A BUSINESS LOGISTICS INFORMATION AND ACCOUNTING SYSTEM FOR MARKETING ANALYSIS

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ABSTRACT

A BUSINESS LOGISTICS INFORMATION AND ACCOUNTING SYSTEM FOR MARKETING ANALYSIS

by Richard Jay Lewis

This research concerns the development of a new system for gathering internal data for controlling marketing activities. The design and use of the system are presented, followed by computer tests employing actual data from a manufacturer of nationally distributed industrial products.

The design of the system stemmed from identifying a fundamental uniqueness of marketing--control of marketing activities requires control of geographically dispersed activities. Certain costs and all of the gross revenues and profits vary geographically. Therefore, a marketing information system must report the spatial dimension of all activities as a primary factor for analysis and control.

After evaluation of several geographic control units, a spherical grid system based on latitude and longitude quadrilaterals measuring 3.75 minutes by 3.75 minutes was selected as having the greatest potential. The spherical control blocks are used for identifying the location of and reporting all marketing activities and costs. A coding system which uses 6-digit numbers was developed. The first

three digits show the vertical position of a block; the last three show the horizontal position. After the control units were developed, one year's sales orders and shipping documents of the company were reclassified to show the control block numbers of the points of origin and destinations for sales and shipments to 18 states. This reclassification permitted the geographic analysis of total dollar sales, sales by product, by customer type, and by container size, total pounds shipped, and costs of shipping.

The system was tested for its ability to: determine geographic variability of marketing activities, account for geographic variability of physical distribution costs, and delineate distribution territories.

The test for determining the geographic variability of marketing activities was made by using the total dollar and pound sales for the states of New York and Georgia. These figures were analyzed by using: the entire state as the control unit, the total number of grid blocks within the state, the number of grid blocks containing sales, and an individual block comparison. The findings showed that the individual comparison of grid blocks provided a superior method for determining geographic variability of activities.

It was also found that grid units could be combined to describe "areas" of activity within a state.

The determination of geographic variable costs of physical distribution consisted of selecting an east-west vector of 99 grid blocks in New York which served as cost centers. Historical costs, available in 37 blocks, were compared to estimated costs which were developed by using regression line analysis to determine motor carrier costs to the blocks. The regression lines associated motor carrier costs to miles shipped, given the freight classification and weight break involved. Miles shipped were estimated by converting airline distances between the blocks and distribution point into highway miles. The average error in comparing estimated costs to actual costs equaled less than one percent. Therefore, it was concluded that physical distribution costs computed for a grid block as a cost center can generalize the costs of serving specific points within the block with minimal error. The findings also showed that for the company studied costs which varied geographically accounted for 51 to 78 percent of total block costs.

To delineate distribution territories, the total cost pattern for direct factory shipments and shipments from factory to distribution point to customer were computed for two products in all control blocks in the same New York vector. The findings showed that distribution territories could be constructed by determining two adjacent blocks in the vector, one of which obtained minimum costs from the factory and the other from the distribution point. By repeating the computations for vectors above and below the original vector, the boundary lines for minimum costs of specific type shipments were delineated around the distribution points.

A BUSINESS LOGISTICS INFORMATION AND ACCOUNTING SYSTEM FOR MARKETING ANALYSIS

By

Richard Jay Lewis

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CHAPTER I

INTRODUCTION

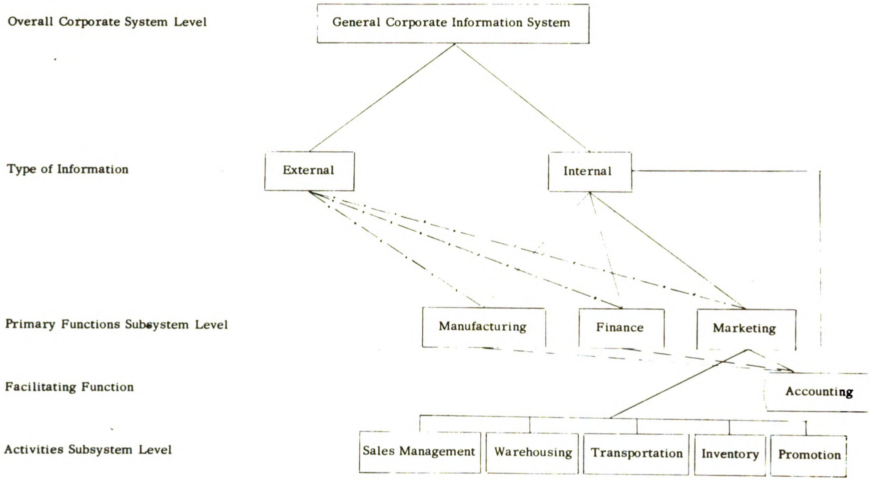
Statement Of Purpose

This dissertation concerns how marketing management gathers its internal data for controlling marketing activities. The design and use of an integrated marketing information system is presented with a computer testing of the system employing actual data from a manufacturer of nationally distributed industrial products.

Figure 1 shows the relationship of the proposed information system to an integrated corporate information system. The overall corporate level encompasses both the information gathered inside the company from records and studies maintained on a continuous basis (internal information) and that gathered outside the company on an intermittent basis (external information). The first level of subsystems for external and internal information provides for the information needs of the primary functions: manufacturing, finance, and marketing. These require information services for three principal activities: record keeping, analyses, and

Figure 1

The Components of Corporate Information



planning. Accounting, as presently utilized, acts as a facilitating function supplying record keeping and some analyses. Each of the primary subsystems contains activities subsystems within itself: in marketing, management of the sales force, inventory, transportation, promotion, and similar activities form the next level.

The purpose of this dissertation is to design and test a computer-oriented integrated internal information system for the marketing area of an integrated corporate system. The system's design provides the information services necessary for record keeping, analysis, and planning of the marketing function.

Background Of The Problem

Since World War II design and management of corporate information systems has evolved as an area of increasing importance. A primary factor causing the increased attention in this area rests upon the development and application of electronic data processing to the collection and analysis of business data. In fact, the phenomenon has been described as no less than an information revolution.[1] Two attributes of electronic computers seem to account for the

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[1] "The Great Information Revolution," Dun's Review and Modern Industry, September, 1963, p. 94.

enormity of the impact on information systems: the high speed at which data can be digested by computers, and the ever-increasing capacity of computers to expeditiously store and merge data over very short time periods.

General application of computers to information gathering and storage resulted in an increasing number of information systems to aid decision making in almost every area of management. Early computer applications centered upon a single or, at most, narrow areas of data gathering for decision making.

Recent literature suggests a need for integrated centrally controlled corporate information systems providing relevant information ranging over broad areas of decision making involving complex processes, heretofore beyond technology and analytical capability.[2] However, integrated information systems require integrated data processing. Some of the clearest statements defining integrated data processing (IDP) recently posited are:[3]

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[2] In 1961 the American Management Association devoted an entire report (AMA Management Report No. 62) to this area entitled Advances In EDP And Information Systems in which many articles called for the integration of corporate information systems, while other articles reported such action by several companies.

[3] Howard Ellis, "Integrated Systems Produce Profits," Advances In EDP And Information Systems, AMA Management Report No. 62 (New York, 1961), pp. 142-143.

1. IDP is designed to cope with the persistently changing patterns of business, that is, to help management control business in the most orderly manner possible despite the seeming disorder arising from change.

2. IDP is a risk-reducing, decision making aid. It generates timely integrated information for all echelons of management.

3. In its narrowest sense, IDP is the mechanization of data at their origin and their continuous processing until their final use. It is, in other words, simply a means of doing clerical work mechanically and its end products are integrated timely information and clerical cost reduction.

4. In its broadest sense, IDP embodies new aids to decision making and makes possible the concept of "management by exception." It is the totally integrated systems approach which:
    a. Pushes the profit motive down the line
    b. Bridges the gap between detailed operation and management decision
    c. Distinguishes the routine from the non-routine
    d. Points out trends
    e. Highlights critical areas for immediate attention
    f. Helps define the responsibility of various levels of management
    g. Supplies succeeding levels with only the information they need to make decisions.

As a consequence of compelling arguments favoring integrated information systems, the authors of two recent articles foresee the creation of a corporate executive position entitled "Vice-President--Information" reporting directly to the chief executive of the corporation.[4] Such an organizational change appears natural, for as the integration of information systems advances it normally involves many phases of business, cutting across organization lines and dealing with the business as a whole rather than with any one individual function.

The rapid increases in data processing technology and the constant need for informed decision making reinforce the trend toward more complete integrated information systems.

The Scope Of The Problem

Although observable trends indicate greater acceptance of integrated, centrally controlled internal corporate information systems, a total system of information as shown in Figure 1 embodies many subsystems, each designed for a specific purpose. The prospect of centrally coordinated information requires that each corporate area review its requests for information to assure that its needs are provided in an integrated whole. Ironically, for some areas in many companies this could be the first time they have viewed their internal informational needs as a system and considered

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[4] "The Great Information Revolution," p. 94; and Edward L. Weinthaler, Jr., "Developing Advanced Business Information Systems," Data Processing for Management, October, 1963, p. 13.

any uniqueness.

The unique needs of an area arise from special types of information required or from the reporting form necessary to make the data more useful for decision making.

Problem Statement

The purpose of this research is to study the requirements of an integrated internal marketing information subsystem,[5] identifying any unique needs, and to design a system to meet these requirements. Having designed the subsystem, an empirical test will be made using the information generated by the subsystem as input data for marketing cost and revenue accounting. The selection of cost and revenue accounting results from the belief that the generation of more and better business information has no meaning unless it is accompanied by a potential for improved profits.

Marketing's Basic Uniqueness

The guiding hypothesis of this research is that a basic uniqueness of the marketing function relates to the problem of overcoming spatial influences[6] in both the demand-creating

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[5] Because of the length of the term "integrated internal marketing information subsystem," it will be referred to as the System.

[6] The basis of this hypothesis is discussed in the section "Some Contributions of the Research" on page 17.

and order-servicing activities. As a result the majority of marketing costs vary geographically. The geographic variability of marketing costs is of two sorts. First are the marketing costs which vary in some relationship with the amount of space involved in performing certain marketing activities. Transportation and the salesman's travel expense per contact illustrate such costs. The second type of variability arises from the particular level of costs associated with operating in a specific area. Local and state tax levels, wage rates, and land values represent costs which vary based on the specific area under consideration. Therefore, a marketing information system must report the spatial dimension of all activities as a primary factor for analysis and decision making.

