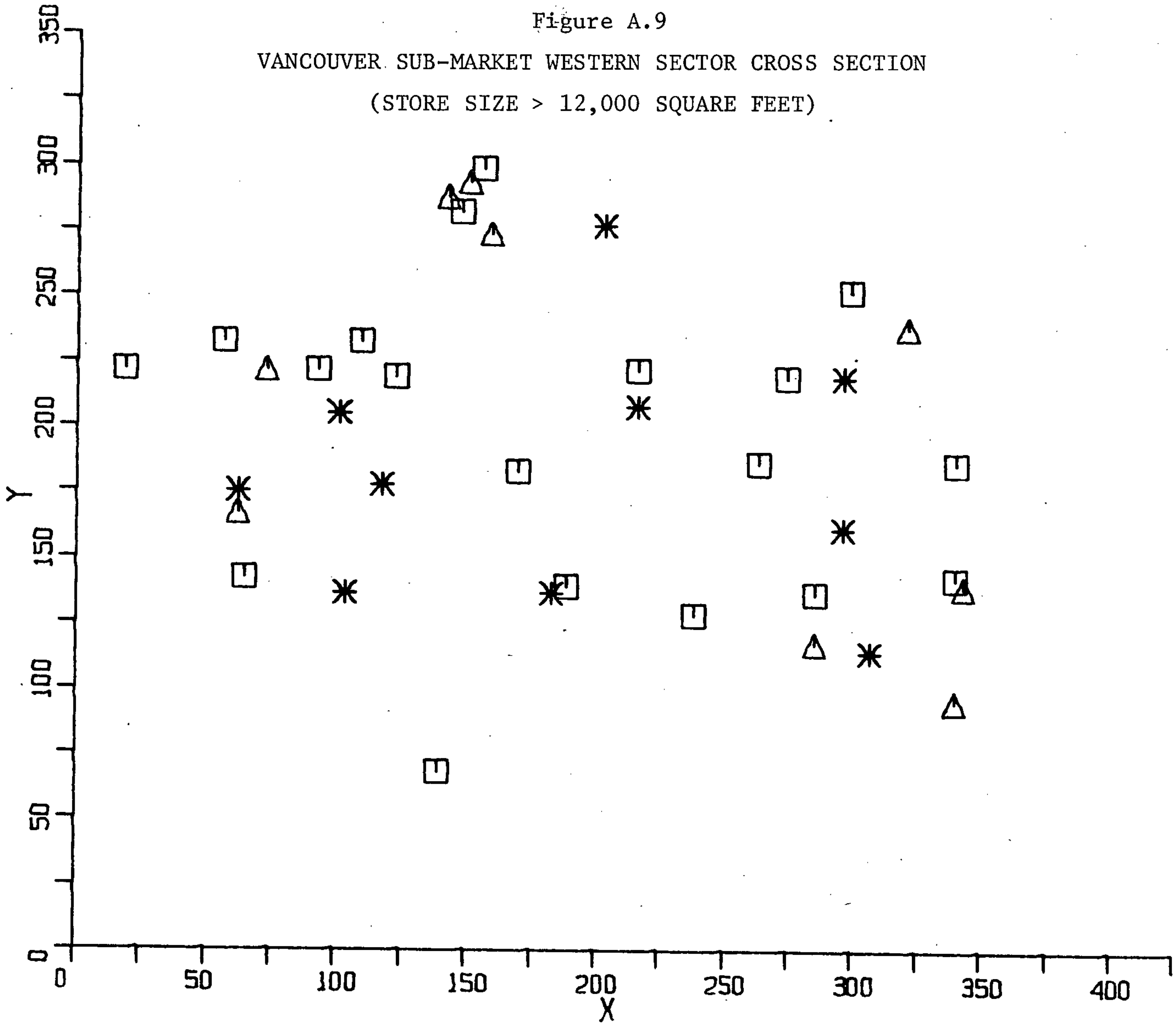


Figure A.10

VANCOUVER SUB-MARKET EASTERN SECTOR CROSS SECTION

(STORE SIZE > 12,000 SQUARE FEET)

