1979

An approach to the delineation of geographical banking market areas

Stephen Allan Mathis
Iowa State University

8010247

MATHIS, STEPHEN ALLAN

AN APPROACH TO THE DELINEATION OF GEOGRAPHICAL BANKING MARKET AREAS

Iowa State University PH.D. 1979

University Microfilms International 300 N. Zeeb Road, Ann Arbor, MI 48106 18 Bedford Row, London WC1R 4EJ, England

An approach to the delineation of geographical banking market areas

by

Stephen Allan Mathis

A Dissertation Submitted to the

Graduate Faculty in Partial Fulfillment of the

Requirements for the Degree of

DOCTOR OF PHILOSOPHY

Major: Economics

Approved:

Signature was redacted for privacy.

In Charge of Major Work

Signature was redacted for privacy.

For the Major Department

Signature was redacted for privacy.

For the Graduate College

Iowa State University
Ames, Iowa

1979

TABLE OF CONTENTS

CHAPTER I. INTRODUCTION

During recent years, considerable research has been directed towards establishing the structure-conduct-performance relationships of the commercial banking industry. The term structure refers to market characteristics such as the number and size distribution of sellers and buyers, the degree of product differentiation, the existence of barriers to entry of new firms, and the ratio of fixed to total costs of the firms in an industry. Conduct refers to behavioral characteristics such as pricing policies and product line strategies. Performance generally refers to the operational and allocational efficiency of an industry. Operational efficiency essentially refers to the degree to which products are produced and services are generated at least cost. Allocational efficiency is the effectiveness by which resources are directed to their alternative uses, i.e., resources should be directed to those uses that are the most highly valued.

Several studies pertaining to the structure-conduct-performance relationships of the commercial banking industry have found a significant relationship between market structure variables and various measures of bank conduct and performance. For example, George G. Kaufman (Kaufman, 1966, p. 438) found that the greater was the number of banks or the lower was the percentage of deposits held by the largest bank the lower were effective interest rates charged on loans, the higher were interest rates paid on time deposits, and the greater was the ratio of time to total deposits. Franklin Edwards found a statistically significant positive association between concentration in local banking markets, as measured by the percentage of total Standard Metropolitan Area deposits held by the largest three banks in each metropolitan area, and the level of interest rates charged by banks (Edwards, 1964, pp. 264-300). Donald R. Fraser and Peter S. Rose conducted a study comparing the effects of bank entry by hypothesizing that "banks operating in communities about to experience the entry of a new bank have performance characteristics different from a set of banks similar in size and location but not experiencing new competition." They concluded that the entry of a new independent bank in the situations analyzed, brought about significant changes in the nature of banking services offered to the local communities by the established banks (Fraser and Rose, 1972, p. 66).

Although these studies tend to indicate the existence of relationships among structure, conduct, and performance variables in the commercial banking industry, those statistical studies are only as valid as the choice of variables used. In particular, the selection of structural variables tends to be oversimplified. Virtually all structure-conduct-performance studies regarding commercial banking use either the concentration ratio or some variation of the concentration ratio, such as the number of banks in a town or county as the measure of structure.

But any concentration measure is only as valid as the market definition on which it is based. For a concentration measure to have meaningful implications, it must be based on a market that is economically relevant, in both a product and geographic sense. Too often, markets are defined in a way that facilitates the process of data collection, but pays little credence to economic relevance. The market areas generally used as the basis for most structure-conduct-performance studies are more of a political than economic nature, e.g., towns, counties, states, etc. There is no reason to believe that these political areas and economic market areas are necessarily coincident. As a consequence, the resulting concentration measures and structure-conduct-performance relationships must be viewed with extreme caution.

The purpose of this study is to construct an operational method for the delineation of economically relevant geographical banking market areas. In a less restrictive sense, the methodology will provide a technique for separating or assigning banks into their respective market areas. An intermediate objective of the thesis is to develop a model which can be used to compare the interdependent pricing functions for spatially separated banks to those of spatially adjacent banks. The intent of this methodology is to determine the impact of geographical separation on potentially interdependent pricing functions within pairs of banks. Where the impact of geographical separation significantly diminishes the degree of interdependence within pairs of banks, one can establish a basis for geographical market area separation. In this manner, geographical market areas can be delineated, and the groundwork can be laid for the calculation of meaningful measures of concentration.

Chapter II contains a literature review pertaining to the nature of banking markets, the choice of structural variables, and the existing methods of market area delineation. Chapter III outlines a theoretical model of market area delineation. The model is first given in a static form and then modified to accommodate dynamic situations. Chapter IV presents a statistical adaptation of the theoretical model in order to facilitate empirical testing procedures. Chapter V consists of a description of the data collection procedure, the calculations performed on the data, and the statistical results. Chapter VI presents a summary and conclusions of the study.

CHAPTER II. REVIEW OF LITERATURE

Before developing a delineation approach, it is useful to describe the nature of the commercial banking industry. Such a description provides a framework from which to view related structural issues.

The Nature of the Banking Industry

A perfectly competitive market can be defined as a free, impersonal market in which the forces of supply and demand determine the allocation of resources. There are essentially four major prerequisites necessary for the existence of this type of market:

1. A large number of buyers and sellers
2. A homogeneous product
3. Free entry and exit to and from the industry
4. Perfect knowledge on the behalf of producers and consumers

The commercial banking industry fails to meet any of these necessary criteria, and thus cannot be viewed within the framework of perfect competition. The banking industry contains a small number of firms--particularly in localized markets. Commercial banks offer a variety of heterogeneous services. Entry into the industry is extremely difficult. And most consumer and producer decisions are made in the absence of perfect knowledge. This lack of competition in commercial banking stems directly from governmental control. Because society has judged that the "banking industry is so charged with the public interest that its success or failure cannot be left entirely to the principle of competitive survival", (Fischer, 1968, p. 214), steps have been taken to eliminate many elements of price competition. This reduction in price competition is a social value judgment which is subject to debate, but for the present time, it creates a constraint which must be taken as given. The drive to eliminate price competition in commercial banking has resulted in laws that restrict both performance and structure.

<u>Performance regulations</u>

Regulations concerning performance constitute a direct attempt to preclude price competition in the banking industry. The Federal Reserve Act of 1914 as amended states, "No member bank shall directly or indirectly, by any device whatsoever, pay any interest on any deposit which is payable on demand." In addition, "the Board of Governors of the Federal Reserve System shall from time to time limit, by regulation, the rate of interest which may be paid by member banks on time and savings deposits, and shall prescribe different rates for such payments on time and savings deposits having different maturities" (Controller of the Currency, 1959, pp. 71-72). Of course various forms of nonprice competition have arisen as a result of these price restrictions. But technically defined, this is not "competition," but instead an activity often termed "rivalry." Rivalry can be defined as "a striving for potentially incompatible positions; combined with a clear awareness by the parties involved that the positions they seek to attain may be incompatible" (Scherer, 1971, p. 9).

Structural regulations

Regulatory authorities have proceeded beyond the performance level to also closely regulate the structure of the banking industry. This has been accomplished by limiting entry into the banking field through stringent chartering policies at both federal and state levels. Both federal and state criteria for approving a bank charter include the standing of the applicants, the demand for a bank in the market, and the prospects of its success if it is established. A 1964 survey of state bank supervision conducted by the American Bankers Association revealed that approximately four-fifths of the states had statutes requiring bank charter applicants to provide information showing a public need for a bank in a proposed location (Fischer, 1968, p. 214). The Joint Economic Committee reported that a number of branch applications have been rejected because of the "priority of another banks application" or that the proposed office might be "detrimental to another bank" (Fischer, 1968, p. 217).

Finally, states may attempt to thwart competition further by limiting both branch banking and holding companies. Because it is typically conceded that due to scale economics it is less costly to enter a market via a branch than via a unit bank, limits on branching become an effective method for controlling any possible competition. As of 1973, thirty-four states maintained some form of branch banking regulation, either completely prohibiting branch banking or restricting the location of branches to limited areas.

In summary, governmental regulations, through restrictive structure and performance measures, have preempted a competitive market structure in the field of commercial banking. As a result, a considerable degree of market power has been introduced into the banking industry, i.e., the banks have a good deal of discretion over output and price within the limits set by the regulatory authorities. In a definitional sense, the banking industry can be described as oligopolistic. An oligopoly is said to exist when more than one seller is in the market, but when the number is not so large as to render negligible the contribution of each. In some specialized cases, it is possible for the oligopolistic market to reduce to one of monopoly. An example of this special case would be a situation in which only one bank is operating in a small and isolated market. The important point to be emphasized, is that any structural measures regarding the banking industry, must be interpreted within the context of the existence of market power. Generally this market power is exercised through an oligopolistic market.

Measures of Market Structure

Virtually all variables used to describe market structure measure structure in the form of some type of market concentration measure.

The concentration ratio

The most fundamental measure of market concentration is the concentration ratio. The concentration ratio is defined as "the percentage of total industry sales (or output, or employment, or value added, or assets) contributed by the largest firms, ranked in order of market shares" (Scherer, 1971, pp. 50-51). Some structure-conduct-performance studies attempt to relate levels of concentration ratios to various indicators of conduct and performance. Others merely look at the concentration ratios themselves as indicators of the existing market structure. These studies implicitly assume that a certain level of market concentration yields certain prescribed conduct and performance characteristics.

The concentration table and the Lorenz curve

An extension of the concentration ratio is the concentration table. The concentration table consists of a list of concentration ratios pertaining to various groups of firms in an industry, e.g., the largest four firms, the largest eight firms, etc. This provides a more complete description of an entire industry than does the single concentration ratio. A method of summarizing the information comprising the concentration table is provided by the Lorenz curve. The Lorenz curve can be defined as "a curve which shows as a continuous function the percentage of total industry sales (or some other variable) accounted for by any given fraction of the total company population, with the firms ranked in order of market share or size" (Scherer, 1971, p. 51).

The Herfindahl index

Another measure of concentration is the Herfindahl index. This measure is calculated by squaring and then summing the market shares pertaining to all firms comprising an industry. When an industry consists of only one firm, the Herfindahl index will equal its maximum value of one. As the number of firms in an industry increases, the index will decrease in value. As the degree of inequality among a given number of firms increases, the index will increase in value. Thus, the Herfindahl index is an extremely useful measure of concentration in that it reflects both the number of firms in an industry and also the degree of inequality among those firms.

Appropriate Market Selection

A major criticism concerning the use of concentration measures is the difficulty of defining the relevant market to use in calculating the measures. Essentially there are two aspects to the problem. First, the relevant product market must be established, and second, the appropriate geographic market area must be delineated.

The product market

The major issue in determining the appropriate product market is obtaining a definition that appropriately allows for the possibilities of substitution. Specifically, in the case of commercial banking, the issue is whether or not to include other financial intermediaries, e.g., savings and loan associations, credit unions, etc. In a legal sense, the courts have excluded other financial intermediaries and specifically defined commercial banking to be a distinct industry. The Supreme Court has stated:

> . . . that the cluster of products (various kinds of credit) and services (such as checking accounts and trust administration) denoted by the term "commercial banking" comprises a distinct line of commerce. Some commercial banking products or services are so distinctive that they are entirely free of effective competition from products or services of other financial institutions; the checking account is in this category. Others enjoy such cost advantages as to be insulated within a broad range from substitutes furnished by other institutions. . . . Finally, there are banking facilities which although in terms of cost and price are freely competitive with the facilities provided by other financial institutions, nevertheless, enjoy a settled consumer preference, insulating them to a marked degree, from competition; this seems to be the case with savings deposits. In sum, it is clear that commercial banking is a market, sufficiently inclusive to be meaningful in terms of trade realities (U.S. vs. Philadelphia National Bank, 1963, 374 U.S. 321, 356-357, and 326, N.S.).

The commercial banking industry is considered a separate and distinct line of commerce due to the fact that it offers such a multitude of financial services. Other financial intermediaries, on the other hand, are limited to only a few specialized services, thus losing any spillover benefits from one service to another.

Regarding the Philadelphia case, the Supreme Court cited the testimony of a savings and loan official who stated that "for fifty years or more in his area the mutual savings banks had offered an interest rate one-half percent or more higher than that paid by commercial banks, yet, the rate of increase in savings accounts in commercial banks had kept pace with (and in some cases exceeded) the rate of increase of deposits in mutual savings banks." Traditional price theory would suggest that prices (or interest rates) within a competitive market should tend toward equality. This sustained interest rate differential between commercial banks and savings and loan associations implies a low degree of product substitution. In keeping with the conventional interpretation of the uniqueness of commercial banking, it is assumed in this study that the commercial banking industry constitutes a separate and distinct product market.

The geographic market

The second aspect of the problem of proper market selection is the difficulty associated with establishing the relevant geographic marmet. The concept of an economic market area can be defined as "the area encompassing all those economic units that exert and react to essentially the same set of competitive forces influencing the price and quality of a specific product or service" (Glassman, 1973, p. 21), or as "a geographic region in which supply and demand forces differ from those in an adjacent area and within which, therefore, prices tend toward the same value while not necessarily tending toward the same value as those in an adjacent area" (Glassman, 1973, p. 19). This definition of a market provides not only a base for determining market concentration measures, but it also can be used to determine the relationship between concentration measures and relevant performance variables. Unfortunately, most concentration measures presently applied to the commercial banking industry may be inappropriate due to improper definition of the relevant market area.

Most market areas used as a base for concentration measure calculations are chosen on the basis of expedience rather than economic relevance. Generally, political areas such as the nation, the state, or the county, are chosen as proxies for economic market areas. But there is very little reason, even at an intuitive level, to confirm the validity of these assumed relationships. There is a disparity of economic and social conditions not only across political areas but within them as well.

In addition, there exists a heterogeneous set of governmental regulations across states concerning the behavior and structure of the banking industry. Throughout the nation and each state, interest rates are far from homogeneous--implying the existence of markets on a much smaller geographic level. The county, on the other hand, may represent an area that is economically too small--often excluding additional economically homogeneous territory.

Existing Geographical Delineation Procedures

A relevant geographic market area cannot be chosen arbitrarily. Instead it must be delineated on the basis of economic considerations. Unfortunately most of the delineation techniques currently in use result in the construction of trade areas rather than market areas. These two concepts must be distinguished.

As defined previously, a market area is "the area encompassing all those economic units that exert and react to essentially the same set of competitive forces influencing the price and quality of a specific product or service" (Glassman, 1973, p. 21). This concept is to be distinguished from a trade area which can be defined as "a geographically delineated region, containing potential customers for whom there exists a probability greater than zero of their purchasing a given class of products or services offered for sale by a particular firm or by a particular agglomeration of firms" (Huff, 1964, p. 38).

Note that the trade area definition says nothing of "competitive forces." The trade area, in essence, outlines the potential customer area for a particular firm or group of firms and usually is based upon such characteristics as transportation costs, town size, or price differentials. A market area, on the other hand, is not defined to identify particular customers or areas of customers, but rather, to identify those firms that are reacting to similar competitive forces. As such, a trade area can be viewed as a subset within the market area. A market area will contain at least one and, often several trade areas. Although the trade area must not be confused with the market area, it is of some indirect benefit in the actual construction of market area boundaries.