Present Accounting Methods Ignore Marketing's Uniqueness

Historically, accounting has provided two major information sources: the profit and loss statement and the balance sheet. The profit and loss statement is gathered internally to reflect the firm's operating results in the aggregate. Balance sheets reflect the firm's capital position and are also reported in aggregate terms. The traditional design of the profit and loss statement provides more attention to accounting controls for production processes than for marketing. The importance given production causes the system to focus attention on internal activities recorded by natural accounts (accounts recording what the expenditure secured--labor, materials, etc.). For this reason the geographic nature of costs and revenues is not revealed, except where a business operates multiple plants. For lack of any more precise delineation the marketing function has constructed sales territories on the basis of political or civil areas. After establishment of the territories, appropriate costs and revenues from the profit and loss statement were allocated to each territory to determine its profitability. Thus, internally derived data were used inappropriately to judge the performance of an external activity. A fundamental basis of marketing was ignored: marketing focuses its attention and activities outside the firm's centralized activities. The overwhelming majority of marketing costs and all its revenues and profits are generated outside the firm's centralized operations in specific geographic locations and markets. The suggested System's application first focuses its attention on the geographic variability of costs, revenue, and profits, establishing sales territories on this basis, and then proceeds to aggregate these figures into the historic profit and loss statement.

The primary problem in designing the system involved the selection of the geographic control units used to gather and analyze the marketing data. The criteria used includes the following:[7]

a) It should be as small as possible, yet practical.

b) It should be as geographically homogeneous as possible.

c) It should be mutually exclusive--no overlap among units.

d) It should be stable through time and not require changes.

Viewing all units as a system, they should:

a) be flexible--able to be agglomerate to describe changing situations

b) be geographically continuous and collectively cover all present and future markets.

General Hypotheses

The geographic dimension of the marketing information system and its subsequent impact on marketing analysis incorporate the subject matter for the hypotheses tested.

The general hypotheses are:

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[7] A complete discussion of geographic control units is found in Chapter II.

A. A geographically integrated internal marketing information system based on small homogeneous control units provides superior ability to reliably identify and define sales and distribution territories when compared to the current methods of using political or civil units for analysis.

B. Distribution cost and revenue accounting employing the System affords profit maximization potential superior to the commonly used present methods of cost and revenue analysis.

The variable of spatial location of marketing activities is regarded as the independent variable with the definition of sales and distribution territories and cost and revenue accounting considered as dependent variables. The structure of the research is expected to allow the hypotheses to be accepted or rejected on the basis of the relationship between the dependent and independent variables.

Method Of Investigation[8]

The initial step in the research requires the investigation and development of a methodology which permits the integration, gathering, and analysis of internal marketing

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[8] A complete outline of methodology can be found in Chapter IV, "Research Design."

data on a rational geographic basis. The investigation involves a search of the academic and trade literature on information systems and results in the construction of the proposed System. After developing the methodology, the research is devoted to an empirical testing of the System and the hypotheses. The empirical test will consist of applying the System to the analysis of one year's marketing data of an actual corporation.

The company studied manufactures industrial goods and distributes them nationally. It operates four plants and eight distribution points. The product line consists of over two hundred products produced for stock, plus many products produced from specifications. These are marketed to a variety of industries and state and federal government agencies.

The application of the System to marketing data encompasses all of the sales and distribution patterns in eighteen states. Although the company has not defined sales or distribution territories, these states represent what are considered as two distribution regions which contain almost half of its customers.

The empirical study begins by using the System to identify the spatial dimension of all products' gross sales and of total weights shipped. The results serve as input data for determining sales territories in terms of total product sales and distribution territories in terms of total weights shipped. A by-product of this analysis is the simultaneous identification of the spatial dimension of gross revenue realized from the sale of the entire product line.

Next, selected products are used to contrast specific products' sales and distribution territories with those identified by aggregate totals. Here again the analysis automatically provides concurrent data on the spatial dimension of gross revenue acquired from the sales of the specific products.

The geographic cost analysis includes the study of transportation costs, warehousing costs, handling costs, order processing costs, and an imputed interest cost on pipeline inventory (i.e., an interest charged against goods during the time they are in transit).[9] These costs are for the specific products used in the previous analysis.

It is recognized that the proposed System has a broad

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[9] While an imputed interest cost on pipeline inventory is justified for shipments to distribution points, it would not be correct for shipments to customers if the terms of sale were f.o.b. In this case title to the goods passes once the vendor delivers the goods to a carrier for delivery to the vendee. In the research it was assumed that terms of sale were other than f.o.b. and title passed when the vendee received the goods.

impact on many marketing activities. All of these are important and several will be mentioned; however, time limitations made it impractical to attempt to study the full effects of the System in each of the decision making areas of marketing. Therefore, the study is limited to the areas outlined.

Terms And Definitions

Information System: An information system refers to a coordinated body of methods which results in an ordered and comprehensive assemblage of and access to data.

Information Subsystem: The term information subsystem relates to the methods used for the assemblage of data of the same or similar nature, concerned with the same function or activity.

Internal Information: Internal information includes data gathered within the corporation from records and studies maintained on a continuing basis.

Integrated Information System: An integrated information system refers to the methods used to combine all information subsystems into one complete system which views the process as a whole. A corporate integrated system views the business process as a single unit and generally requires central control.

Spatial Dimension: The term spatial dimension is used in the research to consider the geographic location of activities or distances involved in order to determine the impact of space on activities and their costs.

Temporal Dimension: Temporal dimension refers to the point in time an activity occurs and/or the length of time required for its accomplishment.

Sales Territory: A sales territory consists of a market or group of homogeneous markets able to be determined by a unique set of homogeneous characteristics contained within an identifiable area.[10]

Distribution Point: A distribution point describes a location where emphasis is placed upon product flow for breaking bulk and customizing outbound orders by regrouping several different products into one shipment.[11]

Distribution Territory: A distribution territory

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[10] The criteria for determining a sales territory depend upon the company policy. For example, if structuring the sales force is the primary factor and the sales force is structured by product lines, then the product mix is appropriate; if by type of end use, then customer mix is appropriate; if by some index of total potential, both may be used.

[11] Basically this definition parallels the definition for a distribution warehouse used by Edward W. Smykay, Donald J. Bowersox and Frank H. Mossman in Physical Distribution Management (New York: The Macmillan Co., 1961), p. 202.

refers to a definable area based on analysis of the physical flow of products in terms of optimizing the transportation, warehousing, handling, order processing costs, and interest cost on pipeline inventory together with the time required for product movements. Therefore, the boundary lines between any two distribution territories occur where identical costs are incurred regardless which distribution point is used.

Marketing Cost: Marketing costs refer to those costs incurred to obtain and service demand for the company's goods and services.

Limitations

The limitations of the research are as follows:

1. The integrated internal marketing information system (System) is designed primarily for a business with customers dispersed over a wide geographic area. It would be of lesser value to a business with highly concentrated customers in a very small geographic market.

2. The System is highly computer oriented, although it is possible to use the System without computers. However, to do so would not be economically feasible unless there were a small number of customers involved.

3. The underlying assumption used in constructing the

cost and revenue hypothesis was that the goals of a business are to maximize profit while minimizing costs. To the extent that some firms may use maximization of gross sales (market share) and be satisfied with profits at a given level, the assumptions may be erroneous.[12] However, even with the goal of maximizing gross sales, it would seem unlikely that a firm would be disinterested in minimizing costs, provided gross sales were not affected.

4. The research is limited to the application of the System to a single firm in the industrial goods field. It can provide insight on the impact of the System in the areas analyzed, but implications for other firms or other industries must still be verified.

5. The study of the System's impact is limited to the areas outlined; therefore, the full worth of the System has not been appraised.

Some Possible Contributions Of The Study

In his article "A Theoretical Approach to Marketing," Professor E. T. Grether states his beliefs concerning the direction marketing theory should take. He sees three basic needs. The first is a more productive approach and better

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[12] The possibility of these goals is pointed out by William J. Baumol in Business Behavior Value and Growth (New York: The Macmillan Co., 1959).

analytical tools of analysis. Second is to seek a conceptual framework that will assist us in asking the right questions and in fitting facts into an orderly pattern with enlarged and significant meaning. The third need is for various types of "applied theory," dynamic in nature and willing to sacrifice the perfection of the craftsmanship of static analysis for the vitality of a strong empirical footing.[13]

When considering the approach to the study of marketing, he states,

> The behavior of the firm should be investigated not only in a price and marketing sense, but, under the conditions of its physical and social environment, in its determination of its location, its spatial outreach in selling and buying, and its relationship in the marketing channel with suppliers on the one hand and buyers on the other.[14]

Two years later he again considered the subject of space implications in marketing as a co-author with Roland S. Vail and Reavis Cox, resulting in the following statements:[15]

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[13] E. T. Grether, "A Theoretical Approach to the Analysis of Marketing," Theory In Marketing, Reavis Cox and Wroe Alderson, Ed. (Homewood, Ill.: Richard D. Irwin, 1950), p. 114.

[14] Ibid., p. 117.

[15] Roland S. Vail, E. T. Grether and Reavis Cox, Marketing In The American Economy (New York: The Ronald Press Company, 1952), p. 487.

> We have made many references to problems that arise out of marketing goods at a distance. For example, in Part I we said that transporting goods through space is one of the basic activities of marketing. In Part II we pointed out that the difficulty of managing the activities of marketing at a distance is an important limitation upon widening the geographic span of an ownership. In Part IV we saw that space is always considered in establishing or defining price structures and makes itself felt throughout the broad system of price.
>
> Space like time, is omnipresent. Its impact upon buyers and sellers and commodities is not uniform, however, for the amount occupied by a firm or by a process varies enormously.
>
> Space provides opportunities for production, marketing, or other activities at various sites and locations. It also erects obstacles in the form of costs of movement that must be borne by buyers and sellers.
>
> In our enterprise economy, space makes its contribution to or lays its restraining hands upon particular firms, specific goods and services, and individual buyers and sellers.