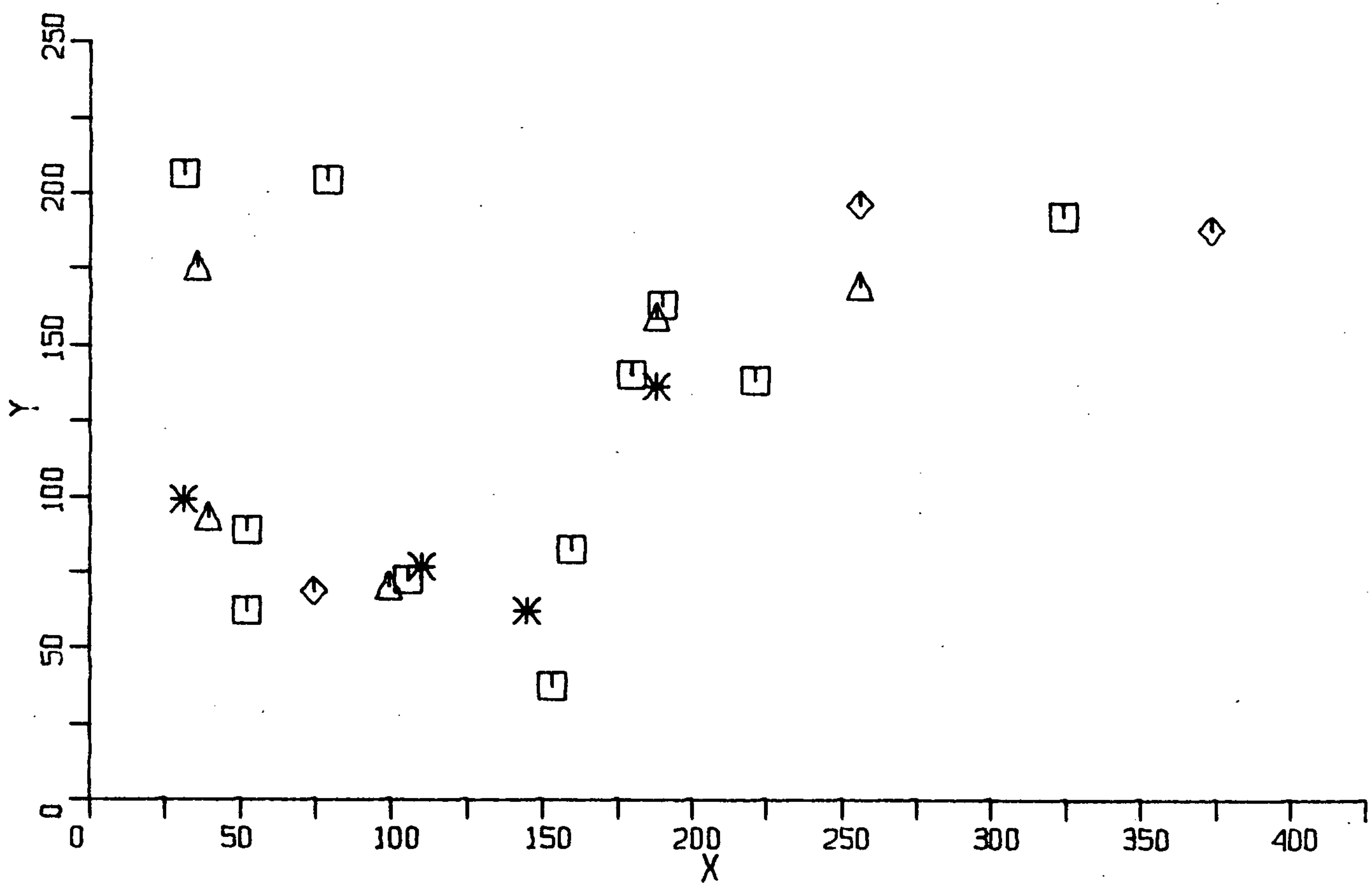


Figure A.11