Trade area delineation

The methodology of trade area delineation can be divided into two major categories--empirical and theoretical.

Empirical techniques   This category of trade area delineation includes such methods as "customer spotting" and "license plate analysis." Customer spotting involves a series of customer interviews at the place of business. These interviews obtain information on the address of the customer to relate business location to customer location. In license plate analysis, license plate numbers of customer cars in the relevant businesses' parking lot are recorded to determine the extent of the trade area (Markin, 1971, pp. 195-196).

Gravitational method   The gravitational method, developed by Reilly and modified by Converse and Huegy, is the foremost theoretical technique for trade area delineation. Essentially, for two towns, A and B, the Reilly model can be specified as:

$$M_B = \frac{D}{1 + \sqrt{P_A/P_B}}$$

where:

M_B is the breaking point between towns A and B (distance from B)

D is the distance between towns A and B

P_A is the population of town A

P_B is the population of town B

(Markin, 1971, pp. 192-193).

The trade area of a firm is thus a function of the distance from its customers and also the size of the town in which it is located. This formula has been modified in some instances to use driving time in place of distance and/or firm size instead of town population. These are useful modifications in the sense that distance is only a proxy for driving time which is in turn a proxy for the cost of transportation.

<u>The economic law of market areas</u> Another theoretical approach to trade area delineation is that developed under the so-called "economic law of market areas," which states:

> The boundary line between the territories tributary to two geographically competing markets for like goods is a hypercircle. At each point on this curve the difference between freight costs from the two markets is just equal to the difference between the market prices whereas on either side of this line the freight differences and the price differences are unequal. The ratio of the price difference to the freight rate, and the ratio of the freight rates from the two markets, determine the location of the boundary line; the higher the relative price, and the lower the relative freight rate, the larger the tributory area (Hyson and Hyson, 1950, pp. 319-327).

Mathematically,

(1) $p + r\,\overline{PA} = q + s\,\overline{PB}$

where:

A and B are two fixed markets

P is an external consuming point

$\overline{PA}$ is the distance between P and A

$\overline{PB}$ is the distance between P and B

p is the market price of the commodity at A

q is the market price of the commodity at B

r is the freight rate between P and A

s is the freight rate between P and B

By rearranging terms,

$$(2)\ \overline{PA} - \frac{s}{r}\,\overline{PB} = \frac{q - p}{r}$$

and

$$(3)\ \overline{PA} - h\,\overline{PB} = \pm\, k$$

where:

$$h = \frac{s}{r}$$

and

$$+\,k = \frac{q - p}{r} \quad \text{when} \quad \frac{q - p}{r} > 0$$

$$-\,k = \frac{q - p}{r} \quad \text{when} \quad \frac{q - p}{r} < 0$$

This approach has two important advantages over the gravitational technique. First, it considers any existing freight rate differentials. Regarding the commercial banking industry, freight rates are replaced by customer travel and transaction costs. The consideration of this variable becomes very important where a road structure becomes heterogeneous. Second, the economic law of market areas takes account of any price differentials between competing firms. As a consequence, it can be used to construct trade area boundaries for firms composing any type of market structure--including an oligopolistic market structure, such as commercial banking, where sustained price differentials may exist.

In summary, the techniques for trade area delineation are useful for identifying the particular customers of individual firms. More importantly they identify the geographically marginal customers on which a firm's pricing decisions are often based. But their use cannot be extended further. They provide little insight into the construction of geographic market areas.

Market area delineation

The foremost conceptual method of market area delineation is the cross-price elasticity concept. This is a measure of performance which can be interpreted to yield structural implications. Specifically, the cross-price elasticity is defined as:

$$E_{ij} = \frac{dQ_j}{dP_i} \cdot \frac{P_i}{Q_j}$$

where:

E_{ij} is the cross-price elasticity variable

dQ_j is the change in firm j's output

dP_i is the change in firm i's price

P_i is the original price maintained by firm i

Q_j is the original quantity of output produced by firm j

This cross-price elasticity takes into account a "total effect" which considers both the substitution and income effects resulting from a price change.

A. G. Papandreou and J. T. Wheeler (1954, pp. 20-39) outlined a procedure for market delineation that is based on cross-demand schedules between firms. They concluded that two products are substitutes and the firms producing those products are in the same market whenever the cross-demand curve for their products is positively sloped. If, however, the cross-demand curve between two firms is nonincreasing, the firms fall into separate markets. Under these specifications, the general concept of a banking market defined above can be modified to be "a region in which the cross elasticity of demand for banking services between banks within the region is significantly higher than that existing between banks in the region and banks outside the region" (Glassman, 1973, p. 22).

The cross-price elasticity relates the percentage change in the quantity demanded of the product of one firm, $\frac{dQ_j}{Q_j}$ to the percentage change in the price of a second firm, $\frac{dP_i}{P_i}$. It is assumed that tastes, nominal incomes, and other product prices--including the price of firm j--remain constant. When $E_{ij} > 0$, the products are determined to be substitutes and the firms are subject to common market demand forces. In other words, the firms are not isolated from each other. This would seem to indicate the existence of either competitive or oligopolistic firms. If $E_{ij} \to 0$, the firms are not subject to common market demand forces. The firms act as isolated sellers--at least with respect to each other. This could indicate the existence of an isolated monopoly, if all the cross-price elasticities for a particular firm in an area equal zero.

Although theoretically appealing, cross-price elasticities are difficult to implement (Cochrane, 1957, pp. 21-39). Often the necessary price-quantity data needed to estimate cross-demand schedules do not exist. Even if the data were available, the cost of estimating cross-demand schedules between all firms would be prohibitive. In addition, the isolated and static nature of the cross-price elasticity concept can create problems of interpretation. In the real world, incomes and prices do not hold constant for the purposes of measurement. As P_i changes, often so does P_j. In a perfectly competitive environment, $P_i = P_j$. The reason is that perfectly competitive firms are by definition price takers and consequently charge uniform prices that are established in the market place. For similar reasons $dP_i = dP_j$. Also, because $dP_i = dP_j$, $dQ_j = 0$, and $E_{ij} \rightarrow 0$, instead of $E_{ij} > 0$ as indicated earlier. In an oligopolistic industry such as commercial banking there are also problems of interpretation. Again if $P_i = P_j$ and $dP_i = dP_j$, then $dQ_j = 0$ and $E_{ij} \rightarrow 0$, and little insight is provided.

An oligopolistic market, by nature, consists of interdependent firms. Price and output decisions are made under the recognition of similar decisions being made by rivals. This being the case, one would expect that dP_i might equal dP_j and hence $E_{ij} \rightarrow 0$ would indicate the presence of nonisolation, rather than the isolation that was previously indicated. To clarify the matter, it is necessary to develop a method of approximating the elements of interdependence that are the result of oligopolistic rivalry. These elements of interdependence are called reaction functions and conjectural variations. In a world consisting of two firms, firm i and firm j, the reaction function of firm i is defined as how firm i will respond to a price change initiated by firm j, i.e., $\frac{dP_i}{dP_j}$. The conjectural variation as perceived by firm i, is defined as how firm i thinks firm j will respond to firm i's own price initiative, i.e., $\frac{dP_j}{dP_i}$. It will be the purpose of the next chapter to construct a model for market delineation based on these variables.

In summary, the commercial banking industry has been described as oligopolistic in nature. The structural measure most often used to estimate the degree of oligopoly is generally some measure of concentration. But a valid concentration measure must be based on an economically defined market area which is relevant to the particular firms under consideration. Most of the so-called market area delineation techniques currently in use, effectively delineate trade areas rather than market areas. They identify each firm's particular set of customers, rather than construct an area that is subject to common market forces. Cross elasticities are theoretically appealing, but are virtually impossible to implement.

The model developed in the next chapter will be designed with an applicability to oligopolistic market structures such as commercial banking. The long-range intent of the model is to lay the groundwork for the calculation of meaningful concentration measures. This should prove useful regarding any future analysis of the "competitive" environment in banking, the operational and allocational efficiency of the banking system, and policy prescriptions for structural change in the banking industry.

CHAPTER III. A THEORY OF BANK INPUT PRICE RESPONSE

The theoretical model to be constructed is an oligopsony model, or more specifically in the two bank case, a duopsony model, from which reaction functions between two potentially rival banks can be developed. A reaction function is defined as a function that relates the price or quantity of one firm as a function of the price or quantity, respectively, of another firm. In other words, the interdependent pricing or output policies of the two firms are specified. Specifically, in the model to be presented, the reaction functions are of the price-price form, where the prices are represented by the input prices paid by each bank.

Mathematical Constructs

Mathematical models are constructed for both spaceless and spatial cases. In both models, deposits are treated as inputs to the banks, where the depositors, or the suppliers of inputs, are treated as atomistic in nature. The banks on the other hand are treated as oligopsonistic, and consequently face upward sloping input (deposit) supply curves. Since it is not the objective of the model to examine the output side of the market, output prices are assumed to be determined exogenously.

There are several additional assumptions that are prerequisite to the model construction. First, the banks behave as profit maximizing firms. Profit maximization is assumed rather than the more general rule of utility maximization for the purpose of simplification. Second, the "Cournot assumptions," that the conjectural variations are equal to zero, are recognized. Third, there can be no price discrimination based on geographical location, i.e., a firm cannot vary its input price as a function of the distance between the customer and the point of production. For example, it might be in a firm's interest to pay higher input prices to customers located on the outer fringe of its trade area. In this manner, the firm could expand the size of its geographical trade area. There is no evidence, however, that the commercial banking industry engages in the practice of geographical price discrimination. Fourth, for simplification, any possible interaction effects between the input and the output sides of the market are ignored. Specifically the bank's customers may be both depositors and loan recipients. It may be possible that the actual input price paid out by the bank to its customers should take into account the availability of future loans to these same customers (Luckett, 1970, pp. 420-434).

The spaceless case

The spaceless case exists when distance is not a factor in the model. Transportation costs are assumed to be equal to zero, i.e., all production is assumed to take place at a point in space. The duopsony model rests on the assumption that there are only two buyers of inputs. These two buyers shall be designated as bank one and bank two. The aggregate input supply functions corresponding to bank one and bank two can be represented as:

$$(1) \qquad X_1 = f_1(W_1, W_2)$$

and

$$(2) \qquad X_2 = f_2(W_1, W_2)$$

where

X_1 = total inputs (deposits) offered to bank one

X_2 = total inputs (deposits) offered to bank two

W_1 = input price paid by bank one

W_2 = input price paid by bank two

It is assumed that

$$\frac{\partial X_1}{\partial W_1} > 0, \ \frac{\partial X_1}{\partial W_2} < 0, \ \frac{\partial X_2}{\partial W_1} < 0, \ \frac{\partial X_2}{\partial W_2} > 0,$$

i.e., the amount of input (deposits) supplied to each bank is directly related to its own input price and inversely related to its rival's input price.

The possibility of interdependent pricing is taken into account by including both input prices in each banks aggregate input supply function. The possibility of some degree of product differentiation is considered by giving each bank's aggregate input supply function a different notational form. This product differentiation may be either real or perceived. Often, in the case of commercial banking, it may be in the form of some type of customer loyalty to a particular bank. The existence of product differentiation explains the potential for sustained input price differentials in the spaceless case.

The production functions of banks one and two can be notationally written as:

(3) $$Q_1 = F_1(X_1)$$

and

(4) $$Q_2 = F_2(X_2)$$

where

Q_1 = quantity of output (loans or investments) of bank one

Q_2 = quantity of output (loans or investments) of bank two

The production functions show each bank's amount of output to be a function of its amount of input, i.e., each bank's amount of loans or investments is a function of its level of deposits.

The profit maximizing equations for each bank can be written as:

(5) $$\pi_1 = P_1Q_1 - W_1X_1 - b_1$$

and

$$(6) \qquad \pi_2 = P_2Q_2 - W_2X_2 - b_2$$

where

π_1 = profits of bank one

π_2 = profits of bank two

b_1 = some level of fixed costs for bank one

b_2 = some level of fixed costs for bank two

Specifically, the profit level for each bank is equal to the difference of the total revenue (P·Q) and the total variable cost (W·X), less the level of fixed cost (b_1 or b_2). Substituting equations (3) and (4) into equations (5) and (6) respectively yields:

$$(7) \qquad \pi_1 = P_1F_1(X_1) - W_1X_1 - b_1$$

and

$$(8) \qquad \pi_2 = P_2F_2(X_2) - W_2X_2 - b_2$$

Substituting equations (1) and (2) into equations (7) and (8) respectively yields:

$$(9) \qquad \pi_1 = P_1F_1[f_1(W_1,W_2)] - W_1f_1(W_1,W_2) - b_1$$

and

$$(10) \qquad \pi_2 = P_2F_2[f_2(W_1,W_2)] - W_2f_2(W_1W_2) - b_2$$

The profit maximizing conditions, or reaction functions, for banks one and two are determined by taking the total derivative of each bank's profit level (π_1 and π_2) with respect its input price (W_1 and W_2) respectively. For bank one:

$$(11) \qquad \frac{d\pi_1}{dW_1} = P_1 \frac{\partial F_1}{\partial f_1} \frac{\partial f_1}{\partial W_1} \frac{dW_1}{dW_1} + P_1 \frac{\partial F_1}{\partial f_1} \frac{\partial f_1}{\partial W_2} \left(\frac{dW_2}{dW_1}\right)^*$$

$$- W_1 \frac{\partial f_1}{\partial W_1} \frac{dW_1}{dW_1} - W_1 \frac{\partial f_1}{\partial W_2} \left(\frac{dW_2}{dW_1}\right)^* - f_1(W_1,W_2) \frac{dW_1}{dW_1} = 0$$

The output price, P, is assumed to be determined exogenously, and therefore is treated as constant. Analogously, for bank two:

$$(12) \qquad \frac{d\pi_2}{dW_2} = P_2 \frac{\partial F_2}{\partial f_2} \frac{\partial f_2}{\partial W_1} \left(\frac{dW_1}{dW_2}\right)^* + P_2 \frac{\partial F_2}{\partial f_2} \frac{\partial f_2}{\partial W_2} \frac{dW_2}{dW_2}$$

$$- W_2 \frac{\partial f_2}{\partial W_1} \left(\frac{dW_1}{dW_2}\right)^* - W_2 \frac{\partial f_2}{\partial W_2} \frac{dW_2}{dW_2} - f_2(W_1,W_2) \frac{dW_2}{dW_2} = 0$$