These statements led the authors to the following conclusion: "Ultimately, therefore, the influence of space can be understood only by looking at its effects upon the production and marketing of particular products or classes of products by particular enterprises or classes of enterprises."[16]

In "The Theory of the Firm and Marketing" Professor George L. Mehren discusses the role and direction of marketing theory and its relationship to economic theory. In his discussion the implications of the spatial impact on

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[16] Ibid.

marketing theory can be seen from the following quotations:

> The single market of the textbook--spaceless and timeless--where both costs and profits are taken to be functions of firm output alone is not a useful theoretical tool except where these two dimensional functions are adducted by elimination from a general solution all other factors affecting cost and profit.[17]
>
> Profit-affecting functions differ widely with the commodity, the competitive context, and the spatial, temporal or other attributes of the market.[18]
>
> The space, time, or other attributes that may separate markets . . . must all be introduced into theory for effective analysis of firm marketing.[19]
>
> The theory of firm profit policy in multiple markets separated by space, time, or other attributes, and with control over profit determinants vary with structure of competition, indicates what the firm must know and do if the most desirable of available locations is to be chosen.[20]

These quotations emphasize the position the authors give to the spatial dimension of marketing activities. E. T. Grether in his attempt to develop a theoretical approach to the analysis of marketing has perhaps emphasized spatial considerations more than any other author. Grether's goal was to develop an applied theory of marketing. He held that marketing science should be: eclectic-interdisciplinary, dynamic rather than static, and contribute a conceptual

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[17] George L. Mehren, "The Theory of the Firm and Marketing," Theory In Marketing, Reavis Cox and Wroe Alderson, Ed. (Homewood, Ill.: Richard D. Irwin, 1950), p. 128.

[18] Ibid., p. 129.

[19] Ibid., p. 130.

[20] Ibid., p. 134.

framework which would organize the facts available. He attempted to uncover the factors which determine the geographic size of market areas for wholesalers, manufacturers, and retailers which he termed intraregional trade. He also studies interregional trade by viewing the social effects of exchange of goods between regions.[21]

Professor George Schwartz in his book Development of Marketing Theory evaluates Grether's approach to analyzing markets and states what he considers the weaknesses, some of which follow:

> Since Grether does not substantiate the theory with data, the extent to which it is pure or applied cannot be stated.[22]
>
> Grether's theory of market area determination can be termed a qualitative presentation of many factors which play a role in the determination of market areas. Certain of these factors tend to enlarge market areas; whereas others operate to diminish the size of a market area. Which factors are more important than others, however, are not stated by the theory; and the theory could not be used to predict the boundaries of any particular market area.[23]
>
> Grether's theory of market area determination, while enlightening, needs to be developed further with the objective of making it less qualitative.[24]

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[21] Grether, "A Theoretical Approach to the Analysis of Marketing."

[22] George Schwartz, Development of Marketing Theory (Cincinnati; South-Western Publishing Co., 1963), p. 83.

[23] Ibid., p. 84

[24] Ibid.

From the preceding quotations it is reasoned that Schwartz's main criticism of Grether's approach is not aimed at his conceptual framework but is directed at his failure to provide an operational system which can be used to empirically test and quantify his conceptual framework.

It is hoped that the System developed and tested in this study will be viewed as a step toward providing the necessary system to convert Grether's conceptual analysis into an operational framework for the gathering and analyzing of marketing data.

The System is developed not only to complement Grether's conceptual framework, but also to serve as a practical tool aiding marketing decision making. Therefore, the introduction of a practical methodology for improving the decision making ability in marketing is intended to be a second contribution of this study. This could be a pilot study for business firms to duplicate and expand to fit their own particular products and markets.

Order Of Presentation

The first chapter is an introduction to the study. Chapter II, "Marketing Information Systems: Strategy and Theory," begins by considering the nature of information systems in general, special types of systems, and the nature of an integrated marketing information system. In Chapter III the present state of the art of distribution cost analysis is considered. Chapter IV contains the research design developed in detail. The findings are reported in Chapter V, with the summary, conclusions, and implications given in Chapter VI.

CHAPTER II

MARKETING INFORMATION SYSTEMS:
STRATEGY AND THEORY

The Nature Of Information Systems

Before proceeding with the design of a marketing information system, attention should be focused on the meaning of information, the nature of information systems in general, and other basic considerations. The dictionary defines information as "the act of informing, state of being informed, something told, communicated or acquired, imparted knowledge of a fact."[1] In this research the term refers to communicated facts. The term information system, as defined earlier, means a coordinated body of methods which provides an ordered and comprehensive assemblage of and access to data. Therefore, an information system requires the organization of information on some meaningful basis. When correctly designed, information systems lead to knowledge[2]--an organized body of information.

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[1] The Little and Ives Webster Dictionary, International Edition (New York: J. J. Little and Ives Company Inc., 1962), p. 684.

[2] Ibid., p. 733.

The essential objective of any information system is to provide the clearest and most meaningful information consistent with its cost and the functions it serves. By its nature, an information system is a means to single or multiple ends and not an end in itself. Thus, the ultimate uses for the information should determine the system's design. Accordingly, the design of an information system should commence only when the ends it serves are fully recognized.

In private enterprise, corporate goals consist of facilitating and ultimate objectives. Facilitating objectives refer to short range goals which serve as the basis for attaining ultimate objectives. The elimination of unprofitable customers and products, the continuous development of new products and differentiation of old products, and the constant balancing of cost and service levels of physical distribution activities illustrate facilitating objectives in the marketing area of a firm. However, whether facilitating objectives are in the marketing, accounting, finance, or manufacturing areas, they should be compatible with and enhance the ultimate objectives of the business as a whole.

There is no common agreement concerning what constitutes ultimate objectives. Generally economists consider profit maximization as the ultimate objective of the firm.

Wroe Alderson lists the following as long range objectives of a company: growth, greater profits, finding investment dollars and development of personnel.[3] Robert F. Lanzillotti reported a complete range of "pricing objectives" he uncovered in a study of large companies. These ranged from maintenance or increase of market share to a specific desired rate of return on investment or sales.[4] E. Jerome McCarthy sees a "target return" as probably the most common pricing objective. The "target" is a certain percentage return on sales or investment or a fixed dollar amount.[5]

Whatever the ultimate objectives may be, the important relationship is that facilitating objectives, serving as means for achieving ultimate objectives, possess extrinsic-instrumental value (i.e., value derived from the ultimate objectives they aid in attaining). Ultimate objectives possess intrinsic value (i.e., they are valued in and of

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[3] Wroe Alderson, Marketing Behavior and Executive Action (Homewood, Ill.: Richard D. Irwin, Inc., 1957), p. 382.

[4] Robert F. Lanzillotti, "Pricing Objectives in Large Companies," American Economic Review, December, 1958, pp. 921-940.

[5] E. Jerome McCarthy, Basic Marketing: A Managerial Approach (Homewood, Ill.: Richard D. Irwin, 1960), p. 615.

themselves).[6] Consequently, an information system constitutes a means used to accomplish facilitating objectives in the pursuit of ultimate objectives and, therefore, acquires derived value from both types of objectives it serves.

A continuing problem facing management involves balancing the value of information with its costs. Information, like labor, equipment, and other items, is an input factor to a firm. The economic equilibrium solution to the problem requires that the firm utilize all input factors to the point where the ratio of the marginal factor cost of each input to its marginal revenue product is equal for all factors. Equilibrium results from the fact that this solution maximizes total output for all factors; any decision to use less of one factor and more of another results in a lower total output. The equilibrium analysis directs attention to the firm's economic reason for not pursuing a state of perfect knowledge. Perfect knowledge describes a position where the marginal value product (marginal utility) of the next unit of information equals zero. Therefore, a firm would not demand perfect information unless it were free.

Adrian McDonough, director of the Taylor Management

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[6] The ideas on extrinsic (instrumental) and intrinsic (final) value are taken from "Economics and Ethics: An Essay on Value," by Professor John F. A. Taylor, an unpublished paper delivered before a graduate marketing class at Michigan State University, January 14, 1963.

Laboratory at the Wharton School of Finance, described the importance of information costs to the economy as "half the cost of running the economy."[7] The individual firm's costs of gathering, storing, manipulating, and organizing information have been estimated as equal to or exceeding direct factory labor costs.[8] Whether viewed in macro terms to the economy or micro terms to the firm, the cost of information represents an imposing expense deserving careful consideration.

To balance the value and cost of an information system is to balance the value and costs of providing a control system for attaining objectives. "The 'lifeblood' of automatic control is information. To receive and act on information is the essential function of every control system . . ."[9] Therefore, the cost of an information system (means) is incurred to help provide a control system for attaining specific goals (ends), while its value is derived from the ends served. It is the basis for and results of all management decisions.

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[7] Richard F. Neuschel, Management by Systems (2d ed.; New York: McGraw-Hill Book Co., Inc., 1960), p. 204.

[8] Marshall K. Evans and Lou R. Hague, "Master Plan for Information Systems," Harvard Business Review, January, 1962, p. 92.

[9] Gilbert King, "What Is Information," Scientific American, CLXXXVII, No. 3 (September, 1952), pp. 83-96.

The Nature Of A Marketing Information System

A marketing information system, constituting a primary function subsystem to a general corporate system, possesses all the characteristics and attributes of a general information system discussed above. Beyond these lie special requirements of a marketing information system imposed by the unique characteristics of the marketing function.

The management of the production and financial functions represents the attempt to control basically geographically concentrated, centralized activities and costs. The fundamental uniqueness of the marketing function, as mentioned in Chapter I, stems from the decentralized, geographic dispersion of its primary activities, costs, and revenues. Therefore, marketing management must focus a substantial portion of its attention outside the centralized activities of the firm.

Management's ability to identify and act on geographic differences in demand caused by seasonal, social, economic, and other variations can spell the difference between marketing success and failure. However, quantifying market demand characteristics is not sufficient. The differences in demand by area must be weighed against the differences in costs of serving each area. Thus, marketing management must qualify markets by profitability as well as quantify their demand characteristics. Therefore, an efficient marketing information system must provide the record keeping necessary for management to analyze, plan, and control a decentralized geographically dispersed corporate function. Recognition of this uniqueness is the first step in designing a marketing information system.

The second step concerns answering two questions suggested by Richard F. Neuschel: "What are the basic elements of performance to be controlled?" and "What is the best indicator of overall marketing performance?"[10] The suggested answers to Neuschel's questions are illustrated in Figure 2.