VANCOUVER SUB-MARKET WESTERN SECTOR TIME SERIES

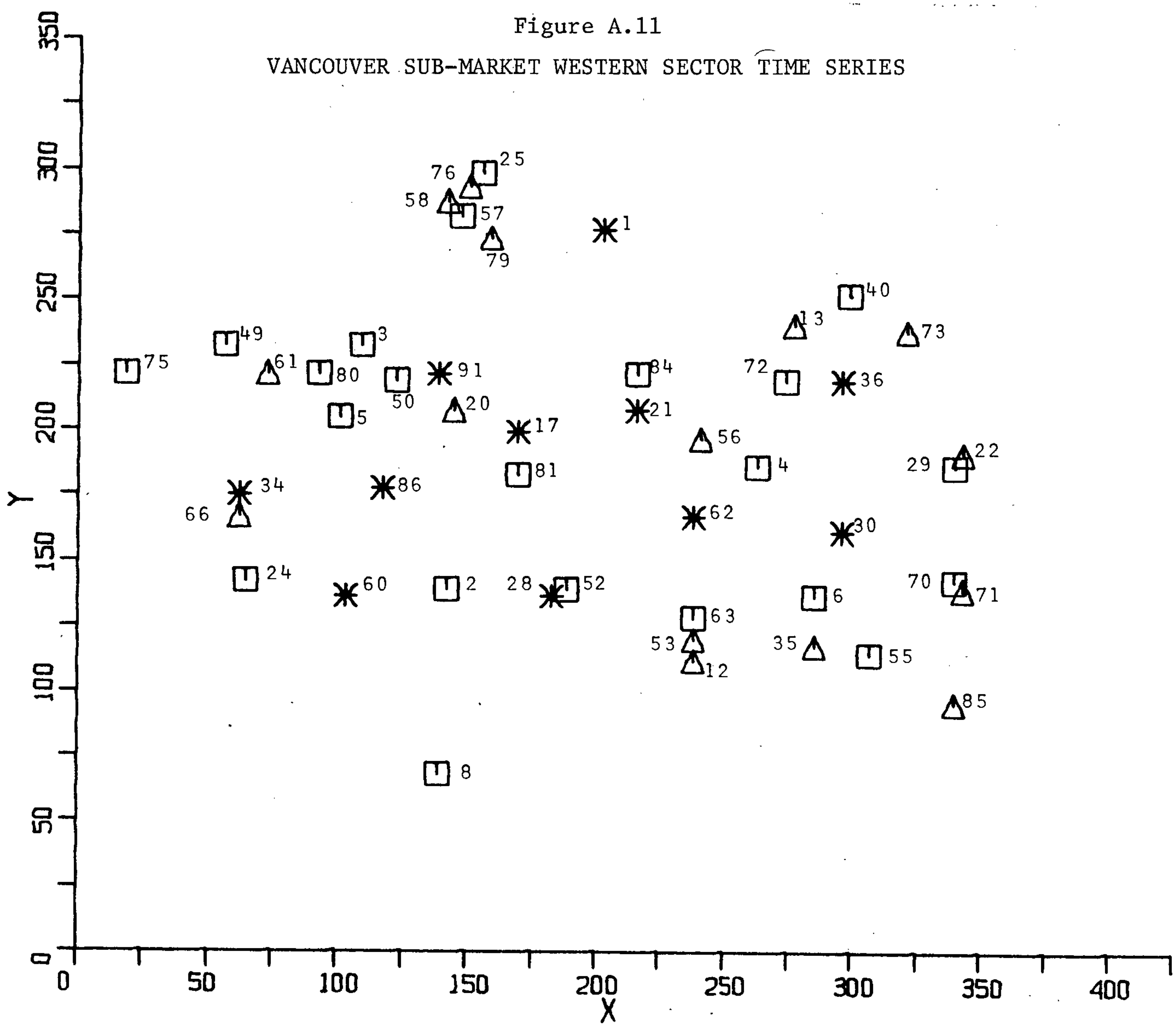