Because equation (11) is the profit maximizing equation for bank one, the conjectural variation is represented by $\left(\frac{dW_2}{dW_1}\right)^*$. This represents how bank one believes bank two will respond to bank one's own price initiative. Equation (12) is the profit maximizing equation for bank two. The conjectural variation in that equation is represented by $\left(\frac{dW_1}{dW_2}\right)^*$. This represents how bank two believes bank one will respond to bank two's own price initiative. In accord with the Cournot assumptions, the conjectural variations are set equal to zero and equations (11) and (12) reduce to:

$$(13) \qquad \frac{d\pi_1}{dW_1} = P_1 \frac{\partial F_1}{\partial f_1} \frac{\partial f_1}{\partial W_1} - W_1 \frac{\partial f_1}{\partial W_1} - f_1(W_1 W_2) = 0$$

$$(14) \qquad \frac{d\pi_2}{dW_2} = P_2 \frac{\partial F_2}{\partial f_2} \frac{\partial f_2}{\partial W_2} - W_2 \frac{\partial f_2}{\partial W_2} - f_2(W_1, W_2) = 0$$

In order to determine how these profit maximizing conditions for each bank change with respect to an input price change initiated by the rival bank, it is necessary to take the total differential of equations (13) and (14). For bank one:

$$(15) \qquad \frac{\partial F_1}{\partial f_1} \frac{\partial f_1}{\partial W_1} dP_1 + P_1 \frac{\partial f_1}{\partial W_1} \frac{\partial^2 F_1}{\partial f_1 \partial W_1} dW_1 + P_1 \frac{\partial f_1}{\partial W_1} \frac{\partial^2 F_1}{\partial f_1 \partial W_2} dW_2$$

$$+ P_1 \frac{\partial F_1}{\partial f_1} \frac{\partial^2 f_1}{\partial W_1^2} dW_1 + P_1 \frac{\partial F_1}{\partial f_1} \frac{\partial^2 f_1}{\partial W_1 \partial W_2} dW_2 - W_1 \frac{\partial^2 F_1}{\partial W_1^2} dW_1$$

$$- W_1 \frac{\partial^2 f_1}{\partial W_1 \partial W_2} dW_2 - 2 \frac{\partial f_1}{\partial W_1} dW_1 - \frac{\partial f_1}{\partial W_2} dW_2 = 0$$

Analogously for bank two:

$$(16) \qquad \frac{\partial F_2}{\partial f_2}\frac{\partial f_2}{\partial W_2}\,dP_2 + P_2\frac{\partial f_2}{\partial W_2}\frac{\partial^2 F_2}{\partial f_2 \partial W_1}\,dW_1 + P_2\frac{\partial f_2}{\partial W_2}\frac{\partial^2 F_2}{\partial f_2 \partial W_2}\,dW_2$$

$$+ P_2\frac{\partial F_2}{\partial f_2}\frac{\partial^2 f_2}{\partial W_2 \partial W_1}\,dW_1 + P_2\frac{\partial F_2}{\partial f_2}\frac{\partial^2 f_2}{\partial W_2{}^2}\,dW_2 - W_2\frac{\partial^2 F_2}{\partial W_2 \partial W_1}\,dW_1$$

$$- W_2\frac{\partial^2 f_2}{\partial W_2{}^2}\,dW_2 - 2\frac{\partial f_2}{\partial W_2}\,dW_2 - \frac{\partial f_2}{\partial W_1}\,dW_1 = 0$$

Equations (15) and (16) can be solved for the ratios $\frac{dW_1}{dW_2}$ and $\frac{dW_2}{dW_1}$ respectively. For bank one:

$$(17) \qquad \frac{dW_1}{dW_2} = \frac{\frac{\partial F_1}{\partial f_1}\frac{\partial f_1}{\partial W_1}\frac{dP_1}{dW_2} + P_1\frac{\partial f_1}{\partial W_1}\frac{\partial^2 F_1}{\partial f_1 \partial W_2} + P_1\frac{\partial F_1}{\partial f_1}\frac{\partial^2 f_1}{\partial W_1 \partial W_2} - W_1\frac{\partial^2 f_1}{\partial W_1 \partial W_2} - \frac{\partial f_1}{\partial W_2}}{- P_1\frac{\partial f_2}{\partial W_1}\frac{\partial^2 F_1}{\partial f_1 \partial W_1} - P_1\frac{\partial F_1}{\partial f_1}\frac{\partial^2 f_1}{\partial W_1{}^2} + W_1\frac{\partial^2 f_1}{\partial W_1{}^2} + \partial\frac{\partial f_1}{\partial W_1}}$$

For bank two:

$$(18) \qquad \frac{dW_2}{dW_1} = \frac{\frac{\partial F_2}{\partial f_2}\frac{\partial f_2}{\partial W_2}\frac{dP_2}{dW_1} + P_2\frac{\partial f_2}{\partial W_2}\frac{\partial^2 F_2}{\partial f_2 \partial W_1} + P_2\frac{\partial F_2}{\partial f_2}\frac{\partial^2 f_2}{\partial W_2 \partial W_1} - W_2\frac{\partial^2 f_2}{\partial W_2 \partial W_1} - \frac{\partial f_2}{\partial W_1}}{- P_2\frac{\partial f_2}{\partial W_2}\frac{\partial^2 F_2}{\partial f_2 \partial W_2} - P_2\frac{\partial F_2}{\partial f_2}\frac{\partial^2 f_2}{\partial W_2^2} + W_2\frac{\partial^2 f_2}{\partial W_2^2} + \partial\,\frac{\partial f_2}{\partial W_2}}$$

Equations (17) and (18) represent the slopes of the input price--input price reaction functions for banks one and two respectively. It should be emphasized that these ratios are not conceptually the same as the conjectural variations, $\frac{dW_2}{dW_1}$ and $\frac{dW_1}{dW_2}$ pertaining to bank one and bank two, respectively, that were previously set equal to zero in equations (11) and (12). The ratios $\frac{dW_1}{dW_2}$ and $\frac{dW_2}{dW_1}$ show how each bank must change its profit maximizing input price in response to an input price change by the other bank--provided the bank intends to keep its profits at a maximum. The signs associated with the ratios, $\frac{dW_1}{dW_2}$ and $\frac{dW_2}{dW_1}$ are ambiguous from a theoretical perspective. It would require an empirical estimation of the cross effects comprising the ratios to establish their appropriate signs. The important point to be recognized in the spaceless case, is that each bank's input supply function is a function of its rival's input price as well as its own input price. Thus any cross effects such as $\frac{\partial f_1}{\partial W_2}$, $\frac{\partial(\frac{\partial F_1}{\partial f_1})}{\partial W_2}$, etc. are direct, i.e., any input price changes initiated by bank two affect bank one's profit maximizing equation directly through bank two's input price variable. The reason the input prices enter the input supply functions in this manner is that in the spaceless case the banks are competing for the same set of geographical customers. Barring product differentiation, there is a zero sum game between the two banks in that one bank's loss is the other's gain. The model does, however, recognize the existence of some degree of product differentiation--at least as perceived by the bank's customers. As a consequence, there may be some disparity between the input prices paid out by the banks--even in this spaceless case. As a result, the ratios $\frac{dW_1}{dW_2}$ and $\frac{dW_2}{dW_1}$, may deviate from the value one at some points in time.

The spatial case

The spatial case extends the spaceless analysis by including distance or customer location as a factor in the model, i.e., the analysis is essentially the same, but it has been generalized to allow for transportation costs (Greenhut, Greenhut, and Kelly, 1977, pp. 210-253). It is necessary to impose two additional assumptions for the spatial case. First, the customers are assumed to be evenly or uniformly distributed between the two banks in the model. Second, the customers are assumed to be of equal size. These assumptions are made to facilitate the aggregation of individual input supply functions.

As a consequence, the aggregate input supply functions for banks one and two can be written as:

(19) $X_1 = f_1(W_1,T_1)$

(20) $X_2 = f_2(W_2,T_2)$

where

X_1 = amount of inputs (deposits) supplied to bank one

X_2 = amount of inputs (deposits) supplied to bank two

W_1 = the input price paid out by bank one

W_2 = the input price paid out by bank two

T_1 = the maximum customer distance from bank one in terms of dollars

T_2 = the maximum customer distance from bank two in terms of dollars

It is assumed that

$$\frac{\partial X_1}{\partial W_1} > 0, \frac{\partial X_1}{\partial T_1} > 0, \frac{\partial X_2}{\partial W_2} > 0, \frac{\partial X_2}{\partial T_2} > 0,$$

i.e., the amount of inputs (deposits) supplied to each bank is directly related to its own input price and also is directly related to the size of its own customer area. For example, by raising its input price, a bank can increase its supply of inputs both by drawing new customers into the market from its own trade area, and by capturing some of its rival's customers by expanding its effective trade area boundary. It should be noted that bank two's input price, W_2, does not enter bank one's aggregate input supply function directly. Similarly bank one's input price, W_1, does not enter bank two's aggregate input supply function directly. Instead, each bank's input price affects the other's aggregate input supply function indirectly via the variables T_1 and T_2. Effectively T_1 and T_2 represent the trade area boundary, in one dimension space, viewed from banks one and two respectively, i.e, T_1 is the distance in dollars from bank one to the demarcation line between the two banks. Similarly, T_2 is the distance in dollars from bank two to the demarcation line. The demarcation line establishes the trade areas or geographical customer areas for the two banks. The value of T_1 is calculated by multiplying the distance, in miles, between bank one and the demarcation line by the total cost of transportation per mile. Consequently, the resulting value of T_1 is expressed in terms of dollars. T_2 is calculated in the same manner (Greenhut, Greenhut, and Kelly, 1977, pp. 210-253).

Because the distance between the two banks is fixed,

(21) $T_1 + T_2 = K$

where

K = the fixed amount of distance in dollar terms between the two banks, Equation (21) can be solved for T_2:

$$(22) \qquad T_2 = K - T_1$$

The demarcation line is variable, however, dependent on the input prices paid by the two banks. Therefore:

$$(23) \qquad T_1 = g(W_1, W_2)$$

where

$$\frac{\partial T_1}{\partial W_1} > 0 \text{ and } \frac{\partial T_1}{\partial W_2} < 0.$$

In other words, as bank one raises its input price, W_1, it tends to increase the size of its trade area T_1. Conversely, as bank two raises its input price, W_2, it tends to increase the size of its own trade area T_2 or decrease the size of bank one's trade area T_1, since $T_1 + T_2 = K$. Substituting equation (23) into equation (22) yields:

$$(24) \qquad T_2 = K - g(W_1, W_2)$$

The production functions for the two banks are defined in the same manner as for the spaceless case:

$$(25) \qquad Q_1 = F_1(X_1)$$

and

(26) $$Q_2 = F_2(X_2)$$

The initial profit equations for the two banks are defined as before:

(27) $$\pi_1 = P_1Q_1 - W_1X_1 - b_1$$

and

(28) $$\pi_2 = P_2Q_2 - W_2X_2 - b_2$$

Substituting for Q_1 and Q_2 in equations (27) and (28) yields:

(29) $$\pi_1 = P_1F_1(X_1) - W_1X_1 - b_1$$

and

(30) $$\pi_2 = P_2F_2(X_2) - W_2X_2 - b_2$$

Substituting for X_1 and X_2 in equations (29) and (30) yields:

(31) $$\pi_1 = P_1F_1[f_1(W_1,T_1)] - W_1f_1(W_1,T_1) - b_1$$

and

(32) $$\pi_2 = P_2F_2[f_2(W_2,T_2)] - W_2f_2(W_2,T_2) - b_2$$

Substituting for T_1 and T_2 in equations (31) and (32) yields:

(33) $$\pi_1 = P_1F_1\{f_1[W_1,g(W_1,W_2)]\} - W_1f_1[W_1,g(W_1,W_2)] - b_1$$

and

$$(34) \qquad \pi_2 = P_2F_2\{f_2[W_2,K - g(W_1,W_2)]\} - W_2f_2[W_2,K - g(W_1,W_2)] - b_2$$

To obtain the profit maximizing conditions for the two banks, it is necessary to take the total derivative of equations (33) and (34) with respect to W_1 and W_2 respectively. Since the Cournot assumptions are to be utilized, it is possible to obtain the simplified profit maximizing conditions by partial differentiation of equations (33) and (34) with respect to W_1 and W_2 respectively. In other words, the conjectural variations, $\frac{dW_1}{dW_2}$ and $\frac{dW_2}{dW_1}$ have been eliminated by treating W_2 constant in equation (33) and by treating W_1 constant in equation (34). The resulting profit maximizing equation for bank one is:

$$(35) \qquad \frac{\partial \pi_1}{\partial W_1} = P_1 \frac{\partial F_1}{\partial f_1} \frac{\partial f_1}{\partial W_1} + P_1 \frac{\partial F_1}{\partial f_1} \frac{\partial f_1}{\partial g} \frac{\partial g}{\partial W_1} - W_1 \frac{\partial f_1}{\partial W_1} - W_1 \frac{\partial f_1}{\partial g} \frac{\partial g}{\partial W_1} - f_1[W_1,g(W_1,W_2)] \text{ .}$$

For bank two the profit maximizing equation is:

$$(36)\qquad \frac{\partial \pi_2}{\partial W_2} = P_2 \frac{\partial F_2}{\partial f_2}\frac{\partial f_2}{\partial W_2} - P_2 \frac{\partial F_2}{\partial f_2}\frac{\partial f_2}{\partial g}\frac{\partial g}{\partial W_2} - W_2 \frac{\partial f_2}{\partial W_2}$$

$$+ W_2 \frac{\partial f_2}{\partial g}\frac{\partial g}{\partial W_2} - f_2[W_2, K - g(W_1,W_2)].$$

To examine the effect of a change in the rival input price for each bank (dW_2 for bank one and dW_1 for bank two), it is necessary to totally differentiate equations (35) and (36) and algebraically solve for the ratios $\frac{dW_1}{dW_2}$ and $\frac{dW_2}{dW_1}$ respectively. These ratios represent the slope of the input price-input price reaction functions for the two banks. For bank one:

$$\frac{\partial F_1}{\partial f_1}\frac{\partial f_1}{\partial W_1}\frac{dP_1}{dW_2} + P_1\frac{\partial F_1}{\partial W_1}\frac{\partial^2 F_1}{\partial f_1\partial T_2}\frac{\partial g}{\partial W_2}$$

$$+ P_1\frac{\partial F_1}{\partial f_1}\frac{\partial^2 f_1}{\partial W_1\partial T_1}\frac{\partial g}{\partial W_2} + \frac{\partial F_1}{\partial f_1}\frac{\partial f_1}{\partial g}\frac{\partial g}{\partial W_1}\frac{dP_1}{dW_1}$$

$$+ P_1\frac{\partial f_1}{\partial g}\frac{\partial g}{\partial W_1}\frac{\partial^2 F_1}{\partial f_1\partial W_1} + P_1\frac{\partial f_1}{\partial g}\frac{\partial g}{\partial W_1}\frac{\partial^2 F_1}{\partial f_1\partial T_1}\frac{\partial g}{\partial W_2}$$

$$+ P_1\frac{\partial F_1}{\partial f_1}\frac{\partial g}{\partial W_1}\frac{\partial^2 f_1}{\partial g\partial T_1}\frac{\partial g}{\partial W_2} + P_1\frac{\partial F_1}{\partial f_1}\frac{\partial f_1}{\partial g}\frac{\partial^2 g}{\partial W_1\partial W_2}$$

$$+ W_1\frac{\partial^2 f_1}{\partial W_1\partial T_1}\frac{\partial g}{\partial W_2} - W_1\frac{\partial g}{\partial W_1}\frac{\partial^2 f_1}{\partial g\partial T_1}\frac{\partial g}{\partial W_2}$$