The diagram shows the suggested basic indicator of marketing performance is the contribution marketing makes to corporate overhead and profit. This contribution is determined by the gross revenue from sales less the distribution, selling, and general marketing expenses incurred in attaining the gross sales level. Selling price and sales volume determine the level of gross revenue. Distribution expenses are composed of inventory, transportation, and order handling and processing costs. Sales expenses consist of personal selling, advertising, and sales promotion

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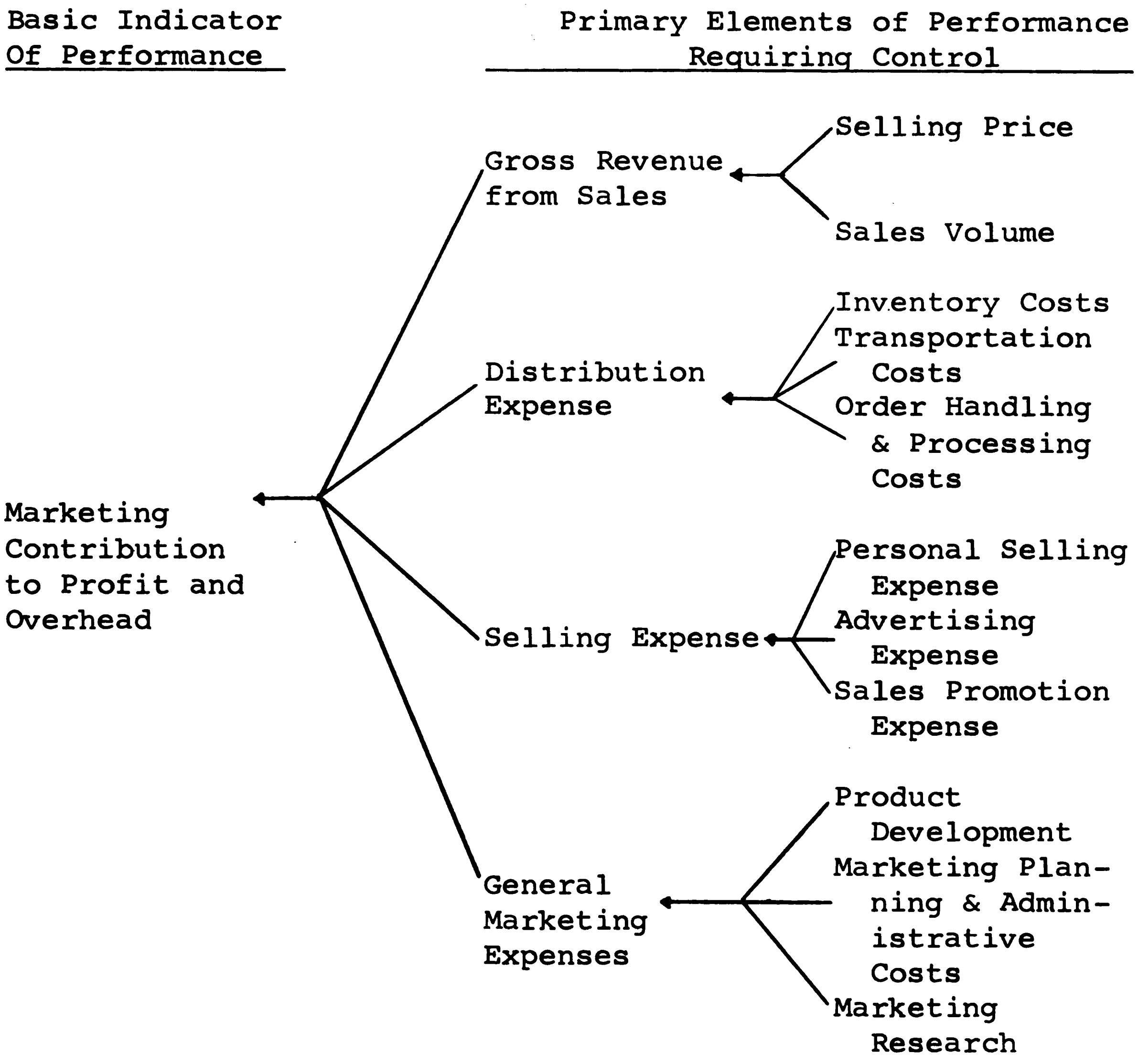
[10] Neuschel, p. 213.

FIGURE 2

FUNDAMENTAL FACTORS GOVERNING MARKETING PERFORMANCE



expenditures. General marketing expenses include marketing research and planning and administrative costs. Other general costs assigned to marketing vary with company organization and philosophy, but can include costs of new product development, package design, and certain costs of product differentiation.

Three factors cause the variations in each of the primary elements of marketing performance: the customer, product, and geographic area involved in each sale. Hence, an integrated marketing information system, needed for control of the primary elements, must account for all three of these variations.

The Geographic Control Unit

As discussed briefly in Chapter I, the geographic control unit refers to the unit used for gathering and analyzing marketing data. Its selection requires extreme care since the reporting and combining of all subsequent data depend upon the initial unit used. Richard D. Crisp describes a control unit as paralleling the sorting rack in front of a mail clerk. "Breaking down your sales into control-units is very much like sorting a pile of letters. You get your control unit totals by adding up the number of letters in each little division of the rack."[11] The analogy illustrates the point that the control unit initially serves to break down the data and subsequently serves to build up additional units for analysis.

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[11] Richard D. Crisp, How To Reduce Distribution Costs (New York: Funk and Wagnalls Company, 1948), p. 45.

Theoretically geographic control units should possess certain ideal criteria. Practically, the choice among units requires reaching an optimum balance among the ideal attributes. The framework for evaluating an information system control unit stems from the objective of the system--control via record keeping, analysis, and planning. In Chapter I the attributes of an ideal control unit were briefly listed; here they are restated and discussed in detail as follows:

1. It should be as small as possible, yet practical.[12] The importance of the size of the geographic control unit relates to its ability to uncover geographic differences in the data rather than masking the differences by considering a larger area containing wide variations in the data. For example, consider the following results from analyzing average population per square mile by state, county, and city geographic units. Ohio has 236.9 people per square mile. Marion County, Ohio, has 149 people per square mile, while the city of Marion has 6,079 persons per square mile.[13]

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[12] This requirement, together with "It should be self-contained," was listed by Richard Crisp. He considered the two as the most important characteristics of a control unit. He considered a unit to be self-contained if sales and costs could be charged to the unit to which they really belonged. Ibid., p. 27.

[13] County and City Data Book 1962 (Washington, D. C.: U. S. Bureau of the Census, 1962), pp. 2, 282, and 546.

These differences illustrate the ability of smaller units to uncover geographic differences in data which the use of aggregate measures based on larger areas tends to mask. Therefore, the smaller the geographic control unit, the greater the ability to identify geographic variation in sales, costs, revenue, and other data, and the greater the ability to analyze such differences and control operations accordingly.

Historically the disadvantages of smaller control units arose from the time and costs incurred in gathering, merging, sorting, storing, and analyzing the data. The introduction of high speed, large capacity computers to data processing now permits smaller, economically feasible control units.

2. It should be as geographically homogeneous as possible. The importance of homogeneity of the units arises from the desire to have a relatively standardized unit of area and configuration for comparing and contrasting the data. The use of standard metropolitan statistical areas portrays the application of basically heterogeneous geographic units. For example, contrasting the San Bernardino-Riverside-Onterio SMSA to the los Angeles-Long Beach SMSA produces the following results.

Characteristic	San Bernardino-R-O	Los Angeles-Long Beach
Land Area	27,308 sq. miles	4,842 sq. miles
Population	30 per sq. mile	1,392 per sq. mi.
Urban Residents	71.8%	98.5%
Rural Farm Residents	2.1%	.1%
Median Income	$5,890	$7,066

Source: U. S. Department of Commerce, Bureau of the Census, <u>County City Data Book 1962</u>

These two SMSA's appear to have only two basic characteristics in common. First, they both are defined as SMSA's and second, they both are located in the state of California. These characteristics by themselves provide a poor standardized unit for measurement and comparison of data on a geographic basis. Ideally the geographic control unit should be a small constant size. This would permit the measurement and comparison of the geographic variability of data in terms of units having a common area.

3. It should be mutually exclusive. A geographic control unit is mutually exclusive when its area is unique unto itself and does not contain area in common with another unit. Mutually exclusive units proclude the possibility of the double consideration of data in overlapping areas and multiple geographic record keeping.

4. It should be stable through time and not require changes. The objections to change result from the costs of

changing an integrated information system once it is programmed and operational, and from the problems created when attempting to compare historical data collected on old units with current data collected on different units. The control unit should possess the ability to reflect geographic changes without having to change itself.

Viewing all the control units as a system, they should:

1. be flexible. Control units possess flexibility when they are easily combined in different ways to describe changing geographic situations. If a city annexed a suburb and small control units (which were already in existence) could be added to the original units used to delineate the city, then the system would possess flexibility to meet change.

2. be geographically continuous and collectively cover all present and future markets. A unit of control which does not cover all present markets requires the use of different units for all other markets (i.e., using city units while some sales are in rural areas). This results in a lack of homogeneity between the units used. The facility to cover future markets provides flexibility by making it unnecessary to change the control unit with future changes in the geographic patterns of business. Continuous units collectively exhaust all the geographic areas of present

markets as well as all future areas.

Some Existing Geographic Control Units

In general the potential geographic control units are divisible into four broad classifications: geographic-political units, geographic-economic units, geographic-social units, and purely geographic units.

Geographic-Political Units

Potential geographic-political units include states, counties, townships, and cities. Evaluation of these units by the criteria for an ideal geographic unit results in the following.

States and counties exceed the ideal size, for they contain too large an area and, as seen earlier, tend to blur geographic variability.

The most serious disadvantage of political-geographic units is the lack of geographic homogeneity of the units. The geographic homogeneity of the units is strongly affected by the units defining unique political areas, for these do not necessarily aggregate into unique sales or distribution areas without incurring a large margin of error. An implicit assumption in applying these units is that a fundamental relationship exists between political areas and sales and distribution territories. Although such a relationship may exist for certain products, the only relationship which is apparent for all products involves the variations in tax levels among political units. Beyond the study of tax effects on sales and distribution territories, little is gained from using political-geographic units.

Although these units are politically homogeneous, their geographic areas vary greatly as shown in Table 1.

TABLE 1

A GEOGRAPHIC AREA COMPARISON FOR SELECTED POLITICAL-GEOGRAPHIC UNITS

Unit	Area Within
States	
Texas	262,840 sq. miles
Rhode Island	1,058 sq. miles
Counties	
Brewster, Texas	6,208 sq. miles
Rockwall, Texas	147 sq. miles
Cities	
Houston, Texas	328.1 sq. miles
Kingsville, Texas	5.3 sq. miles
Townships	
Union, Ohio	66.1 sq. miles
Warrensville, Ohio	2.9 sq. miles

Source: (For states, counties, and cities)
<u>County City Data Book 1962</u>
(For townships) <u>Areas of the United States 1940</u>
U.S. Dept. of Commerce, Bureau of the Census

This makes them a poor standard unit for measurement and comparison.