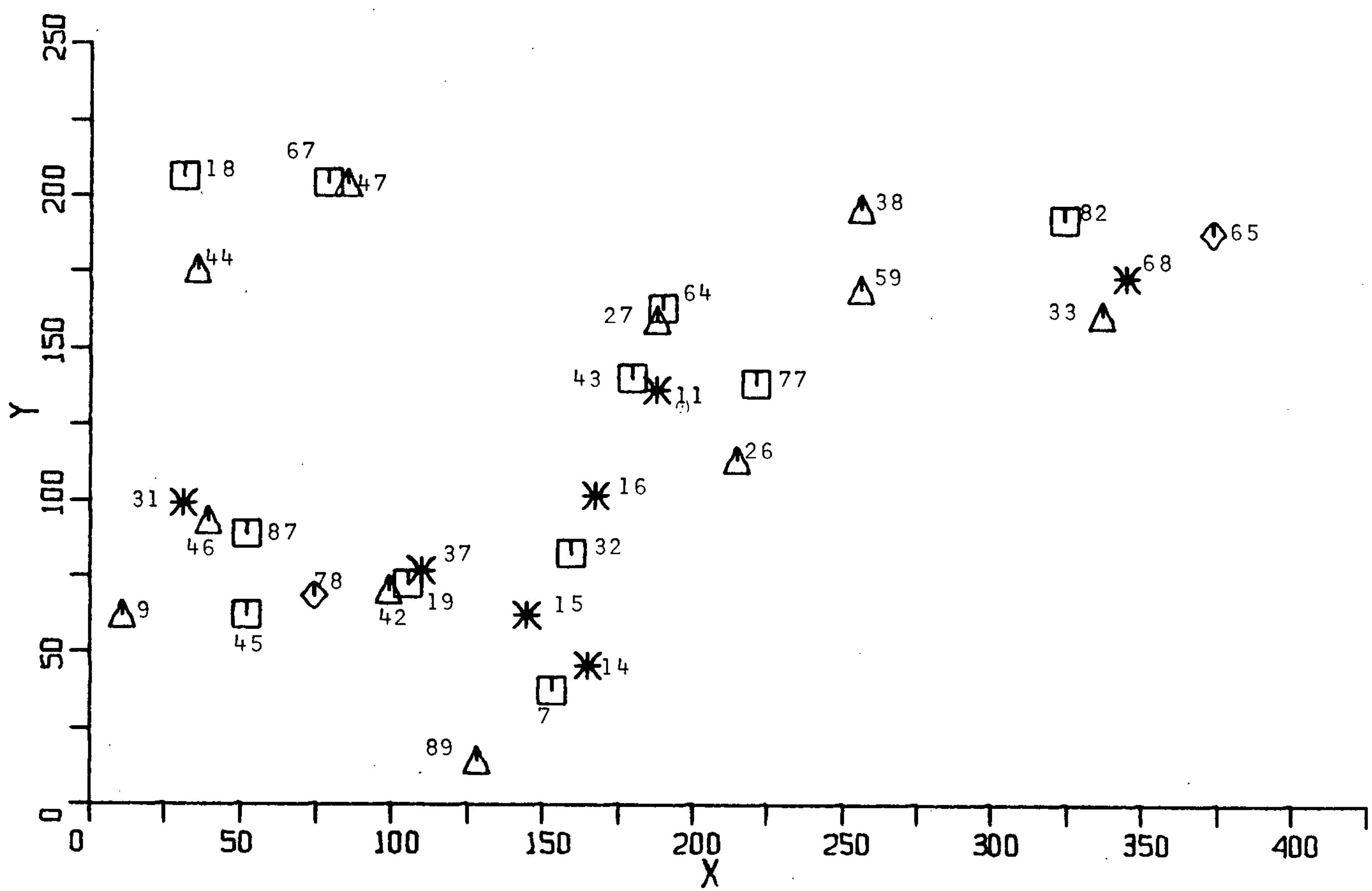