(37)
$$\frac{dW_1}{dW_2} = \frac{- W_1\frac{\partial f_1}{\partial g}\frac{\partial^2 g}{\partial W_1\partial W_2} - \frac{\partial f_1}{\partial g}\frac{\partial g}{\partial W_2}}{\begin{aligned} & - P_1\frac{\partial f_1}{\partial W_1}\frac{\partial^2 F_1}{\partial f_1\partial W_1} - P_1\frac{\partial f_1}{\partial W_1}\frac{\partial^2 F_1}{\partial f_1\partial T_1}\frac{\partial g}{\partial W_1} - P_1\frac{\partial F_1}{\partial f_1}\frac{\partial^2 f_1}{\partial W_1^2} \\ & - P_1\frac{\partial F_1}{\partial f_1}\frac{\partial^2 f_1}{\partial W_1\partial W_2}\frac{\partial g}{\partial W_1} - P_1\frac{\partial f_1}{\partial g}\frac{\partial g}{\partial W_1}\frac{\partial^2 F_1}{\partial f_1\partial T_1}\frac{\partial g}{\partial W_1} \\ & - P_1\frac{\partial F_1}{\partial f_1}\frac{\partial g}{\partial W_1}\frac{\partial^2 f_1}{\partial g\partial W_1} - P_1\frac{\partial F_1}{\partial f_1}\frac{\partial g}{\partial W_1}\frac{\partial^2 f_1}{\partial g\partial T_1}\frac{\partial g}{\partial W_1} \\ & - P_2\frac{\partial F_1}{\partial f_1}\frac{\partial f_1}{\partial g}\frac{\partial^2 g}{\partial W_1^2} - W_1\frac{\partial^2 f_1}{\partial W_1^2} - W_1\frac{\partial^2 f_1}{\partial W_1\partial T_1}\frac{\partial g}{\partial W_1} \\ & + \frac{\partial f_1}{\partial W_1} + \frac{\partial f_1}{\partial g}\frac{\partial g}{\partial W_1} + W_1\frac{\partial g}{\partial W_1}\frac{\partial^2 f_1}{\partial g\partial W_1} + W_1\frac{\partial g}{\partial W_1}\frac{\partial^2 f_1}{\partial g\partial T_1}\frac{\partial g}{\partial W_1} \\ & + W_1\frac{\partial f_1}{\partial g}\frac{\partial^2 g}{\partial W_1^2} + \frac{\partial f_1}{\partial g}\frac{\partial g}{\partial W_1}\end{aligned}}$$

Analogously, for bank 2:

$$
\begin{aligned}
&\frac{\partial F_2}{\partial f_2}\frac{\partial f_2}{\partial W_2}\frac{dP_2}{dW_1} - P_2\frac{\partial f_2}{\partial W_2}\frac{\partial^2 F_2}{\partial f_2 \partial T_2}\frac{\partial g}{\partial W_1} \\
&- P_2\frac{\partial F_2}{\partial f_2}\frac{\partial^2 f_2}{\partial W_2 \partial T_2}\frac{\partial g}{\partial W_1} - \frac{\partial F_2}{\partial f_2}\frac{\partial f_2}{\partial g}\frac{\partial g}{\partial W_2}\frac{dP_2}{dW_1} \\
&+ P_2\frac{\partial f_2}{\partial g}\frac{\partial g}{\partial W_2}\frac{\partial^2 F_2}{\partial f_2 \partial T_2}\frac{\partial g}{\partial W_1} + P_2\frac{\partial F_2}{\partial f_2}\frac{\partial g}{\partial W_2}\frac{\partial^2 f_2}{\partial g \partial T_2}\frac{\partial g}{\partial W_1} \\
&- P_2\frac{\partial F_2}{\partial f_2}\frac{\partial f_2}{\partial g}\frac{\partial^2 g}{\partial W_2 \partial W_1} + W_2\frac{\partial^2 f_2}{\partial W_2 \partial T_2}\frac{\partial g}{\partial W_1}
\end{aligned}
$$

$$
(38) \qquad \frac{dW_2}{dW_1} = \frac{- W_2\frac{\partial g}{\partial W_2}\frac{\partial^2 f_2}{\partial g \partial T_2}\frac{\partial g}{\partial W_1} + W_2\frac{\partial f_2}{\partial g}\frac{\partial^2 g}{\partial W_2 \partial W_1} - \frac{\partial f_2}{\partial T_2}\frac{\partial g}{\partial W_1}}{\begin{array}{l}
- P_2\frac{\partial f_2}{\partial W_2}\frac{\partial^2 F_2}{\partial f_2 \partial W_2} + P_2\frac{\partial f_2}{\partial W_2}\frac{\partial^2 F_2}{\partial f_2 \partial T_2}\frac{\partial g}{\partial W_2} - P_2\frac{\partial F_2}{\partial f_2}\frac{\partial^2 f_2}{\partial W_2^2} \\
+ P_2\frac{\partial F_2}{\partial f_2}\frac{\partial^2 f_2}{\partial W_2 \partial T_2}\frac{\partial g}{\partial W_2} + P_2\frac{\partial f_2}{\partial g}\frac{\partial g}{\partial W_2}\frac{\partial^2 F_2}{\partial f_2 \partial W_2} \\
- P_2\frac{\partial f_2}{\partial g}\frac{\partial g}{\partial W_2}\frac{\partial^2 F_2}{\partial f_2 \partial T_2}\frac{\partial g}{\partial W_2} + P_2\frac{\partial F_2}{\partial f_2}\frac{\partial g}{\partial W_2}\frac{\partial^2 f_2}{\partial g \partial W_2} \\
- P_2\frac{\partial F_2}{\partial f_2}\frac{\partial g}{\partial W_2}\frac{\partial^2 f_2}{\partial g \partial T_2}\frac{\partial g}{\partial W_2} + P_2\frac{\partial F_2}{\partial f_2}\frac{\partial F_2}{\partial g}\frac{\partial^2 g}{\partial W_2^2} \\
+ W_2\frac{\partial^2 f_2}{\partial W_2^2} - W_2\frac{\partial^2 f_2}{\partial W_2 \partial T_2}\frac{\partial g}{\partial W_2} + \frac{\partial f_2}{\partial W_2} - \frac{\partial f_2}{\partial g}\frac{\partial g}{\partial W_2} \\
- W_2\frac{\partial g}{\partial W_2}\frac{\partial^2 f_2}{\partial g \partial W_2} + W_2\frac{\partial g}{\partial W_2}\frac{\partial^2 f_2}{\partial g \partial T_2}\frac{\partial g}{\partial W_2} \\
- W_2\frac{\partial f_2}{\partial g}\frac{\partial^2 g}{\partial W_2^2} + \frac{\partial f_2}{\partial W_2} + \frac{\partial f_2}{\partial T_2}\frac{\partial g}{\partial W_2}
\end{array}}
$$

Again, as in the spaceless case, the signs associated with the ratios, $\frac{dW_1}{dW_2}$ and $\frac{dW_2}{dW_1}$, are ambiguous from the perspective of economic theory. An empirical estimation of the cross effects comprising the ratios is needed to establish their appropriate signs. The point to be realized from the spatial case is that a change in a bank's input price affects the slope of the rival's reaction function by way of the trade area boundary--represented by the variables T_1 and T_2. The slope of bank one's reaction function is given by equation (37). It can be seen that any change in the rival bank's input price, W_2, affects the terms in equation (37) through the cross partial $\frac{\partial g}{\partial W_2}$. Equation (23) was:

$$T_1 = g(W_1, W_2)$$

Therefore, $\frac{\partial T_1}{\partial W_2} = \frac{\partial g}{\partial W_2}$. Also since $\frac{\partial T_1}{\partial W_2}$ was assumed to be negative, so must $\frac{\partial g}{\partial W_2}$. Descriptively, as bank two increases its input price, W_2, it tends to push the trade area boundary out towards bank one. As a consequence, bank one's trade area boundary, T_1, declines and so does the amount of deposits, X_1, supplied to bank one. As a consequence, bank one is forced to make a price revision if it is to maintain a profit maximizing position. Any analysis pertaining to the slope of bank two's reaction function is analogous.

The point of difference between the spatial and spaceless cases is the degree of impact one rival has on another, i.e., the degree of impact is total in the spaceless case barring product differentiation. The reason for this is that the spaceless rivals are competing for the same set of geographical customers. Regarding the spatial case, this is only partly true. The spatial rivals only compete directly for their geographically marginal customers. The nonmarginal customers, in a geographical sense, are figuratively "locked in" to each respective bank's trade area by transportation costs. As a consequence, the spatial banks' price reactions may not be so extensive as for the spaceless banks. This is particularly in reference to price changes that are initiated by internal factors, e.g., increased efficiency on the part of one of the banks. It is realized that changes in common exogenous parameters (common market forces) will cause similar price reactions by the affected banks.

The element of geographical separation can become even more pronounced when the assumption of a uniform customer distribution is relaxed. To the extent that there might exist areas of sparsely populated land between two potential rivals, coupled with the fact that price changes are generally not infinitesimally small, the geographical market separation may be complete.

From these theoretical models it is possible to hypothesize that one can delineate, or at the least, assign banks to their respective geographic banking markets by examining the extent of the reaction functions between potentially rival banks. The crucial assumption prerequisite to the empirical analysis in the following chapter, is that the spaceless banks a priori constitute a population of rival banks. Technically the term "rivalry" is defined as "the striving for potentially incompatible positions, combined with a clear awareness by the parties involved, that the positions they seek to attain may be incompatible" (Scherer, p. 9). It is implicit, that the degree of product differentiation is not so great as to classify the spaceless banks in different markets. Theoretically, the magnitude of the slopes of the reaction functions for these spaceless or rival banks can be compared to the magnitude of the slopes of the reaction functions for the spatially located banks. Thus, it is theoretically possible to determine the impact of distance on the slopes of the reaction functions. Where the impact is significant, or where the reaction function slopes of spatial banks significantly differ from those for the spaceless or rival banks, one can conclude that the spatially located banks are not behaving as rivals and consequently operate in different market areas.

A Revised Interpretation of the Reaction Functions

The reaction function measures that have been presented have been developed in a static context. There are two major problems associated with using a static analysis. First, it is necessary to assume either that price adjustments are instantaneous or that sufficient time is allowed to elapse such that a complete adjustment can occur. Realistically, where significant information and decision lags exist, a bank may make a series of adjustments in response to a rival's price change. These intermediate adjustment prices are not recognized in a static analysis.

The second major problem associated with using a static analysis is the selection of the appropriate time unit. In other words, it is necessary to use price changes per unit of time, as the measurement variables. The selection of the appropriate time unit, however, can be quite difficult. It may be possible to select a unit of time that is too long, resulting in relatively homogeneous price levels--even for nonrival banks. A time unit that is too long might allow for exogenous parameters to change, consequently affecting a change in the endogenous variable. If this is the case, then any differences in reactions might be meaningless.

An alternative measure of firm interdependence that is sensitive to dynamic price adjustments would help to circumvent these two major problems. In a dynamic framework, the price reaction function can be evaluated by investigating the response time function $\frac{dt_1}{dW_2}$, where dt, is the amount of time elapsed between any change in the price of bank one, and a change in the price of bank two. The response time incorporates the use of all price adjustments, whether or not they are market clearing. Also, consideration is given to the timing of a price response. Finally, the dynamic framework avoids the problem of making any arbitrary time unit selections.

Due to its complexity, a dynamic model shall not be developed here. The economic intuition associated with the static and dynamic models is essentially the same, as far as it pertains to this study. Consequently, the dynamic framework shall be viewed only as a practical modification of the static analysis presented previously.

In the absence of search costs, information or decision lags, and product differentiation, response time will be either zero or infinite. If the two banks are rivals, one will respond immediately to a price action by the other--response time will be zero. If the two banks are nonrivals, bank one will never respond to price action by bank two--response time will be infinite.

CHAPTER IV. AN EMPIRICAL ADAPTATION OF THE THEORETICAL MODEL

Observed Versus Theoretical Response Times

Although the dynamic theory elaborated in the preceding chapter implies that the response time of one bank to another will be either zero or infinite, in reality, it can be expected that response times will be nonzero but finite. For two rivals, price reactions may not be instantaneous for two reasons. First, there may be some degree of product differentiation--not so much as to classify the two banks in different markets--but enough to yield different input supply curves for the two banks. In other words, because of some degree of product differentiation, a bank may have a cushion against another's price initiative, and consequently may not react instantaneously. Second, there may be information or decision lags. If bank one changes its price, it may be some time before bank two is aware of that change. Or, even if bank two immediately discovers the change in bank one's pricing policy, the decision process may result in a delay before bank two can implement its own price changes. Thus, it is likely that for rivals, the response time will be nonzero.

Likewise, even for two nonrivals, it is unlikely that the observed response time will be infinite. Bank two bases its pricing decisions on variables other than the price charged or offered by other banks. Even though bank two does not respond to bank one's price, it may alter its price at some future date in response to other changing conditions. Thus, violation of ceteris paribus conditions will cause observed responses of nonrivals to be finite.

Because both rivals and nonrivals may exhibit nonzero, but finite, response times, it is necessary to develop an empirical procedure that can identify significant differences in finite response times. Standard statistical methods offer such a procedure.

Rationale for an Empirical Technique

The basic assumptions of the empirical market delineation procedure are that banks can be classified into two groups, rivals and nonrivals, and that the average response time between nonrivals is significantly greater than the average response time between rivals. For example, let M_R represent a sample of response times drawn from a response time population of rival banks. Then $\bar{M}_R$, the sample mean, is an estimate of the average response time for rival banks. Now let M_U represent a sample of response times drawn from two unclassified banks, and $\bar{M}_U$ the average response time of those banks. If $\bar{M}_U$ is significantly greater than $\bar{M}_R$, the two banks can be classified as nonrivals and be included in separate markets. If $\bar{M}_U$ is not significantly greater than $\bar{M}_R$, the two banks can be classified as rivals and be included in the same market.

The statistical adaptation also assumes that exogenous factors other than action by a rival are randomly and identically distributed over both classes of banks. Differences in response times among rival banks which are used to generate the distribution of response times for rivals will be caused by changes in factors other than rival prices. Those same "other factors" will impact unclassified banks as well. The statistical model assumes that the mean response time of rivals will be shorter than the mean response time of non-rivals. The effect of exogenous influences on response time will be reflected in the standard deviations of response times and thus become a part of the significance test.