These units do meet the mutually exclusive criteria so long as there is no attempt to combine the use of two or more different units in the same system (i.e., using a combination of cities, counties, and townships).

States possess stability; however, counties, cities, and townships are subject to change. "Between 1950 and 1960, the number of counties declined by three . . . . During the same period, county equivalents in conterminous United States increased by five . . . ."[14] Cities are subject to change by annexation and by new municipalities arising. Townships are subject to complete absorption by other townships as well as redefinition of their areas.

Political-geographic units possess poor ratings on their characteristics when viewed as a system. Basically they are neither flexible nor continuous. States and counties provide very poor flexibility primarily because their relatively large size makes it difficult to easily combine them to describe changing geographic situations, unless the change takes place over a very broad geographic area. Townships normally contain smaller areas and consequently possess greater flexibility.

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[14] Ibid., p. XIII.

With the exception of states, none of the political-geographic units are geographically continuous and collectively exhaust all present and future market areas. Connecticut abandoned its counties, and Alaska has never been divided into counties--using instead election districts and places of 25,000 or more population. Louisiana uses the designation of parish rather than county; however, the rationale behind the two units are the same.

Townships are not continuous, since only twenty-two states use this division and most all states using it exclude all or parts of populated areas from township designations.[15] Cities, as illustrated earlier, lack the facility to define continuous geographic areas.

Economic-Geographic Units

Economic-geographic units consist of state economic areas combined with standard metropolitan statistical areas, and trading areas. State economic areas are the product of a special study sponsored by the Bureau of the Census, Bureau of Agricultural Economics, and several state and private agencies for the 1950 census. These areas consist

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[15] The term township as used here includes governmental units legally termed "towns" in New York, Wisconsin, and the New England states. U.S., Bureau of the Census, U.S. Census of Governments: 1957, III, No. 3; Finances of Municipalities and Township Governments (Washington: U.S. Government Printing Office, 1959), p. 1.

of a single county or group of counties which have similar economic and social characteristics. The boundaries were drawn so that each state was subdivided into relatively few parts. The combination of counties into State economic areas covered the entire country. Where standard metropolitan statistical areas had been recognized, these were used as separate units and designated as metropolitan State economic areas.[16] The State economic areas were designed for use in tabulating and publishing census data of various types.[17]

State economic areas, including SMSA's, meet the criteria of being mutually exclusive and geographically continuous, covering all present and future markets. Their disadvantages arise from their inability to meet the other criteria. As shown earlier, counties and SMSA's are large areas of varying geographic size. Thus, State economic

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[16] The definition of a Standard Metropolitan Statistical Area (SMSA) involves two considerations: first, a city or cities of specified population to constitute the central city and to identify the county in which it is located as the central county; and second, economic and social relationships with contiguous counties so that the periphery of the specific metropolitan area may be determined. For a detailed treatment of the procedure, see: Bureau of the Budget, Standard Metropolitan Statistical Areas (Washington: 1961).

[17] For complete materials on State economic areas, see Bureau of the Census, State Economic Areas (Washington: U.S. Government Printing Office, 1957).

areas composed of single or multiple counties and SMSA's possess the same disadvantages of size and geographic homogeneity, and the aggregation of counties further magnifies the disadvantages of size.

Stability is affected by the changes in definitions of SMSA's which occur during a new census. These changes result in certain areas being added to or deleted from SMSA's which were originally in nonmetropolitan State economic areas. This results in changing the area of the SMSA as well as the surrounding State economic areas which lose to the SMSA.

Flexibility is affected because the government, rather than the firm, controls the patterns of agglomeration, and the size of the units requires that major area changes must occur before a shift can be made in area definitions.

The American Marketing Association defines a trading area as:

> A district whose size is usually determined by the boundaries within which it is economical in terms of volume and costs for a marketing unit or group to sell and/or deliver a good or service.[18]

This definition identifies a trading area by economic considerations as viewed by a specific marketing unit (firm).

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[18] Marketing Definitions: A Glossary of Marketing Terms (Chicago: The American Marketing Association, 1960), p. 22.

The problem inherent in this approach stems from the boundaries requiring economic identification in terms of sales volume and costs unique to a specific firm and its products. Herein lies the dilemma. How is the firm to gather the data to determine the boundaries without predetermining the boundaries in the act of collecting the data? In other words, the selection of the control unit has a direct effect on the subsequent ability to delineate the economic boundaries which determine the firm's trading areas. Consequently, trading areas as defined by the AMA become units of control _after_ sales volume and costs of various areas have been gathered and analyzed. They cannot serve as control units for information gathering, since they result from the analysis of information after it is gathered.

"A trading area consists of a city whose trade flows to that given retail or wholesale center"[19] is a second definition. Here a trading area is defined in terms of an area within which customers habitually direct the major share of their purchases toward a dominant center. Several studies by private and government agencies have attempted to determine trading area patterns of various types. _Trading_

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[19] Paul H. Nystrom (ed.), _Marketing_ _Handbook_ (New York: The Ronald Press Company, 1958), p. 828.

Area Systems of Sales Control, published by Hearst Magazines Inc., uses thirty-three factors grouped under Physical Characteristics, People and Homes, Transportation, Communication, Distribution Machinery, Valuation of Products and Sources of Personal Income, Volume of Business and Wealth and Standards of Living to develop 626 consumer trading areas. It is claimed that these "principal trading centers" yield 70% of all retail sales in the United States. Similar studies are available for the wholesale trade and for specialized industries.[20]

The use of trading areas has been recommended on the basis that their boundaries are derived from economic considerations and they possess a certain amount of economic homogeneity, plus the advantage gained in reducing the number of data gathering areas. Although this is true, two dangers exist in using trading areas determined by outside private and governmental agencies. First is the implicit assumption that the trading areas derived from an industry's sales or, if these are not available, from all retail or

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[20] Some other trade area studies available are: 184 Wholesale Grocery Trading Areas, Marketing Research Series No. 19 (Washington: U.S. Department of Commerce, 1927 and 1938); 46 Dry Goods Trading Areas, Economic Series No. 12 (Washington: U.S. Department of Commerce, 1941); Market Areas for Shopping Lines (Research Department, Curtis Publishing Company, 1947).

wholesale sales, reflect the trading areas of a specific company and its particular product lines. Second, if costs were considered in establishing these trading areas, it must be assumed that the typical costs of the industry or of typical retail or wholesale sales represent those of the particular firm using these trading areas as its own. If costs were not considered by the outside agencies, then the firm must still establish the costs of serving these areas to determine which reported areas are economically feasible to serve.

With today's high speed computers, a reduction of the number of data gathering points may not be an asset unless reasonable accuracy is also maintained.

The use of trading areas for information control units results in geographic units larger than city units, since a trading area is always a city plus surrounding areas. The lack of geographic homogeneity would not be serious *if* the trading area truly reflected a specific company's actual trading area. Normally these units are mutually exclusive areas, but they are not necessarily stable. Shopping patterns, geographic costs, location of businesses, and population masses and characteristics all tend to change, causing the configuration of trading areas to change. When change occurs, the firm must rely on the areas being updated by an outside agency.

The flexibility of trading areas as a system of control units can be fairly good. However, a potential danger arises from the possibility that trading areas for total retail or wholesale sales might remain stable while the trading areas for specific products of a given firm are changing, and the possible reverse of this situation.

Trading areas are not geographically continuous and, therefore, do not inherently cover all present and future markets.

Social-Geographic Units

The census tracts used by the Bureau of the Census represent unique social-geographic areas. Census tracts are small areas into which large cities and their adjacent areas are divided for reporting purposes. The tract boundaries are designed to achieve some uniformity of population characteristics, economic status, and living conditions. Initially the tract boundaries contained about 4,000 residents, with the intention of holding them constant to permit comparison from census to census. The 1960 housing and population data were published for 180 areas. Of the

180 areas, all but two were SMSA's.[21]

For a corporate information control unit, census tracts consist of very small units with geographically heterogeneous areas. They are mutually exclusive and relatively stable. As a system of control units, they are basically flexible and geographically continuous. The major disadvantage occurs from their limited use in only 178 of the 216 SMSA's and only two areas outside SMSA's.

Pure Geographic Units

Pure geographic units refer to control units which define a geographic area on the basis of its specific location or area it contains without political, social, economic, or other considerations. The purely geographic units comprise latitude-longitude, PICADAD, and various grid systems.

Latitude-Longitude

The division of the earth's surface by degrees, minutes, and seconds of the latitude-longitude lines provides an almost infinite set of points for location over the entire world. Identification of a given point is purely on the basis of its position on the earth's surface. As a control

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[21] Census Tract Manual, Fourth Edition (Washington: U.S. Department of Commerce, Bureau of the Census, 1958), various pages.

unit, latitude-longitude provides extremely small units--points in space. In fact, latitude-longitude provides such a small unit that it is disadvantageous because its capability is limited to identifying unique points in space, but not unique areas. The impracticality of the small unit and the inability to easily agglomerate units to describe a particular area constitute the main disadvantages. A latitude-longitude unit possesses the criteria of geographically homogeneous, mutually exclusive, stable, and, as a system, geographically continuous.

PICADAD

The Bureau of Census developed the PICADAD information system for sampling bills of lading. The information is then coded in terms of PI (place identification), CA (characteristics of area), and DAD (machine procedure for computing distance and direction).[22]

The place identification consists of a five-digit number which identifies the city or town and state of origin and destination of each shipment. A four-digit number represents the area characteristics, with one number for the

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[22] Donald E. Church, PICADAD--A System for Machine Processing of Geographic and Distance Factors in Transportation and Marketing Data (Washington: U.S. Department of Commerce, Bureau of the Census, June 6, 1961).

census division and another for the state within the division. The third number shows whether it is or is not in a standard metropolitan statistical area, while the last digit indicates the population size class of the specific place. This provides a basis for matching data from bills of lading with data from the Census Bureau's *County City Data Book*.

The use of a latitude-longitude coordinate system provides for computation of distance and direction. The coordinates pinpoint the place in terms of an arithmetic mileage grid. The first four digits show the location of the place in terms of miles north of a baseline that lies south of Texas. The last four digits are the number of miles west of a designated eastern baseline.

PICADAD provides two methods of delineating an area. It can delineate an area by using the political areas associated with the location of the point or it can identify the area by determining the northern, eastern, western, and southernmost points and consider the area contained within these limits.