Figure A.12

VANCOUVER SUB-MARKET EASTERN SECTOR TIME SERIES



Notes to Figures A.11 and A.12

$2(F_s)$ --- $10(F_k)$ --- $51(cf)$

$12(F_k)$ --- $54(cf)$

$14(cf)$ --- $23(F_k)$

$9(F_k)$ --- $41(cf)$

$22(F_k)$ --- $74(cf)$

$26(F_k)$ --- $83(cf)$

$20(F_k)$ --- $48(cf)$

$55(F_s)$ --- $90(cf)$

$38(F_k)$ --- $69(F_o)$

$5(F_s)$ --- $88(cf)$

$16(cf)$ --- $39(F_k)$

Figure A.13

VANCOUVER SUB-MARKET WESTERN SECTOR TIME SERIES

(STORE SIZE > 12,000 SQUARE FEET)

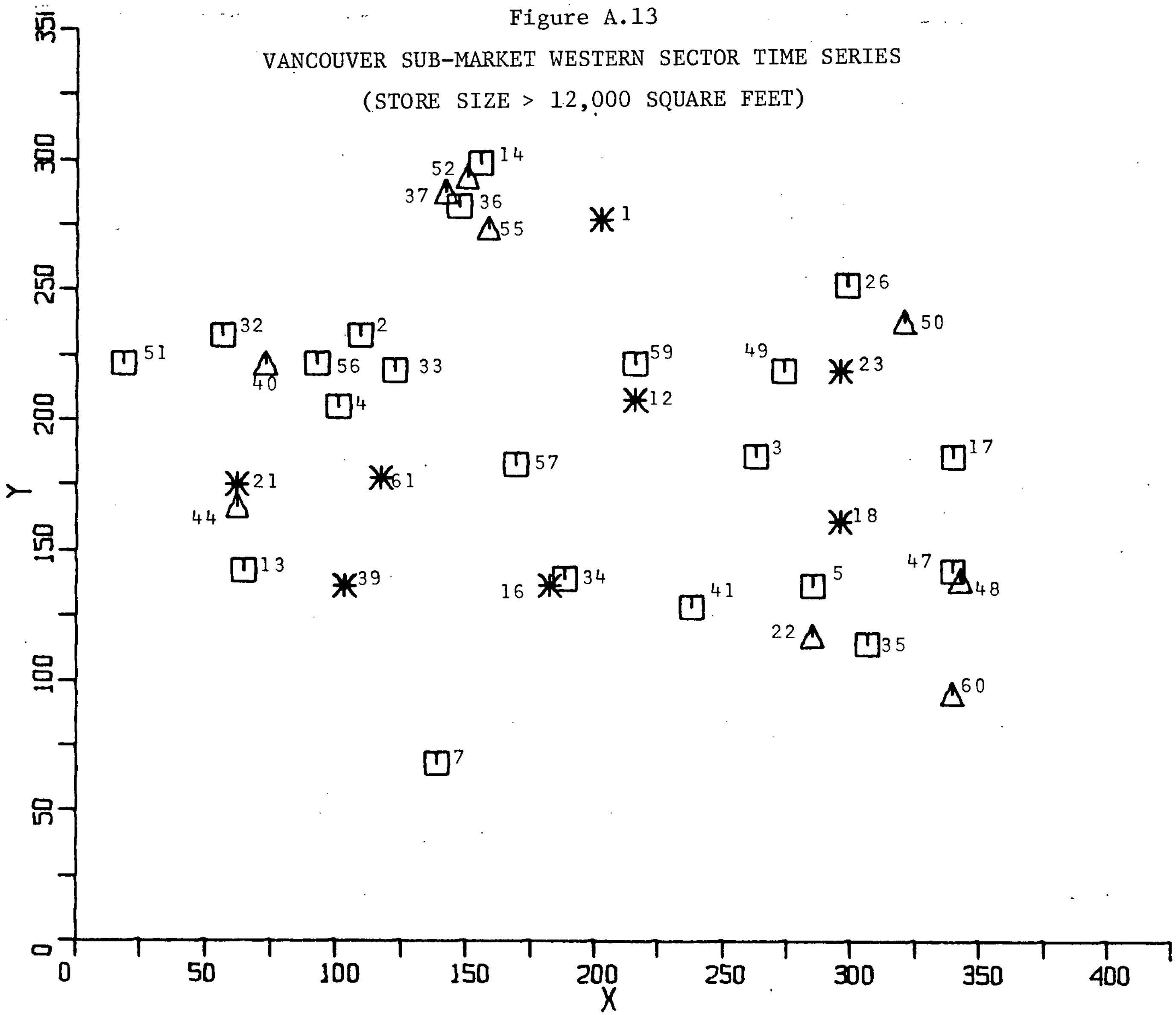
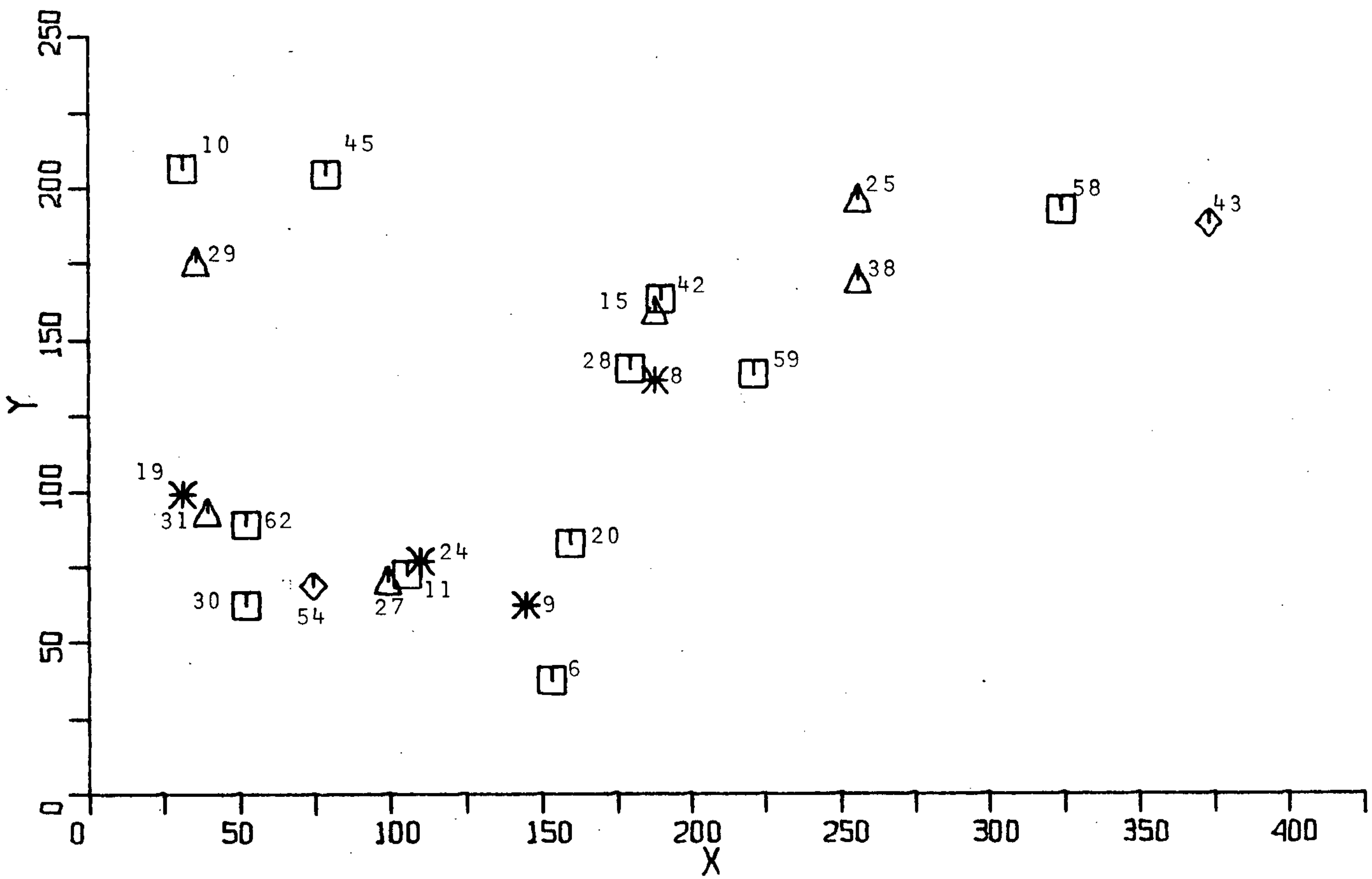


Figure A.14

VANCOUVER SUB-MARKET EASTERN SECTOR TIME SERIES

(STORE SIZE > 12,000 SQUARE FEET)



Notes to Figures A.13 and A.14

$4(F_s)$ --- $63(cf)$

$25(F_k)$ --- $46(F_o)$

$35(F_s)$ --- $64(cf)$