The Statistical Techniques

Any statistical technique that evaluates the significance of differences in measures of central tendency is a candidate for use in the delineation procedure. The theory outlined above discussed differences in the mean response times of different classes of banks. However, because there is no information on the form of the underlying distributions of response times, it is most appropriate to use a nonparametric technique. A nonparametric hypothesis does not involve the population parameters, but is concerned with the form of the population frequency distribution. Nonparametric techniques make it possible to test two or more samples to see if they have been drawn from a common distribution, without necessitating the standard assumptions regarding the form of the distribution. Two types of nonparametric methods are used in this study.

The Wilcoxon-Mann-Whitney test

One nonparametric method used in this study to distinguish differences in mean response times tests for level (or location) differences between two populations and is referred to as the Wilcoxon-Mann-Whitney (MWM) test (Fryer, 1966, pp. 190-193). The WMW test is useful in testing hypotheses regarding the mean response time of an individual pair of unclassified banks vs. the mean response time of the overall rival sample. The WMW test normally is a one-tailed test with the hypotheses Ho: $[F(X_1) = G(X_2)]$ versus Ha: $[F(X_1) > G(X_2)]$ for all points along the X scale of measurement, where F and G are the cumulative distribution functions for X_1 and X_2 respectively. The test is based upon the general assumption that, if the magnitude of the size of the X_1's is greater than the magnitude of the size of the X_2's, and if one draws random samples x_1 and x_2 of sizes n_1 and n_2 from the X_1 and X_2 populations, respectively, the x_1's in the combined array of x_1's and x_2's should outrank the x_2's.

Specifically, one forms an ordered array for the combined samples of x_1's and x_2's and computes the variate:

$$(1) \qquad U = n_1 n_2 + \frac{n_1(n_1 + 1)}{2} - T,$$

where T is the sum of the ranks of the x_1's in the combined array. The variable U has an approximately normal frequency distribution with a true mean of:

$$(2) \qquad \mu_U = \frac{n_1 n_2}{2},$$

and a true variance of:

$$(3) \qquad \sigma_U^2 = \frac{n_1 n_2 (n_1 + n_2 + 1)}{12} .$$

Thus, the sampling variate

$$(4) \qquad \lambda = \frac{U - (n_1 n_2)/2}{[(n_1 n_2)(n_1 + n_2 + 1)/12]^{\frac{1}{2}}}$$

has a N(0, 1) frequency distribution, and Ho can be tested with the use of the cumulative standard normal distribution tables.

<u>The Kruskal-Wallis test</u>

The Wilcoxon-Mann-Whitney test for two independent samples has been extended to the problem of analyzing more than two independent samples, by Wallis and Roberts (Wallis and Roberts, 1956, pp. 583-621). The experimental situation is one where k samples have been obtained, with one sample being drawn from each of k possibly different populations. The objective is to test the null hypothesis that all of the samples have been drawn from an identical population against the alternative hypothesis that some of the samples have been drawn from different populations. In other words, one can test the null hypothesis that all of the populations possess observed values of similar magnitudes, against the alternative hypothesis that some of the populations may possess observed values of differing magnitudes. The Kruskal-Wallis test is particularly useful as a tool for testing various collections of rival bank pairs so as to generate a valid overall rival sample. Specifically, if there are k samples, of sizes n_1, n_2, ..., n_k, a total of N in all samples, all N observations are ranked, and the sums of the ranks, R_1, R_2, ..., R_k, are computed for the separate samples. Then one can compute the variate

$$(5) \qquad H = \frac{12}{N(N+1)} \sum_{i=1}^{k} \frac{R_i^2}{n_i} - 3(N+1) .$$

The standard normal variable

$$(6) \qquad K = \sqrt{2H^2} - \sqrt{2k - 3}$$

can be calculated in order to approximate the probability of the variate H. Alternatively, the calculated value K can be compared to critical K values obtained from a cumulative standard normal distribution table.

CHAPTER V. AN EMPIRICAL ILLUSTRATION OF THE DELINEATION PROCEDURE

The purpose of this chapter is to apply the statistical methodology, presented in Chapter IV, to the basic hypothesis underlying the procedure for bank market delineation. The hypothesis, which was stated in Chapter IV, is concerned with whether or not pairs of unclassified or spatially located banks behave differently than an overall sample of rival banks. Specifically, if the mean response time for an unclassified pair of banks is significantly greater than the mean response time for an overall sample of rival banks, then the two unclassified banks are classified as nonrival banks and are included in separate markets. Conversely, if the mean response time for an unclassified pair of banks is significantly less than or equal to the mean response time for an overall sample of rival banks, the two unclassified banks are classified as rivals and are included in the same market. Using this methodology, any number of spatially separated banks can be assigned to their respective geographical market areas.

Research Design

The measurement variable

As stated in Chapter III, the variable chosen for measurement, is the amount of time elapsed between any change in the input price of bank one, and a change in the input price of bank two. It should be emphasized that the measurement variable is calculated within bank pairs. Since the theoretical model elaborated in Chapter III was exclusively concerned with the input side of the market, only input prices have been selected for measurement. Several categories of bank input prices have been chosen. These categories include: passbook savings accounts; three-, six-, or nine-month certificates of deposit; one-year certificates of deposit; one to two and one-half year certificates of deposit; and two and one-half to four year certificates of deposit. Fortunately, these categories of input prices (deposits) were reasonably homogeneous across the banks chosen for survey. Homogeneity across banks is guaranteed by federal regulations pertaining to characteristics of time deposit accounts. It is possible, of course, that markets defined by using time deposit rates may be different from those that would be defined by using loan rates or other criteria.

Data collection procedure

Data on changes in time deposit rates during 1960-75 were collected from sixteen banks in Iowa. All banks are unit banks and none are associated with a holding company. Microdata from nine banks in four towns were initially selected to potentially generate the rival sample. Three of the nine banks are located in a town of 26,900 people, two are located in a town of 12,600 people, two are located in a town of 4,500 people and two are located in a town of 3,200 people.

Data from seven additional unclassified banks in the area were used to test the delineation procedure. Two of the seven unclassified banks are located in a town of 3,200 people, and the other five are located in four towns ranging in size from 370 to 2,300 people. All the unclassified banks are located within a radius of fifteen miles.

A single-page mail survey with personal follow-up was used to collect date-of-change data from each bank. A copy of the questionnaire used in the survey is provided in Appendix A. Although some banks expressed difficulty in completing the survey, others indicated that the data were readily available from minutes of board of directors' meetings or posting ledgers for active time-deposit accounts.

Calculation of response times

In determining the response times for the rival or spaceless sample, the number of days that elapsed from the date of rate change by the lead bank and a rate change in the same deposit category by the rival was calculated. Because interest rates were relatively stable prior to the 1960-75 period, any initial price changes in the sample were assumed to indicate lead bank price initiatives. The original lead banks, however, did not necessarily remain the price leaders throughout the time period.

To separate price responses between banks that are due to interdependent pricing functions from price responses that are due to changes in exogenous parameters, the data calculation was conducted according to two different procedures. The first procedure was the imposition of a 365-day limitation on response time. If the elapsed time between price changes exceeded 365 days, the response time was specified as 365 days, and any subsequent rate change by any rival bank was designated as a new lead. The second procedure was the imposition of a 180-day limitation on response time. If the elapsed time between price changes exceeded 180 days, the response time was specified as 180 days and again any subsequent rate change by any rival bank was designated as a new lead. Under both procedures, only rate changes within the same deposit category were considered as legitimate responses. Furthermore, any rate change within the same category, even if rates were not equalized, was considered as a response.

Next, response times for the unclassified or spatial banks were determined. The response time for an unclassified bank pair was calculated as the elapsed time in days from the date of change for the unclassified lead bank and the date of response by the other unclassified bank. Other rules for a legitimate response were the same as for the rival sample.

Identification of the rival sample

In Chapter III, spaceless banks were assumed to be the same as rival banks, i.e., they were assumed to be one and the same, provided any degree of product differentiation within the rival or spaceless bank pairs is not so great as to include the banks in separate markets. In the empirical adaptation, the rival or spaceless banks are taken to be banks located within the same city. Since the sample was drawn from a collection of relatively small towns, this assumption closely approximates reality. Most of the rival banks are located merely a few city blocks apart, thus virtually negating any transportation costs between them.

To generate a sample of rival or spaceless banks, it is hypothesized that it is possible to pool the response times within rival bank pairs across different towns. As stated earlier, nine banks located in four towns were chosen for survey as potential rivals. Three of the banks are located in one town and shall be designated as banks A, B, and C. Two of the remaining six banks are located in a second town and shall be designated as banks D and E. Two more are located in a third town and shall be designated as banks F and G. The final two banks are located in a fourth town and are designated as banks H and I. The response times were calculated for each of the six rival bank pairs, AB, AC, BC, DE, FG, and HI, under each of the procedural assumptions pertaining to response time. The procedural assumptions were a 365-day limitation on response time, and a 180-day limitation on response time. The data are presented in Tables B.1 and B.2 in Appendix B.

The Kruskal-Wallis test, presented in Chapter IV, was conducted on various combinations of rival bank pairs to determine which combinations can be validly pooled to generate the rival sample. The test was conducted on the combination of all six rival bank pairs, all possible combinations of any five of the six bank pairs, and all possible combinations of any four of the six bank pairs. In addition, the test was conducted on all such combinations, for each of the procedural assumptions pertaining to response time limitations. The calculated results are presented in Tables B.3 and B.4 of Appendix B.

The null hypothesis pertaining to these calculations, is that all samples (pairs) in each combination of bank pairs have been drawn from an identical population. The alternative hypothesis is that some of the samples (pairs) in each combination have been drawn from different populations. Consequently, it is best to use a two-tailed test. The calculated K values, as described in Chapter IV, can be compared to critical K values obtained from a cumulative standard normal distribution table. A significance level of 10 percent has been selected because of the relatively small sample size. Consequently the critical K value obtained from the standard normal distribution table pertaining to a two-tailed test is approximately 1.65.

For the 365-day limitation on response time, the only bank pair combination which has a K value less than 1.65 is the combination BC, DE, FG, and HI. The calculated K value for this combination is 1.48. Consequently, one cannot reject the null hypothesis that these bank pairs have been drawn from a common distribution. At the 10 percent level of significance, this combination of bank pairs constitutes a valid pool of rival response times. The remaining combinations of bank pairs, under the 365-day limitation on response time, yield calculated K values exceeding the critical value, 1.65. This leads to the rejection of the null hypothesis that they are all drawn from a common distribution. Instead, the alternative hypothesis that one or more of the pairs come from a different distribution, is accepted. The economic rationale underlying this hypothesis, is that some of the bank pairs possess a degree of product differentiation which is high enough to warrant their exclusion from a common rival sample.

For the 180-day limitation on response time, two bank pair combinations yield calculated K values of less than 1.65. Combination AB, BC, FG, and HI yields a K value of 1.61, and combination AC, DE, FG, and HI yields a K value of .93. The null hypothesis cannot be rejected for either case, and both combinations are taken to constitute valid overall samples of rival bank pairs. The remaining combinations of bank pairs, under the 180-day limitation on response time, yield calculated K values that are greater than 1.65. Consequently, for these remaining combinations, the null hypothesis must be rejected, and it cannot be concluded that these bank pairs have been drawn from a common distribution.

In summary, these preliminary tests on various combinations of rival bank pairs have generated three valid overall rival samples. The first is the combination BC, DE, FG, and HI which was calculated under the 365-day response time limitation. The second and third are the combinations AB, BC, FG, and HI; and AC, DE, FG, and HI which were calculated under the 180-day response time limitation.

Each of these overall rival samples provides a base for comparisons with pairs of unclassified or spatially located banks.

Results

The next step of the delineation procedure is to test each of the unclassified, or spatially located, bank pairs against each of the rival samples. Specifically, the test consists of determining whether there is a significant difference between the response times within pairs of unclassified or spatially located banks and the response times within the pairs of spaceless banks comprising the rival samples.

The seven unclassified banks are all located within adjacent trade or customer areas. Two of the banks are located in one town, and are designated as banks H and I. It should be noted that these two banks also comprised part of the initial sample of rival or spaceless banks. The reason they are treated as spatial or unclassified banks in this second sample, is that the two banks are now being treated as one unit. Specifically, banks H and I in the spatial sample, will not be tested against each other as was the case for the spaceless or rival sample, but instead shall be tested against other spatially located banks. They are treated as one unit in the sense that only the first of the two banks to make a price adjustment is recorded. Another two of the spatially located banks are located in one town and shall be designated as banks K and L. The remaining three spatially located banks are located in three separate towns, and shall be designated as banks J, M, and N. The calculated response times for each of the unclassified, or spatially located, bank pairs are listed in Tables 5.1 and 5.2 according to the procedural assumptions of a 365-day limitation on response time, and a 180-day limitation on response time respectively.

The pairs of unclassified, or spatially located, banks were tested against each of the rival samples by use of the Wilcoxon-Mann-Whitney test. The Wilcoxon-Mann-Whitney test, described in Chapter IV, is specifically designed to determine if two samples have been drawn from a common distribution. The null hypothesis associated with the Wilcoxon-Mann-Whitney test is that the response times within the unclassified bank pairs tend to be less than or equal to the response times within bank pairs comprising the rival samples. The alternative hypothesis is that the response times within the unclassified bank pairs tend to be greater than the response times within the bank pairs comprising the rival sample. These types of hypotheses dictate the use of a one-tailed test. The one-tailed test, and the hypothesis structure just described have been selected because of the underlying economic intuition. The economic theory presented in Chapter III implies that the price reactions between spatially located, or unclassified, banks might not be as large as the price reactions between spaceless or rival banks. This intuition was extended to a dynamic analysis where the length of time elapsed between price changes became the variable of

Table 5.1. Calculated response times for unclassified banks, in days, using a 365-day limitation on response time

J to (H or I)	(K or L) to (H or I)	M to (H or I)	N to (H or I)	J to M	J to (K or L)	J to N	M to (K or L)	M to N	N to (K or L)
365	365	365	365	0	6	365	0	0	365
122	365	365	365	365	72	365	365	0	365
365	40	365	18	365	365	365	365	14	365
137	23	12	365	365	160	365	20	31	51
12	33	365	365	0	20	31	0	73	9
365	365	365	365	0	0	0	365	357	0
51	365	365	13	365	11	365	365	365	365
63	365	365	12	37	365	319	365	365	5
31	174	365	365	19	10	6	365	365	20
7	365	59	365	62	40	19	0		365
	8	365	365				365		9
	34	365	365				365		0
	365	26	192				9		365
	365	185	13				82		365
	365	60	12						5
	365								20
	40								
	194								
	33								

Table 5.2. Calculated response times for unclassified banks, in days, using a 180-day limitation on response time

J to (H or I)	(K or L) to (H or I)	M to (H or I)	N to (H or I)	J to M	J to (K or L)	J to N	M to (K or L)	M to N	N to (K or L)
180	180	180	180	0	0	180	0	180	180
112	180	180	180	180	72	180	180	31	180
180	40	180	180	180	180	180	180	0	180
137	23	12	180	180	160	180	20	180	51
180	33	180	18	0	20	31	0	180	9
12	180	180	180	0	0	0	180	0	0
180	180	180	180	180	11	180	180	180	180
51	180	180	180	37	180	180	180	180	5
63	174	180	180	29	10	180	180	14	20
180	180	59	13	62	40	5	0	73	180
7	8	180	12			19	180		9
	34	180	180				180		0
	180	26	180				9		180
	180	180	180				82		180
	180	180	180						5
	180	60	180						20
	40		180						
	180		180						
	180		13						
	33		12						

measurement. The resulting implication is that the length of response time between price changes for spatially located banks might be of a greater magnitude than the length of response time between price changes for spaceless banks. The economic rationale for these implications, is that spatial banks, due to customer transportation costs, often enjoy a cushion against price rivalry.