The application of the first method results in the same advantages and disadvantages of using political-geographic control units. The second method results in defining an area on the basis of its extremes and can result in a large margin of error depending upon the configuration of the area described. In general, the closer the area's configuration to a rectangle or square, the less the error. Figure 3 illustrates this method.

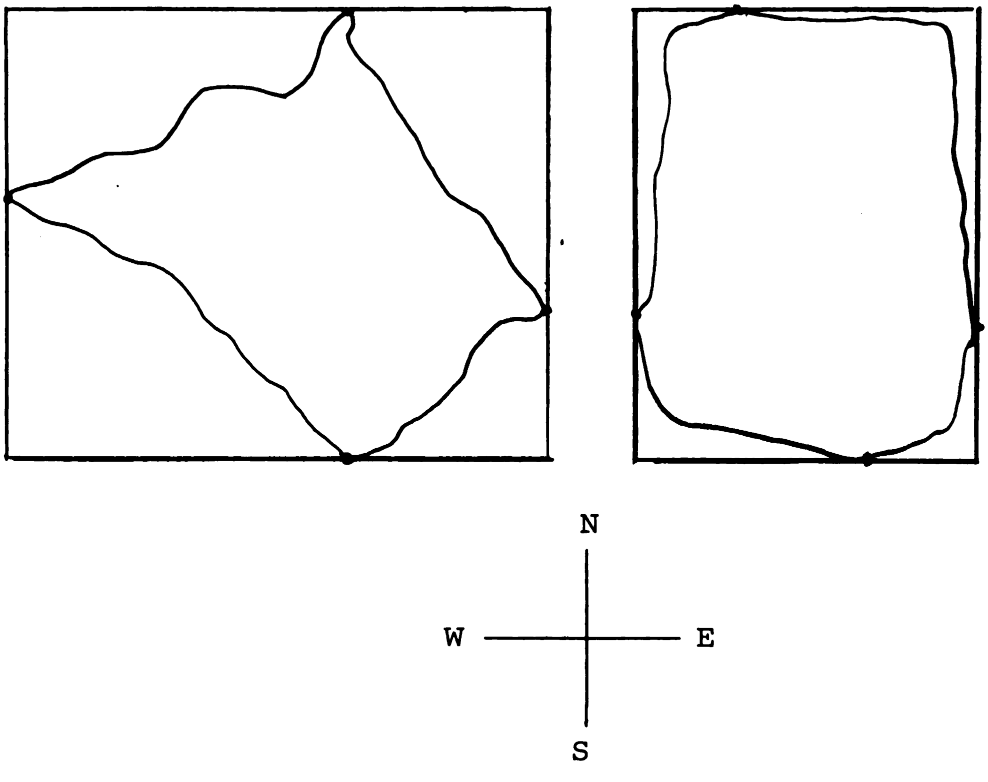
Spherical Grid

It appears that the Railway Express Agency employed the first corporate grid system in the United States sometime in the 1800's. The grid is formed by the one-degree lines of latitude and longitude which cross the United States. Numbering the spaces between the lines provides a coordinate system for identifying the blocks within the grid. The one-degree latitude and longitude lines are then subdivided into four equal parts, creating sixteen sub-blocks from each original block. The sub-blocks are assigned letters A through Q (omitting J).

Shipping points are assigned the number and letter corresponding to their major and sub-block location. For example, Cleveland, Ohio, is in block 800-44, sub-block F. Figure 4 is a reproduction of the REA one-degree latitude-longitude grid. This shows that Cleveland is located in the block composed of the eighth row and forty-fifth column of blocks. The lettered sub-blocks are not shown. This simplifies rate-making by reducing the number of rate base

FIGURE 3

THE DELINEATION OF AN AREA BY PICADAD ON THE BASIS OF ITS EXTREME POINTS



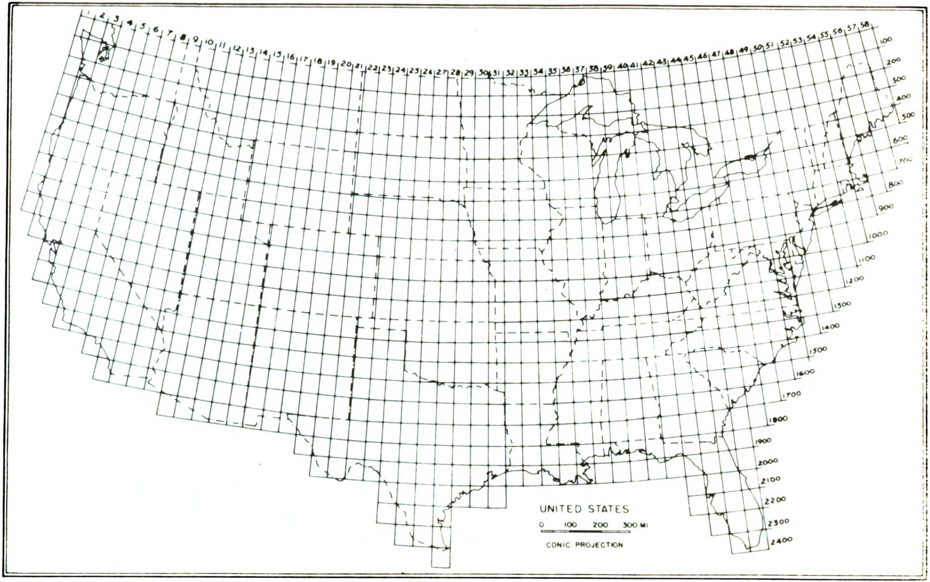


FIGURE 4

RAILWAY EXPRESS AGENCY SPHERICAL GRID SYSTEM points from several hundred thousand to 952 major blocks, or less than 15,232 alphabetic sub-blocks.[23]

Because of the spherical shape of the earth, the sizes of the grid blocks vary depending upon their location on the earth's surface. The length of one degree on the 49th parallel, the northernmost boundary of the United States, equals 45.469 statute miles. The length of one degree on the 25th parallel, the southernmost boundary of the United States, equals 62.729 statute miles. A degree of longitude between the 48th and 49th parallels equals 68.096 statute miles, while the length between the 25th and 26th equals 68.833 statute miles.[24] Therefore, a grid block between the 48th and 49th parallels measures 69.096 by 45.469 statute miles, with the average sub-block measuring 17.274 by 11.367 statute miles, or 196.35 square miles. A grid block between the 25th and 26th parallels measures 68.833 by 62.729 statute miles, with the average sub-block measuring 17.208

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[23] The total is less than 15,232 because the major blocks along the coast, Great Lakes, and boundaries of Canada and Mexico are only partially occupied by land area or by area within the United States.

[24] Arthur H. Robinson, Elements of Cartography (New York: John Wiley & Sons Inc., 1953), Appendix C, pp. 223-4. A complete listing of statute miles for various degrees of latitude and longitude is given on pages 90 and 92.

by 15.682 statute miles, or 269.856 square miles.[25]

These grid blocks and sub-blocks completely fulfill the mutually exclusive and stability requirements of the ideal control unit. As a system they meet the geographically continuous requirement and collectively cover all present and future markets.

Although the grid blocks do not contain a constant amount of area, they are geographically homogeneous by latitude and longitude measurements. The primary weakness results from their large size and, hence, lack of flexibility to describe changes in other than extremely large areas.

Arithmetic Grid

A second type of grid system employs standard size squares, usually arithmetic graph paper, overlaid on a section of the country. Researchers of business logistics developed this technique as a means of solving plant and

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[25] It is important to note that these blocks were reported to consist of 450 fifty-mile-square blocks, which were further subdivided into ten-mile-square blocks. These figures were reported by Herbert D. Whitten in A Proposal For A Standard Transportation Geographic Code, The Chesapeake and Ohio Railway Co., March 26, 1964, page 34. Because of the discrepancy, the system was thoroughly analyzed and the figures in the text were derived and verified by empirical application.

warehouse location problems.[26] The following method developed by Leonard C. Yaseen is a typical illustration of the procedure used in constructing and calculating the center of markets for plant location:

1. First, a large scale map of the market area to be serviced by the new plant is obtained, and an overlay is made on graph paper. (It is imperative that the number of squares per unit of measurement be equal in each direction.)
2. Customer locations (identified by code) are plotted on the graph paper according to their graphic position determined from the base map.
3. Horizontal and vertical axis lines are constructed with their origin as close to the lower left-hand corner as possible. The location of these lines with respect to the plotted points is immaterial, provided the entire market area is included within them. The graph now represents quadrant one of a Cartesian coordinate.
4. A uniform scale is laid out along the horizontal or "X" axis and the vertical or "Y" axis.
5. The number of distance units along the "X" axis and along the "Y" axis of each destination are found and then entered in a table.
6. An arithmetic mean is determined along the "X" axis by adding together all of the distance units and then dividing by the number of points plotted. The arithmetic mean along the "Y" axis is determined in a similar manner.
7. That point located at the intersection of the mean number of units along the "X" axis and the mean number of units along the "Y" axis is the geographic center of markets. It is a "simple"

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[26] This technique is reported in the following texts: Leonard C. Yaseen, Plant Location (New York: The American Research Council, 1960); Edward W. Smykay, Donald J. Bowersox, and Frank H. Mossman, Physical Distribution Management (New York: The Macmillan Company, 1961), Chapter VIII; and J. L. Heskett, Robert M. Ivie, and Nicholas A. Glaskowsky, Jr., Business Logistics (New York: The Ronald Press Company, 1964), Chapter 8.

> geographic center in that each of the destinations has been weighted equally with no regard to the actual magnitude of tonnage to the individual point.[27]

Yaseen then adds tonnages to the above calculations to arrive at a "weighted" geographic center of markets.

The size of individual grid blocks depends upon the scale of the arithmetic grid overlay. Arithmetic grids must assume that the earth is flat and, hence, blocks of a constant size contain equal areas of the earth's surface. This assumption results in minor error when analyzing small geographic areas; however, the accuracy diminishes rapidly for larger areas because of the spherical shape of the earth. Figure 5 illustrates the problem.

Although arithmetic grid blocks can provide small control units, the nature of the earth's surface causes them to vary in size and results in geographically heterogeneous units.

The units are mutually exclusive, stable, and as a system are flexible and geographically continuous. However, they cannot cover all present and future markets without the large margin of error illustrated above.

Table 2 summarizes the ability of the various potential control units to meet the criteria of an ideal unit.

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[27] Yaseen, pp. 19-21.

FIGURE 5

AN ILLUSTRATION OF THE INHERENT ERROR IN USING AN
ARITHMETIC GRID TO PORTRAY A SECTION
ON THE EARTH'S SPHERE

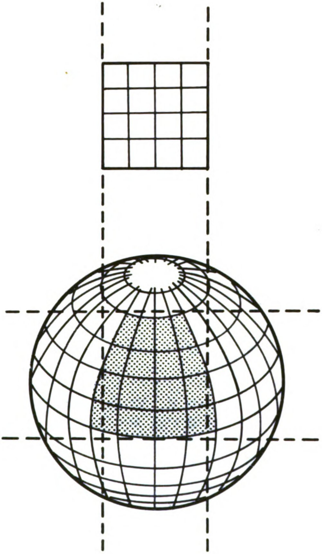

TABLE 2

A SUMMARY EVALUATION OF POTENTIAL GEOGRAPHIC CONTROL UNITS BASED ON THE CRITERIA FOR AN IDEAL UNIT

					Criteria As A System	
Potential Geographic Control Units	Small, Practical	Geographically Homogeneous	Mutually Exclusive	Stable	Flexible	Geographically Continuous
Political						
States	U	U	E	E	U	E
Counties	M	U	E	M	U	E
Cities	A	U	A	M	U	U
Townships	A	U	E	U	A	U
Economic						
State Economic Areas	U	U	E	M	U	E
Trading Areas	A	U	A	M	M	U
Social						
Census Tracts	E	U	E	M	A	U
Pure Geographic						
Latitude-longitude	U	*	E	E	U	E
PICADAD	M	U	A	A	M	E
Spherical Grid	U	E	E	E	U	E
Arithmetic Grid	A	U	E	E	A	U

Code: E = Excellent
A = Acceptable
M = Marginal
U = Unacceptable

*can only define a point

CHAPTER III

DISTRIBUTION COST ANALYSIS

Introduction

Distribution cost analysis is the study of the costs incurred to obtain demand for and to supply the products and services of a firm. The objective of distribution cost analysis is to supply marketing management with the information needed to plan, direct, and control the primary elements of marketing performance.[1]

Cost analysis approaches the control of the primary elements by bringing to management's attention product, customer, and geographic variations in costs of the primary elements and in the revenues generated. Since the primary elements must be adjusted to fit variations in the product, customer, and geographic area involved in a particular sale, it follows that the costs of the primary elements will also vary in relation to the three basic factors. To illustrate

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[1] The primary elements of marketing performance were shown in Chapter II, Figure 2, page 31. They consist of Selling Price and Sales Volume; Inventory, Transportation, Order Handling and Processing Costs; Selling, Advertising and Sales Promotion Expenses; and Product Development, Marketing Research, and Planning and Administrative Costs.

the point, consider the variations in the primary elements of marketing performance and costs required for marketing a full line of air conditioners including window units, central home, and commercial chiller units. The air conditioning industry has traditionally considered window units as appliances and, therefore, attempts to distribute them through discount houses, department stores, and appliance stores. Normally these outlets require: a joint cost arrangement to share expenses of retail advertising; point of purchase literature, displays and signs; and the ability of the supplier to replenish rapidly the retail outlet's inventory for any models needed. Because window units are considered appliances and there are a sizable number of manufacturers, any one manufacturer must either heavily promote his product's brand name directly to the consumer or allow the retail outlets a higher margin to induce them to carry the line and push the brand.

The distribution of central home and commercial units requires establishing a contractor-dealer organization. The manufacturer must either entice established dealers to switch to his line of products or must educate and train potential dealers in the sale, design, installation, and servicing of central air conditioning units. High unit value and the wide variety of unit sizes precludes the average dealers from carrying units in inventory. Often the complexity of commercial installations requires that the manufacturer send a field engineer to aid the dealer in designing the system.

The manufacturing process is highly concentrated, as witnessed by Chrysler Airtemp's single plant in Dayton, Ohio. This industry feature and the units' high value (inventory costs), heavy weight, and bulk (transportation costs) combine to raise substantially the geographic costs of serving areas distant from the plant.

The difference in the geographic density of outlets for air conditioners causes a further variation in geographic costs. The limited number of dealer-contractors for central units creates a situation favoring centralized inventory by the supplier. Numerous outlets and high sales volume for window units permit decentralizing the inventory at various locations in the field. The two supply patterns possess wide variations in their distribution cost components. Concentration of central unit inventories in a single or limited number of points reduces the speed of delivery, unless premium cost high speed transportation is used. However, inventory holding costs are reduced by keeping a single safety stock level under what would be needed to maintain multiple safety stocks at a larger number of distribution points.[2]

Decentralization of the window units has the reverse effect of increasing the speed of delivery without purchasing premium transportation methods, but it increases the inventory holding costs by requiring the maintenance of multiple safety stocks at a large number of points.

The illustration presents only a limited number of the variations in primary elements of marketing caused by differences in customers, products, and geographic areas found in the air conditioning industry. The point of the illustration is to show that to control the costs of the primary elements, marketing management must collect and analyze costs in a manner which uncovers the product, customer, and geographic nature of cost variations in the primary elements.

The Nature Of Distribution Costs

[Distribution costs divide naturally into the two functions of distribution: costs of obtaining demand for the products and services of a firm, and costs of servicing and supplying the demand. Costs of obtaining demand include personal selling, advertising, sales promotion,

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[2] The reduction in inventory holding costs resulting from centralized inventory and safety stock occurs because the geographic variations in demand tend to average out and offset each other in a centrally controlled system as opposed to a decentralized system.

merchandising, and marketing research. The objectives of these costs are to: identify the customer's needs and desires, make the customer aware of his needs and desires, demonstrate how the company's goods and services are the best need satisfiers available in the market place, and provide information to continually adjust the products and demand-inducing forces to changes in the market place.

Costs of servicing demand are incurred by the firm through its efforts to coordinate supply with demand for its products and services. The coordination requires that the firm have the right products in the right place at the right time.

Since the 1950's the term physical distribution management has been applied to the coordination of the firm's supply and demand. One author described physical distribution as "the other half of marketing," stating that it represents one-half the total costs of marketing.[3] The two functional components of distribution costs and their respective elements are shown in Illustration 1.

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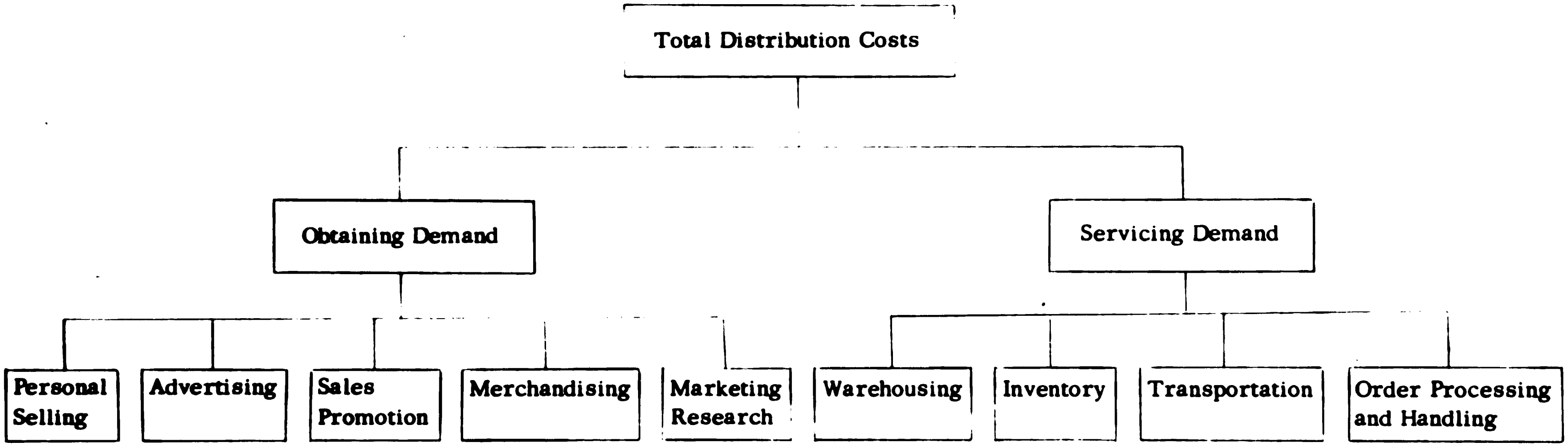
[3] Paul D. Converse, "The Other Half of Marketing," *Twenty-Sixth Boston Conference on Distribution* (Boston: Boston Trade Board, 1954), pp. 22-25; reprinted in Alfred L. Seelye (ed.), *Marketing In Transition* (New York: Harper and Row, 1958), pp. 114-121.

Illustration 1

The Components of Distribution Costs



Different Control Objectives, Yet Interrelated

The natural division of distribution costs into obtaining and servicing demand based on the function of the costs is further justified by the difference in the objectives of controlling the two types of costs. The objective of controlling costs of obtaining demand is to maximize the effectiveness per dollar spent on the various activities. In contrast, the objective of cost control over activities to service demand is to minimize the costs consistent with constraints imposed by the required level of customer service and other constraints imposed outside the firm's control by competitors.

The level of customer service deals with the time period required by the firm between accepting an order and getting the products to the customer and the level of demand the firm can fill. If the firm maintains stock levels sufficient to fill 100% of its demand at any time, it increases its inventory costs. If the firm lowers its inventory costs by keeping a stock level to fill only 80% of demand at any time, it either increases the time period necessary to fill some orders or entirely loses the sale. The greater the cross elasticity of demand between the firm's products and its competitors', the more sales the firm will lose.

However, the firm may be able to use its demand obtaining forces to cause the customer to view its product as a specialty good and thereby lower the cross elasticity of demand.

The analysis above points out that, although costs of obtaining and servicing demand lend themselves to a natural division by the function of activities and objective of cost control, they are interrelated and interdependent, in the final analysis.

The Total Cost Approach to Cost Control

The interrelationship of costs is well documented in physical distribution literature by development of the total cost approach.[4] This approach views the costs of the various activities of servicing demand as a system of costs resulting in a total cost of performing the supply function.