To maintain consistency with the previous statistical analysis, a significance level of 10 percent has been selected. Because of the employment of a one-tailed test, a 10 percent level of significance yields a critical λ value of 1.28. The λ statistic, described in Chapter IV, was assumed to be normally distributed and consequently the critical λ value can be obtained from a standard normal distribution table.

The calculated T, U, and λ values pertaining to the ten possible pairings of unclassified, or spaceless banks are presented in Tables 5.3, 5.4, and 5.5. The values presented in Table 5.3 are the result of calculations conducted on response times calculated under the 365-day limitation. Each pair of unclassified banks has been tested against the sample BC, DE, FG, and HI, which is the overall sample of rival bank pairs generated under the 365-day limitation on response time. The values presented in Tables 5.4 and 5.5 are the result of calculations conducted on response times calculated under the 180-day limitation. As a consequence, two sets of results are obtained. Table 5.4 presents the results obtained by testing each pair of unclassified banks against the overall rival sample AB,

Table 5.3. Calculated T, U, and λ values for unclassified bank pairs with a 365-day limitation on response time. The rival bank pair combination used as the comparison sample is AB, AC, DE, HI

Unclassified bank comparisons	T	U	λ
J to (H or I)	356.5	159.5	1.58
(K or L) to (H or I)	881.5	201.5	3.47
M to (H or I)	700	125	3.74
N to (H or I)	641	184	2.77
J to M	317	108	.57
J to (K or L)	296	229	.12
J to N	379.5	145.5	1.88
M to (K or L)	532	231	1.68
M to N	297.5	170.5	.91
N to (K or L)	573.5	314.5	.97

Table 5.4. Calculated T, U, and λ values for unclassified bank pairs with a 180-day limitation on response time. The rival bank pair combination used as the comparison sample is AC, DE, FG, HI

Unclassified bank comparisons	T	U	λ
J to (H or I)	375	219	.88
(K or L) to (H or I)	821.5	348.5	1.77
M to (H or I)	667	237	2.28
N to (H or I)	840	330	2.01
J to M	267	268	.58
J to (K or L)	241	294	1.11
J to N	375	219	.88
M to (K or L)	462	315	.35
M to N	301	234	.12
N to (K or L)	494	410	.40

Table 5.5. Calculated T, U, and λ values for unclassified bank pairs with a 180-day limitation on response time. The rival bank pair combination used as the comparison sample is AB, BC, FG, HI

Unclassified bank comparisons	T	U	λ
J to (H or I)	440	264	.90
(K or L) to (H or I)	976	394	2.13
M to (H or I)	788	276	2.47
N to (H or I)	983	387	2.21
J to M	320	315	.43
J to (K or L)	283	352	1.07
J to N	448	256	1.03
M to (K or L)	544	373	.47
M to N	360.5	274.5	.26
N to (K or L)	574	490	.34

BC, FG, and HI. Table 5.5 presents the results obtained by testing each of the unclassified bank pairs against the overall rival sample AC, DE, FG, and HI.

The statistic of interest is the test statistic, λ, which can be compared to the critical λ value of 1.28. The calculated λ values are again presented in Figures 5.1, 5.2, and 5.3, according to their respective conditions of calculation. These figures also provide the geographical structure for the unclassified banks. Calculated λ values greater than the critical value of 1.28 lead one to reject the null hypothesis that the unclassified, or spatially located, bank pair in question, tends to have response times less than or equal to the response times exhibited by the overall sample of rival banks. Instead, one must accept the alternative hypothesis that the unclassified bank pair in question tends to demonstrate response times that are greater than the response times resulting from the overall sample of rival banks. Calculated λ values less than the critical value of 1.28 indicate that one cannot reject the null hypothesis that the unclassified, or spatially located, bank pair in question tends to have response times less than or equal to the response times yielded by the overall sample of rival banks.

The assumption basic to the delineation procedure, is that any two banks comprising an unclassified bank pair that does not demonstrate significantly greater response times, at the 10 percent level of significance, than the overall sample of rival banks, are considered to behave as rival banks and should be included in the same

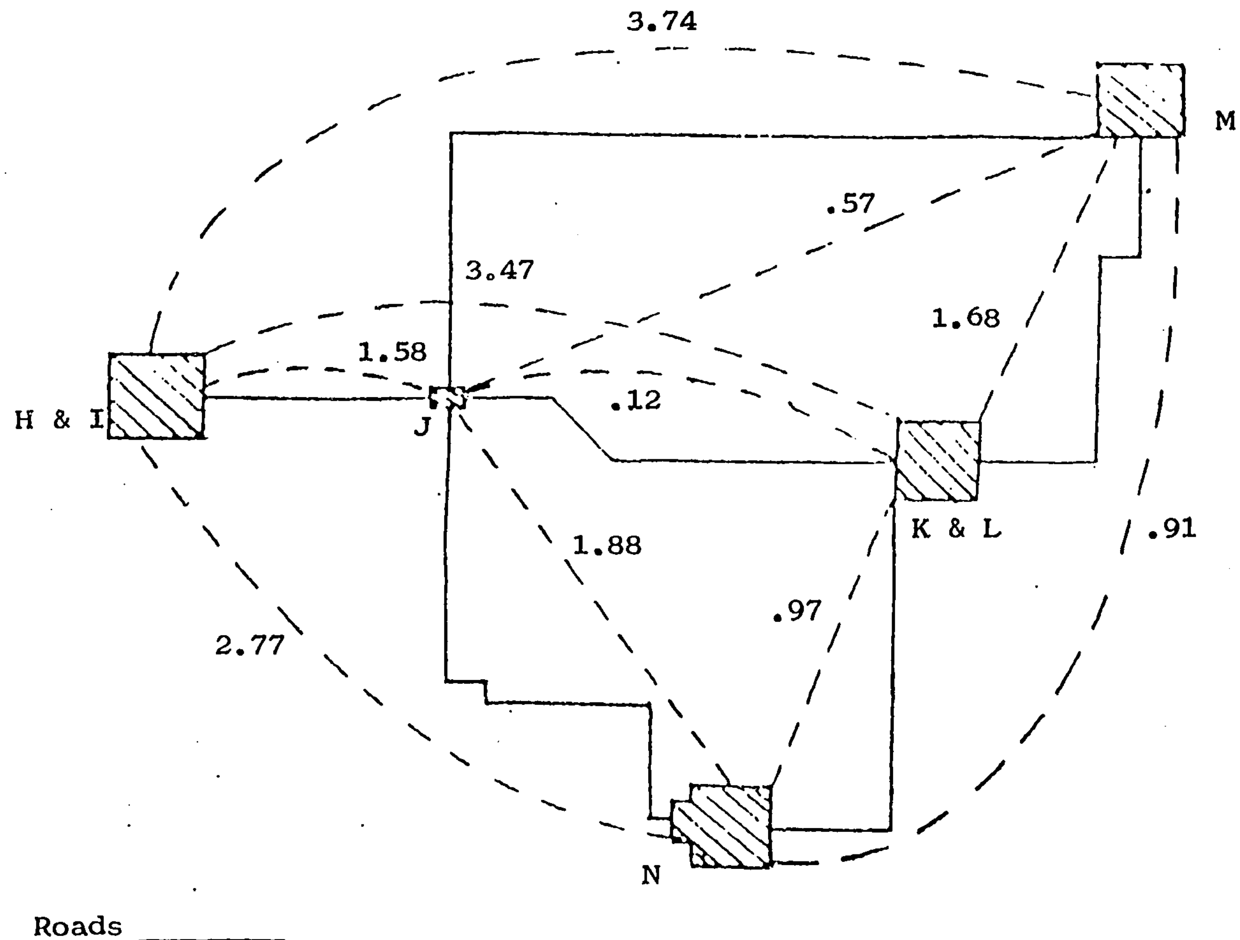

Figure 5.1. λ values for unclassified bank pairs with a 365-day limitation on response time

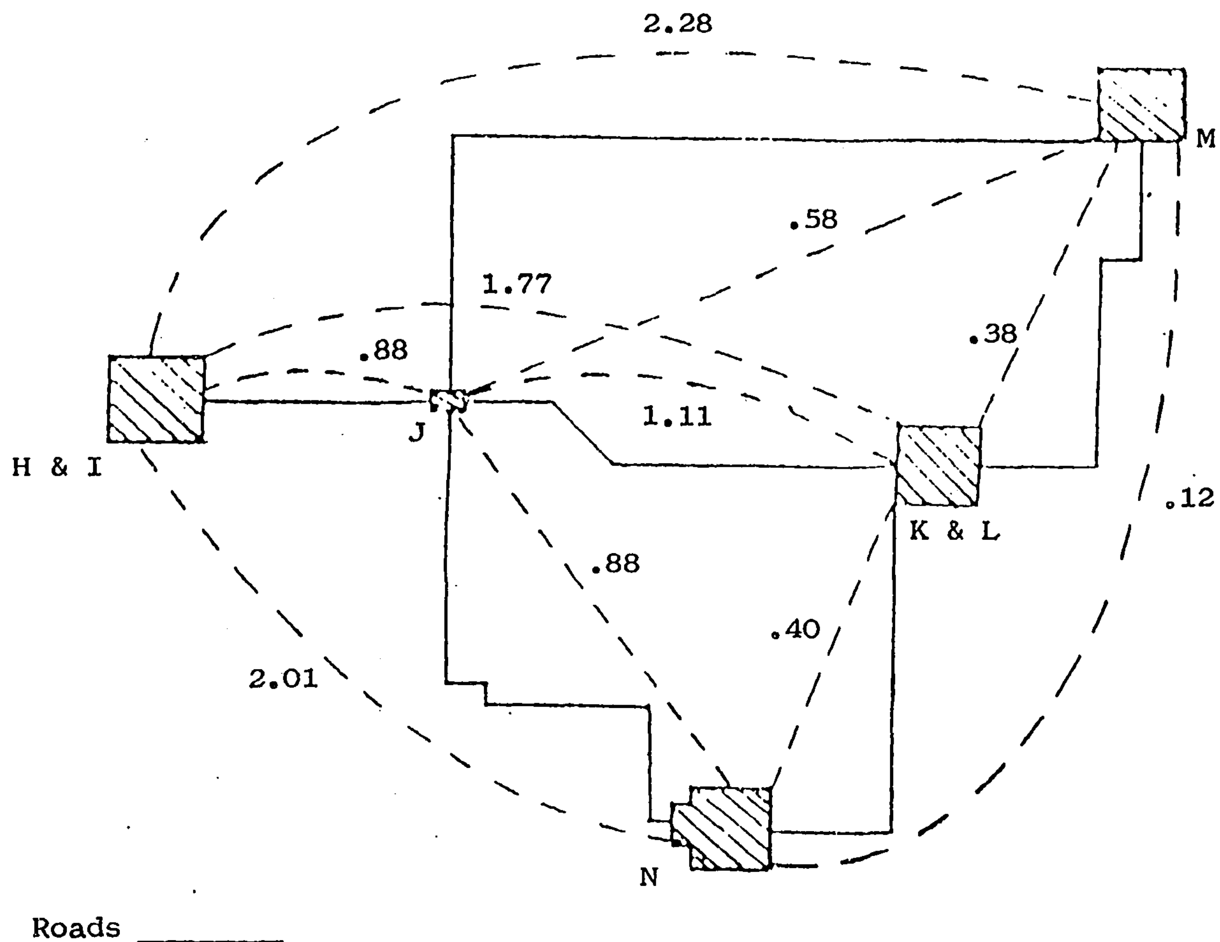

Figure 5.2. λ values for unclassified bank pairs with a 180-day limitation on response time. The rival bank pair combination used as the comparison sample is: AC, DE, FG, and HI

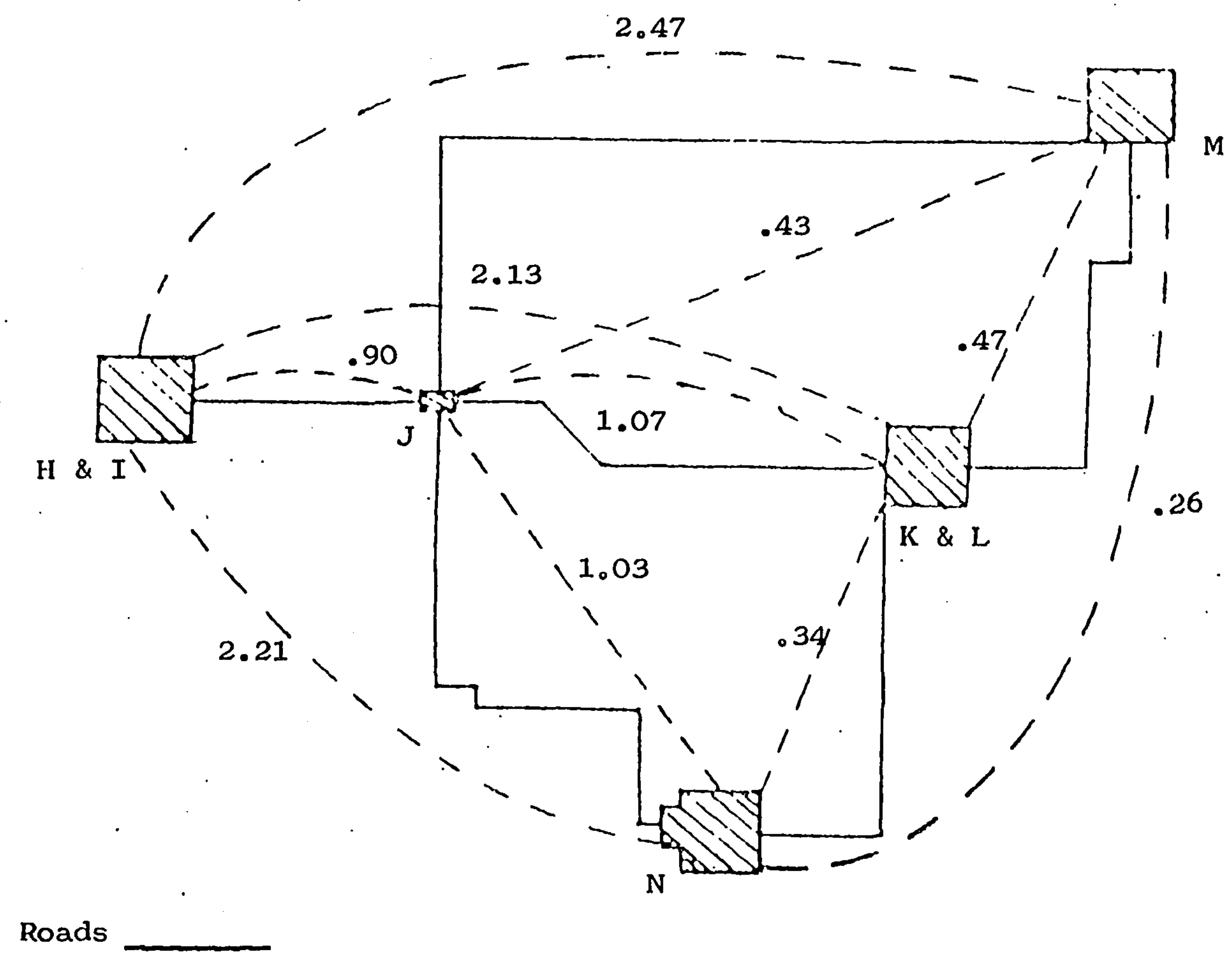

Figure 5.3. λ values for unclassified bank pairs with a 180-day limitation on response time. The rival bank pair combination used as the comparison sample is: AB, BC, FG, and HI

market. Conversely, any two banks comprising an unclassified bank pair that does demonstrate significantly greater response times, at the 10 percent level of significance, than the overall sample of rival banks, are not considered to behave as rival banks and should not be included in the same market.

From Table 5.3 or Figure 5.1, which represent values calculated under the 365-day limitation on response time, it can be seen that all bank pairs involving H or I reflect λ values greater than 1.28. As a result, it can be concluded that banks H and I unambiguously must be included in a market area separate from the other banks in the survey. The results provided by the rest of the unclassified bank pairs are not as conclusive. The bank pairs J to N and M to (K or L) yield λ values greater than 1.28 and lead one to conclude that the banks comprising each pair do not behave as rivals and consequently should be included in separate markets. The remaining unclassified pairs of banks yield λ values less than 1.28, leading one to conclude that the banks comprising each bank pair behave as rivals and must be included in the same market. Because bank pairs J to N and M to (K or L) do not behave as rivals, it is not possible to conclude that banks J, N, M, K and L, all belong in one market area.

The values provided by Tables 5.4 and 5.5, and Figures 5.2 and 5.3, indicate slightly different results than those provided by Table 5.3 and Figure 5.1. The values in Tables 5.4 and 5.5 and Figures 5.2 and 5.3 have been calculated under the 180-day limitation on response time, using overall rival samples AC, DE, FG, and HI; and AB, BC, FG, and HI respectively. It should be noted that the values calculated using these different rival samples, under the 180-day limitation, provide results that are consistent with each other. As a consequence, the discussion pertaining to the 180-day response time limitation can be generalized to cover both sets of results. All but one of the bank pairs involving (H or I) yield λ values greater than 1.28. The exception is the pair J to (H or I). This pair has associated λ values of .88 and .90 pertaining to rival combinations AC, DE, FG, and HI; and AB, BC, FG, and HI, respectively. The conclusion derived from these results is that banks M, N, and (K or L) belong in a different market area from banks (H or I). Bank J, on the other hand, should be included in the same market area as banks (H or I). The remaining unclassified bank pairs yield λ values that are less than 1.28 leading one to conclude that they all behave as rivals and should, therefore, be included in a common market area.

Discussion of Results

An apparent point of inconsistency resulting from the above analysis demonstrates the need for further discussion of the methodology. Under the 180-day limitation on response time, bank J has been shown to behave as a rival both when compared to banks (H or I), and also when compared to the other unclassified banks in the survey. However, banks (H or I) have been shown not to behave as a rival combination when compared to the other unclassified banks in the survey. There are several possible answers to this apparent problem of intransitivity. First, the sample sizes may be insufficiently small. As can be seen from Tables 5.1 and 5.2, the samples of unclassified bank pairs range in size from 10 observations to, at most, 20 observations. It may be possible, that by increasing the sample sizes, either by increasing the time period of the survey, or by initially selecting banks that are more price active, any problem of intransitivity might be eliminated. A second solution to the intransitivity problem might lie in more experimentation with the appropriate limitation on response time. The problem of whether to include bank J in the same market as banks (H or I), does not arise with the 365-day response time limitation. Other inconsistencies arise, however, involving bank pairs J to N and M to (K or L). The point is that there is nothing absolute about the choice of 365 days or 180 days as the limitation on response time. Further testing might yield a response time limitation that would provide more consistent results. The third answer to the apparent problem of intransitivity might lie in an examination of the economic intuition underlying the delineation procedure. Specifically, one must be careful not to over interpret the results provided by the methodology. The data used in this study consist of response times related to input price changes within pairs of banks. Any or all price changes within the appropriate input price categories chosen, have been recorded. The price changes have not been broken down according to their initiating causes. Generally a price change is due to one, or both, of two major causes. First, a price change may be the result of factors internal to the bank. A bank may experience increased efficiency and hence decreased operating costs which enable it to alter the prices paid to its factors of production (depositors). Another internal factor leading to a price change might be a change of attitude on behalf of the bank's management, e.g., it might decide to become more aggressive with its pricing policies. The second major cause, underlying a change in prices, is that of changing market conditions, e.g., a change in customer incomes or tastes. These are changes exogenous to the bank, but nevertheless they will provoke price adjustments. The point of contention, is that whether or not a bank responds to another's price initiative, or to what degree the bank responds, may depend on the initiating cause of the price response.

Some other factors to consider are whether or not spatially located banks behave as if they are spatially isolated. A spatially located bank may react to another's price initiative because of an even customer distribution between them, i.e., the banks will react to each other because each will attempt to protect its trade area. Conversely, some spatially located banks enjoy spatial isolation. There may be an uneven customer distribution that makes it unnecessary for one bank to react to another's price initiative, i.e., the trade area may be so sparsely populated that it does not merit protection--at least at its outer fringe.

The final factor of consideration is whether or not the banks are influenced by similar market conditions. As stated before, market conditions refer to exogenous factors such as customer incomes and tastes.

When a price initiative is the result of the internal policies of one bank, the influence on the other bank's price response depends strictly on the degree of spatial isolation. A bank's price response is strictly a move to protect its trade area from the other's price initiative. If market factors are constant, it does not matter whether or not the two banks are influenced by common market forces.

When a price initiative is the result of changing market conditions, the degree of price response depends on several factors. If two banks are influenced by common market conditions, then both banks should adjust prices according to the changing market conditions, regardless of their degree of spatial isolation. If two banks are influenced by different market conditions, then as the market conditions of one bank change while the market conditions of the other bank remain constant, any degree of price response between the banks depends on the degree of spatial isolation. If the banks are spatially isolated, there should be no price response. If the two banks are not spatially isolated, then there should be some degree of price response, as the effects of a price initiative by one bank affect the trade area boundary separating the two banks. It is an assumption of this study that price responses that are the result of changing market conditions are greater, and resultingly quicker, than price responses that result from changing internal factors affected through spatially effective trade areas.

This discussion may explain the cause of the intransitivity problem. The data were calculated for any price changes initiated for any reason, i.e., it is the composite of price changes initiated by both internal factors and market factors. The overall rival samples used as the basis for comparisons were generated by combining banks that are influenced by both similar market conditions and a spaceless geographic distribution. As a result, the calculated price responses were virtually complete, and were initiated very quickly. The reason the price responses were not instantaneous can be ascribed to a degree of product differentiation. When the pairs of unclassified, or spatially located, banks are compared to this overall rival sample, the acceptance of the alternative hypothesis that the unclassified bank pairs yield significantly greater response times indicates one or both of two possibilities. The unclassified, or spatially located, banks may be spatially isolated from each other; the unclassified banks may be influenced by separate market factors; or the unclassified banks may be affected by a combination of both factors. As a consequence, the statistical results must be interpreted carefully.

For example, under the 180-day response time limitation, it was found that banks (H or I) did not belong in the same market area as banks (K or L). However, bank J appeared to exist in the market area of both bank pairs (H or I) and (K or L). A reason for this apparent inconsistency is that bank J might possess common market factors with one of the bank pairs, and possess uncommon market factors, but a spatially effective trade area with the other pair of banks. Suppose bank J is influenced by market factors common to banks (K or L). The statistical analysis would reveal bank J and banks (K or L) to behave as rivals and indicate that they should be included in similar markets. Now suppose bank J and banks (H or I) are not influenced by common market factors, but are linked by a spatially effective trade area. The statistics might also reveal bank J and banks (H or I) to behave as rivals, and indicate that they should also belong in similar markets. But because price responses are assumed to be less extensive when they are the result of spatially effective trade areas than when they result from common market factors, it is entirely possible that the statistics will not reveal banks (H or I) and (K or L) to behave as rivals. This stems from the fact that the price responses used in this study are taken as a composite, and are not broken down according to their underlying causes. This discussion may provide an intuitive answer as to why the problem of intransitivity exists, but it has not provided a solution--other than to suggest a more extensive statistical analysis.

There are two approaches to the intransitivity problem, however, that may preclude any further statistical analysis. The first, is that it may be unnecessary, if not impossible, to construct actual geographical market area boundaries. An effective market area, in reality, is not necessarily an either/or situation, but a matter of degree. It has been the objective of the statistical analysis used in the project, to determine the extent of the degree of price response, by calculating the associated λ values and their underlying probabilities.

The second approach to the intransitivity problem is an extension of what has already been done. This approach, however, requires the establishment of a "market center" or an anchoring town, which becomes the base for the statistical tests (Cochrane, 1957, p. 26). The purpose of establishing a market center, or anchor, is to prevent the formation of indefinite chains of trade areas falling into one market area. The choice of a market center is somewhat arbitrary. A logical choice, for the purposes of this project, is the largest town in the survey of unclassified banks. This choice can be justified on the basis that the largest town tends to attract the largest volume of customers, and at least from an arbitrary perspective, should wield the most influence. The largest town in the survey of unclassified banks is the town of 3,200 people. This town contains the banks H and I. As a result, the relevant statistical tests for the survey of unclassified banks are the tests that include banks (H or I). These tests, which can be designated as the primary tests, are J to (H or I), (K or L) to (H or I), M to (H or I), and N to (H or I). The tests pertaining to the remaining pairs of unclassified banks are designated as secondary tests, and do not influence the results or implications of the primary tests.

For the 365-day limitation on response time, all of the primary tests yield calculated λ values greater than the critical value of 1.28. As a result, banks (H or I) are included in a market area that is separate from the other unclassified banks in the survey. For the 180-day limitation on response time, the primary tests pertaining to all bank pairs except J to (H or I), yield λ values greater than 1.28. As a consequence, banks J and banks (H or I) are included in a common market area that is separate from the other unclassified banks in the survey. Thus the market center approach provides a method of dealing with any problems of intransitivity that might arise from the statistical analysis. Whether to use the market center approach, or to use a direct interpretation of the calculated λ values, depends on the goals of any subsequent studies that might employ the use of the delineation procedure. If the goal requires the calculation of measures of concentration, then the market center approach is particularly useful in delineating an actual market area. If the goal is satisfied by just examining the degrees of interdependence, then sufficient information is provided by an interpretation of the λ values themselves.

CHAPTER VI. CONCLUSIONS

The accurate delineation of geographical banking markets is an important aspect of the analysis of structure-conduct-performance relationships regarding the commercial banking industry. In addition, any analysis of existing or proposed regulations pertaining to price rivalry in commercial banking requires the delineation of geographical banking markets as a prerequisite. Virtually all studies concerning the structure-conduct-performance relationships of the commercial banking industry measure structure in the form of some type of concentration measure, e.g., the concentration ratio, the concentration table, etc. A concentration measure must be based on an economically relevant geographical market area if it is to be an accurate measure of market structure. Too often structure-conduct-performance studies simply avoid the problem of appropriate market area delineation by using political areas such as the county or the state as the market areas on which to base the concentration measures. There is little reason, however, to believe that such political areas necessarily represent economically valid market areas.

There are several geographical delineation procedures in existence. However, most of these procedures are designed to delineate trade areas rather than market areas. Trade areas represent the actual customer areas pertaining to each individual firm or bank. Market areas, on the other hand, represent areas containing firms or banks that are influenced by common competitive forces. Some examples of trade area delineation techniques are empirical techniques such as customer spotting and license plate analysis, and theoretical techniques such as the gravitational method and the economic law of market areas. The trade areas delineated by these procedures are not necessarily coincident with the market areas needed as the basis for valid concentration measures.

A method that is theoretically appealing as a market delineation procedure is the cross-price elasticity method. Unfortunately this method is difficult to implement empirically. Often the data necessary to perform the calculation of cross-price elasticities are unavailable. Furthermore, because of the static nature of cross-price elasticities, the statistical results are difficult to interpret. In summation, there is a strong need for an operational method for the delineation of economically relevant geographical banking markets. It has been the purpose of this project to develop such a method.

The economic theory underlying the delineation procedure was developed in Chapter III. A two-bank oligopsony model was developed for each of two categories of banks. The first category was designated as the spaceless bank case where transportation costs between the two banks in the model were assumed to be zero and thus were not a factor in the model. The second category was designated as the spatial bank case where transportation costs between the two banks in the model were assumed to be nonzero and thus were a factor in the model. The decision variables for both the spaceless and spatial bank cases were the bank input prices. In the spaceless case, each bank's input supply function contains both its own input price and the input price of its rival. In the spatial case, each bank's input supply function contains its own input price and a variable representing its trade area boundary. The variable representing each bank's trade area boundary was assumed to be a function of the input prices paid by each bank. Price-price reaction functions for both the spaceless and the spatial categories of banks were developed. Next, the slopes of the reaction functions pertaining to each case were developed to show how each bank, assuming it is a profit maximizer, must adjust its input price in response to its rival's price initiative. It is hypothesized that the reaction function slopes will be greater for the spaceless banks than for the spatial banks, i.e., profit maximizing spaceless banks are apt to make a more complete price adjustment to a rival's price initiative than would profit maximizing spatial banks. The reason for this hypothesis is that spaceless banks must compete for a common set of geographical customers. The spatial banks, on the other hand, compete only for the geographically marginal customers.

To facilitate empirical adaptation of the theoretical analysis, the model was modified to accommodate a dynamic framework. Accordingly, the amount of time elapsed between bank input price adjustments was adopted as the variable of measurement. The empirical adaptation establishes a two-category scheme for bank classification, rivals and nonrivals. Rivals are banks that, due to product similarity and a small degree of spatial isolation, respond to each other's pricing adjustments and are thus in the same market. Those spaceless banks possessing an insignificant degree of product differentiation were hypothesized to behave as rival banks. Nonrivals are banks that, due to dissimilar market conditions or a large degree of spatial isolation, do not respond to each other's pricing adjustments and are thus in separate markets. The spatial banks, since they represent the test banks, were renamed unclassified banks, and could ultimately be determined to be either rivals or nonrivals. If the degree of spatial isolation is insignificant, then the relevant unclassified banks can be classified as rivals. But if the degree of spatial isolation has a significant impact on behavior, then the relevant unclassified banks may be classified as nonrivals. The statistical adaptation of the theory is based on the assumption that the response time of a bank to a nonrival's price change will be significantly greater than the response time of that same bank to a rival's price change.

Data on the amount of time elapsed between input price changes within pairs of banks were collected for several categories of bank input prices. These categories include passbook savings accounts and various certificates of deposit. The data were calculated according to two different rules regarding response time limitation. The first rule was the imposition of a 365-day limitation on response time. If the elapsed time between price changes within a bank pair exceeded 365 days, the response time was specified as 365 days, and any subsequent rate change by either bank was designated as a new price lead. The second rule, was the imposition of a 180-day limitation on response time. If the elapsed time between price changes within a bank pair exceeded 180 days, the response time was specified as 180 days and any subsequent rate change by either bank was designated as a new price lead.

The spaceless banks were designated to be bank pairs located within the same town. The Kruskal-Wallis test was conducted on nine spaceless banks, or six spaceless bank pairs, across four different towns to generate an overall sample of rival banks. The underlying intuition of the test is that because the towns are geographically separated, some of the rival bank pairs might possess differing degrees of product differentiation. The test was conducted for each of the rules regarding response time limitation, on numerous combinations of the spaceless bank pairs. The statistical results provide three different overall rival samples; one pertaining to the 365-day response time limitation, and two pertaining to the 180-day response time limitation. These overall rival samples provide the bases from which to compare the unclassified or spatially located bank pairs.

Data from seven unclassified, or spatially located, banks in five different towns, were collected for testing the delineation procedure. The pairs of unclassified banks were tested against each of the rival samples by use of the Wilcoxon-Mann-Whitney test.

The results of these tests provide valuable information on the degrees of price rivalry within the pairs of unclassified banks. When the largest town was selected as a market center, or anchoring town, it was possible to separate the unclassified banks into their respective market areas. Thus the delineation technique has potential for use in evaluating the existence of price rivalry between banks, the competitive inpact of regulatory change, and the effect on price rivalry of proposed mergers.

The procedure, however, is not without shortcomings. To use the procedure accurately, information on date-of-change in the appropriate response variable, must be obtained. Such information may not be available in secondary data sources. In regulated industries such as banking, regulatory authorities could collect date-of-change data as part of their regular examinations. For other industries, personal interview or surveys may be required. However, the data needs of the methodology proposed here are modest in comparison to that required for the traditional cross-price elasticity approach.

In addition, the dates of price (rate) or nonprice changes for all firms (banks) must be obtained. For example, if rate change dates are missing or incomplete for one bank, it is impossible to determine in which market that bank belongs. Also, the test is strongest for confirming that two banks are in separate markets. Acceptance of the null hypothesis that response times for unclassified banks are not significantly greater than those of rival banks does not necessarily mean that the unclassified banks are in the same market. However, acceptance of the alternative hypothesis that response times between unclassified banks are significantly different is a strong indication that the banks are not in the same market.

Furthermore, because of potential problems of intransitivity, a market center must be specified to use as the base for the test. If this base is not used, elongated chains of rival banks may be identified and "gray areas" between well-defined market areas may arise.

The quantification of long delays or, essentially, nonresponses also presents difficulties. Although two different limitations--the 365-day and 180-day rates--on response time were used in the test of the approach. Other rules for quantifying long delays may result in different numerical results. Also, only responses within the same deposit category were considered legitimate responses in the empirical test. If any change within the entire maturity structure was considered as a legitimate response, different results again might be obtained.

In applying the delineation procedure to the banking industry, the choice of the time deposit rate variable as the response measure may result in problems. Although time deposit categories are homogeneous by law across banks, rates on time deposits also are highly regulated. In recent years, most banks have paid ceiling rates, and many banks have adjusted their rates when changes have been made in the ceiling regulations. These exogenous, artificial ceiling regulations not only may impede competition, but also may confound the measurement of competitive responses and delineation of bank markets. Thus, other response measures such as a change in services or deposit maturities should be evaluated using the delineation methodology presented here.

Finally, the proposed methodology focuses only on the speed of response and ignores the extent of response. It is likely that the magnitude of response is an important factor in the dynamics of firm interaction. Additional work is necessary to incorporate response magnitude considerations.

It has been the purpose of this project to develop a basic approach to the delineation of geographical banking market areas. Because of the pilot nature of this project, the research has been developed as a basic level. As a consequence, there is room for a good deal of future research related to refining the delineation procedure itself. For example, it might be possible to convert each response into a "compound equivalent" where the compound equivalent is defined as the continuous rate of increase in the price variable necessary to achieve the actual change at the time of response. A larger response would result in a larger compound equivalent, and a longer delay in response would result in a smaller equivalent. Thus, the compound equivalent would capture the importance of both the magnitude and timing of responses and could be calculated and compared for rivals and unclassified firms. In addition, further research is needed regarding the appropriate response-time limitation. Finally, research is needed to develop a method of separating price responses that are due to changing market conditions from price responses that are due to spatially effective trade areas. Once the procedure has been refined, it has numerous applications to future research related to the analysis of structure-conduct-performance relationships. The delineation of economically relevant banking market areas should result in the calculation of concentration measures that are more economically valid than those currently in use. As a consequence, the delineation procedure could have a significant impact on structure-conduct-performance relationships and the resulting implications toward policy prescriptions. A good deal of future research is required to determine the extent of any such impact.

BIBLIOGRAPHY

Cochrane, Willard W. "The Market as a Unit of Inquiry in Agricultural Economics Research." J. Farm Econ. 39 (1957): 21-39.

Controller of the Currency. National Banking Laws and Related Statutes. Washington, D.C.: U.S. Government Printing Office, 1959.

Converse, Paul D., and Huegy, Harvey W. The Elements of Marketing. Englewood Cliffs, N.J.: Prentice-Hall, 1952.

Edwards, Franklin R. "Concentration in Banking and Its Effect on Business Loan Rates." The Review of Economics and Statistics 46 (1964): 294-300.

Fischer, Gerald C. American Banking Structure. New York, New York: Columbia University Press, 1968.

Fraser, D. R., and Rose, Peter S. "Bank Entry and Performance." Journal of Finance 27 (1972): 65-78.

Fryer, H. C. Concepts and Methods of Experimental Statistics. Boston: Allyn & Bacon, 1966.

Glassman, Cynthia A. "Banking Markets in Pennsylvania." Changing Pennsylvania's Branching Laws: An Economic Analysis. Philadelphia, Penn.: Federal Reserve Bank, 1973.

Greenhut, John G.; Greenhut, M. T.; and Kelly, W. H. "A Spatial-Theoretical Perspective for Bank Merger Regulations." Federal Reserve Bank of Chicago, Proceedings of Bank Structure and Competition. Chicago, Ill.: n.p. 1977.

Huff, David L. "Defining and Estimating a Trade Area." J. Mktg. 28 (1964): 34-38.

Hyson, C. D., and Hyson, W. P. "The Economic Law of Market Areas." Quart. J. Econ. 64 (1950): 319-27.

Kaufman, George C. "Bank Market Structure and Performance: Evidence from Iowa." S. Econ. J. 32 (1966): 429-39.

Luckett, Dudley G. "Credit Standards and Tight Money." Journal of Money, Credit, and Banking 2 (1970): 420-34.

Markin, Rom J., Jr. Retailing Management. New York: Macmillan Co., 1971.

Papandreou, Andres G., and Wheeler, John T. Competition and Its Regulation. Englewood Cliffs, N.J.: Prentice-Hall, 1954.

Reilly, William J. The Law of Retail Gravitation. Austin: University of Texas, 1931.

Scherer, F. M. Industrial Market Structure and Economic Performance. Chicago, Ill.: Rand McNally and Company, 1971.

United States v. Philadelphia National Bank et al. United States Reports. Washington, D.C.: U.S. Government Printing Office, 1963.

Wallis, W. Allen and Roberts, Harry V. Statistics: A New Approach. Glencoe, Ill.: Free Press, 1956.

ACKNOWLEDGEMENTS

I would like to express my appreciation to Dr. Duane Harris, Dr. Michael Boehlje, Dr. Dudley Luckett, Dr. Jean Adams, and Dr. Kenneth Elvig, for serving on my committee. These people have been extremely helpful and tolerant in every possible way, and have helped make my duration at Iowa State University a very pleasurable experience. I am particularly grateful to Dr. Duane Harris for his input, encouragement, and patience regarding my work on this thesis. It has truly been an honor to have worked with Duane. I would also like to express special thanks to Dr. Michael Boehlje for his ideas and contributions pertaining to this thesis. In addition, I would like to express my appreciation to Ms. Anita Serovy for her excellent typing and technical expertise. Finally, I must pay tribute to my close friend, Judy Stein, for her never-ending support and encouragement.

APPENDIX A: QUESTIONNAIRE

Would you please record your passbook interest rate as well as the interest rate on any of the listed certificates of deposit as of January 1, 1960.

RATES PAID

Date	Passbook	3, 6 or 9 months	1 year	1-2½ years	2½-4 years
1/1/60	______	______	______	______	______

Please list below by year, month, and day, the effective dates of change in any of these interest rates since January 1, 1960. Also, please list the corresponding new interest rates in the respective blanks. This information should be readily available from such sources as minutes of board of director's meetings or posting ledgers for active time-deposit accounts.

NEW RATES

Date of Change	Passbook	3, 6, or 9 months	1 year	1-2½ years	2½-4 years
______	______	______	______	______	______
______	______	______	______	______	______
______	______	______	______	______	______
______	______	______	______	______	______
______	______	______	______	______	______
______	______	______	______	______	______
______	______	______	______	______	______
______	______	______	______	______	______
______	______	______	______	______	______
______	______	______	______	______	______

Have you made a change from quarterly to daily compounding on passbook savings accounts? If so, please list the effective date of that change. ______________

Name______________________________

Bank______________________________

Figure A.1. Time deposit rate questionnaire

Would you please record your passbook interest rate as well as the interest rate on any of the listed certificates of deposit as of January 1, 1960.

RATES PAID

Date	Passbook	3, 6 or 9 months	1 year	1-2½ years	2½-4 years
1/1/60	______	______	______	______	______

Please list below by year, month, and day, the effective dates of change in any of these interest rates since January 1, 1960. Also, please list the corresponding new interest rates in the respective blanks. This information should be readily available from such sources as minutes of board of director's meetings or posting ledgers for active time-deposit accounts.

NEW RATES

Date of Change	Passbook	3, 6, or 9 months	1 year	1-2½ years	2½-4 years
______	______	______	______	______	______
______	______	______	______	______	______
______	______	______	______	______	______
______	______	______	______	______	______
______	______	______	______	______	______
______	______	______	______	______	______
______	______	______	______	______	______
______	______	______	______	______	______
______	______	______	______	______	______
______	______	______	______	______	______

Have you made a change from quarterly to daily compounding on passbook savings accounts? If so, please list the effective date of that change. ______________

Name______________________________

Bank______________________________

Figure A.1. Time deposit rate questionnaire

APPENDIX B: TABLES CONTAINING DATA AND RESULTS PERTAINING TO RIVAL BANKS

Table B.1. Calculated response times for rival banks, in days, while using a 365-day limitation on response time

(A to B)	(A to C)	(B to C)	(D to E)	(F to G)	(H to I)
120	105	14	58	14	213
123	38	161	8	365	332
365	365	216	14	3	1
365	76	8	58	365	365
61	183	14	8	4	365
365	28	14	14	3	365
30	365	161	307	15	31
230	365	202	8	4	1
20	28	8	14	162	213
275	365	253		3	192
61	41	14			31
	76	14			1
		161			
		8			
		8			
		14			

Table B.2. Calculated response times for rival banks, in days, while using a 180-day limitation on response time

(A to B)	(A to C)	(B to C)	(D to E)	(F to G)	(H to I)
120	105	14	58	14	180
123	38	161	8	180	180
180	180	180	14	3	180
180	76	8	58	180	180
61	180	14	8	4	1
180	28	14	14	3	180
30	180	161	180	15	180
180	180	180	180	4	31
20	28	8	8	162	1
180	180	180	14	3	180
180	41	14			180
61	76	14			180
30		161			180
20		8			180
33		8			31
61		14			1

Table B.3. Calculated H and K values for classified banks with a 180-day limitation on response time

Combinations of bank pairs	Sample size	H	K
AB, AC, BC, DE, FG, HI	80	13.76	16.46
AB, AC, BC, DE, FG	64	13.16	15.97
AB, AC, BC, DE, HI	70	10.57	12.31
AB, AC, BC, FG, HI	70	11.11	13.07
AB, AC, DE, FG, HI	64	10.35	12.00
AB, BC, DE, FG, HI	68	10.97	12.87
AC, BC, DE, FG, HI	64	10.20	11.78
AB, AC, BC, DE	54	10.10	12.04
AB, AC, BC, FG	54	10.67	12.85
AB, AC, DE, FG	48	10.75	12.96
AB, BC, DE, FG	52	9.40	11.06
AC, BC, DE, FG	48	8.30	9.49
AB, AC, BC, HI	60	7.23	7.98
AB, AC, DE, HI	54	6.00	6.24
AB, BC, DE, HI	58	8.52	9.81
AC, BC, DE, HI	54	7.89	8.92
AB, AC, FG, HI	54	6.49	6.94
AB, BC, FG, HI	58	2.72	1.61
AC, BC, FG, HI	54	8.56	9.86
AB, DE, FG, HI	52	8.42	9.67
AC, DE, FG, HI	48	2.24	0.93
BC, DE, FG, HI	52	6.01	6.26

Table B.4. Calculated H and K values for classified banks with a 365-day limitation on response time

Combinations of bank pairs	Sample size	H	K
AB, AC, BC, DE, FG, HI	70	13.78	16.49
AB, AC, BC, DE, FG	58	15.14	18.77
AB, AC, BC, DE, HI	60	12.43	14.94
AB, AC, BC, FG, HI	61	12.97	15.70
AB, AC, DE, FG, HI	54	10.32	11.95
AB, BC, DE, FG, HI	58	12.40	14.90
AC, BC, DE, FG, HI	59	12.03	14.37
AB, AC, BC, DE	48	13.85	17.35
AB, AC, BC, FG	49	11.20	13.60
AB, AC, DE, FG	42	12.28	15.13
AB, BC, DE, FG	46	12.95	16.07
AC, BC, DE, FG	47	9.55	11.26
AB, AC, BC, HI	51	7.61	8.52
AB, AC, DE, HI	44	8.03	9.12
AB, BC, DE, HI	48	8.90	10.35
AC, BC, DE, HI	49	8.21	9.37
AB, AC, FG, HI	45	4.85	4.62
AB, BC, FG, HI	49	6.97	7.62
AC, BC, FG, HI	50	6.74	7.29
AB, DE, FG, HI	42	7.10	7.80
AC, DE, FG, HI	43	6.94	7.57
BC, DE, FG, HI	47	2.63	1.48