Prior to the total cost approach to physical distribution management, the practice was to consider each activity separately. Attempts to minimize the costs of each activity were made independently with little or no attention given to

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[4] See John Magee, "The Logistics of Distribution," Harvard Business Review, XXXVIII, No. 4 (July-Aug., 1960), pp. 89-101; Edward W. Smykay, Donald J. Bowersox and Frank H. Mossman, Physical Distribution Management (New York: The Macmillan Company, 1961), Chapter IV; H. G. Miller, "Accounting for Physical Distribution," Transportation and Distribution Management, December, 1961, pp. 6-12.

what impact this had on the other elements of supply. At least one author suggested that this approach leads to "the popular corporate pastime of relocating rather than reducing costs."[5] An example often used to illustrate the idea is the attempt by the traffic department of a firm to minimize its costs. Such an attempt normally leads to larger infrequent shipments by slower, lower cost modes of transportation. Having purchased the lowest cost mode of transportation which was feasible and moved only large size shipments, the traffic department sits back, surveys the reduction in its costs, and points with pride to the savings it has accomplished for the firm. However, the cost savings realized by the traffic department do not reflect the impact of the actions on the costs of other supply activities. While the traffic department succeeded in reducing its costs, it is highly probable the warehouse manager is extremely unhappy with his rising costs from holding more inventory and providing more space. If the firm charges an interest cost on pipeline inventories, then this cost will also rise due to the increased time inventory is held in the pipeline as a result of using a slower mode of transportation.

The interactive nature of supply activities' costs is

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[5] Miller, p. 11.

the basis for the total cost approach and can be viewed as the management of trade-offs. "In a sense, cost increases are traded for cost decreases presumably when a net gain results to the company instituting the change."[6] Therefore, the total cost approach requires centralized cost control over the various supply activities, which may cause cost increases in some activities that will be more than offset by cost reductions in other activities. Similarly, centralized cost control would not permit indiscriminate cost reductions in any one supply activity if the net effect were to raise the costs of other supply activities above the cost savings and, hence, increase the total costs of supply.

The necessity for centralizing the control over costs of servicing demand does not preclude the individual management of the various activities. It does, however, require that constraints be placed on the various activities which will allow the firm to minimize its total costs of servicing demand.

Expanding the Total Cost Approach

The application of the total cost approach to physical

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[6] J. L. Heskett, Robert M. Ivie and Nicholas A. Glaskowsky, Jr., Business Logistics: Management of Physical Supply and Distribution (New York: The Ronald Press Company, 1964), p. 446.

distribution is to be commended as a significant step forward in distribution cost control. However, to stop with its application to costs of servicing demand would be unfortunate. The principles involved in the approach are equally as applicable to control over minimizing or optimizing: costs of obtaining demand, the costs between obtaining and servicing demand, and the total costs of the manufacturing, financing, and distributing functions.

The costs and efficiency of activities for obtaining demand are also interrelated. To illustrate this point, suppose the firm decides to conduct a program of intermittently contacting its customers and prospects by a direct mail promotional effort. The result would be an increase in sales promotion expense. However, this could result in a decrease in personal selling expense per call by permitting the salesmen to make fewer calls in a given time period and allowing the letters to fill in for the eliminated calls. The salesmen could then utilize their newly acquired time to contact new prospects and attempt to open new accounts. This could result in an increase in effectiveness per dollar spent on the activities which, it should be remembered, is the control objective.

If the firm plans a promotion centered around bringing its dealers together for a showing and promotion of its product line, the increase in sales promotion expense again could be offset by freeing the salesmen at the corresponding time of the promotion to make additional calls on new accounts. On the other hand, the showing could result in increases in advertising expense to create sufficient interest among the dealers to insure the necessary attendance to make the promotion a success.

Point-of-purchase promotional materials in many companies require the salesmen to spend additional time per call in setting up and maintaining displays. Therefore, an increase in point-of-purchase sales promotion tends to increase the personal selling expense by increasing the time spent per call. If budgets are imposed upon the various activities, the sales managers may object to the increase the sales promotion program imposes on their costs. Here again, central cost control must be used to evaluate the trade-offs in attempting to maximize the efficiency per dollar spent among the various activities.

Although central cost controls over obtaining and servicing demand are necessary conditions, they are not sufficient conditions for the control of distribution costs. The control of distribution costs must also optimize the costs between obtaining and servicing demand. For example, the speed of delivery can be a very important motivating force in obtaining demand. The desire of the sales department for rapid delivery must be balanced against the desire of the distribution function to minimize its costs. The balance, if possible, is obtained when the sales department is given a delivery period sufficient to meet or beat competition, and the supply costs are raised by the minimum amount possible.

Finally, the control of distribution costs cannot be managed as a separate independent cost center. Cost trade-offs exist among the manufacturing, financial, and distribution functions as well as between the costs of obtaining and servicing demand. Manufacturers must continually evaluate how many units of a given product must be made per run to provide the minimum manufacturing costs per unit. Where the sizes of these runs are substantial and the sales period necessary to dispose of the economic quantity is quite long, inventory costs may increase significantly. This situation requires the minimization of the total costs of manufacturing and inventorying the products. Neither function may be able to minimize its respective costs, but if both move the necessary distance from their individual minimums, the total costs to the firm can be minimized.

The interrelationship between distribution and financial costs may be seen by the cost trade-offs involved when the distribution function proposes investment in new order handling equipment to realize cost savings. These savings must be measured against alternative uses of capital for the firm.

Structuring Control for the Total Cost Approach

The overwhelming number of potential interrelationships and variables of cost control illustrated above may appear to be a jungle of chaos unable to be managed. Hopefully, such is not the case. The total cost approach does require an ordered collection system of cost information by controllable units and coordinated decision making centers at various levels. The nature of distribution costs discussed in this section suggests that an ordered system of cost information should provide marketing management with the ability to determine product, customer, and geographic cost variations inherent in marketing activities. The initial cost centers for collecting information are the individual elements which compose the functions of obtaining and servicing demand. The management of these elements comprises the activities level of control over cost trade-offs and is limited to trade-offs within the respective activities consistent with the constraints imposed by the management of the trade-offs within each function. The management of the functional areas of obtaining demand and servicing demand constitutes the subfunction level of decision making and controls the cost trade-offs among the various activities within their respective functions consistent with the constraints imposed by management of trade-offs between their functions. The highest level of distribution cost control is the overall management of the marketing function and represents intrafunction cost control. Here the management of cost trade-offs between obtaining and servicing demand takes place consistent with the constraints imposed by management of cost trade-offs among the marketing, manufacturing, and financial functions. The control of trade-offs among these functions represents interfunction control and is the source of initial constraints imposed on all other levels. The nature of distribution cost control and identification of the various levels of control necessary for the management of cost trade-offs within the firm are shown in Illustration 2.

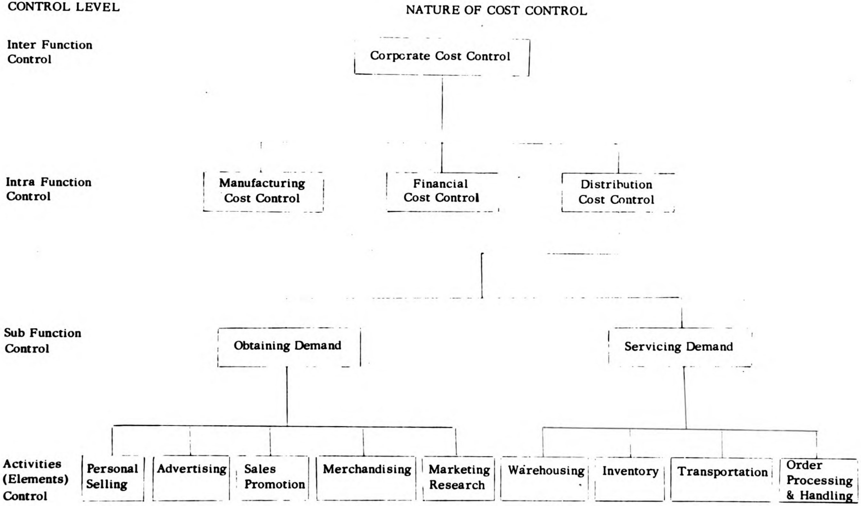
Distribution Cost Analysis Literature

A leading scholar in distribution cost analysis credits the Department of Commerce's "Distribution Cost Studies," conducted from 1928 to 1932, as being the first major work

Illustration 2

The Relationship of Distribution Costs Control To The

Various Control Level



in the field.[7] The series consisted of fourteen studies of electrical goods, groceries, drugs, confections, and other lines and focused attention on the different costs and profits in marketing the various items. These studies were followed by the first books in the field and later by books suitable for textbooks to teach the subject. An historical list of the literature follows.

Hilgert, Joseph R., Cost Accounting for Sales. New York: The Ronald Press Co., 1926.

Department of Commerce, Distribution Cost Studies. Washington: Government Printing Office, 1928-1932.

Castenholz, William B., The Control of Distribution Costs and Sales. New York: Harper Brothers, 1930.

Eastwood, Robert Parker, Sales Control by Quantitative Methods. New York: The Columbia University Press, 1940.

Heckert, J. Brooks, The Analysis and Control of Distribution Costs. New York: The Ronald Press Co., 1940.

Longman, Donald R., Distribution Cost Analysis. New York: Harper and Brothers, 1941.

Federal Trade Commission, Case Studies in Distribution Cost Accounting for Manufacturing and Wholesaling. Washington: Government Printing Office, 1941.

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[7] Donald R. Longman, "Recent Developments in Distribution Cost Analysis," Proceedings: Conference of Marketing Teachers From Far Western States, Delbert J. Duncan, ed. (Berkeley: University of California, 1958), p. 60.

Sevin, Charles H., *Distribution Cost Analysis*. Economic Series No. 50. Washington: U.S. Department of Commerce, 1946.

Sevin, Charles H., *How Manufacturers Reduce Their Distribution Costs*. Economic Series No. 72. Washington: U.S. Department of Commerce, 1948.

Crisp, Richard D., *How To Reduce Distribution Costs*. New York: Funk and Wagnalls Co. in association with *Modern Industry* magazine, 1948.

Heckert, J. Brooks and Miner, Robert B., *Distribution Costs*. New York: The Ronald Press Co., 1953.

Longman, Donald R. and Schiff, Michael, *Practical Distribution Cost Analysis*. Homewood, Ill.: Richard D. Irwin, Inc., 1955.

A study of the list reveals three features of the distribution cost analysis literature. First, the literature is relatively young compared to the literature in other marketing areas. Second, the number of books is relatively few and has been supplemented by government studies; and third, a few authors (Heckert, Longman, and Sevin) have accounted for a substantial amount of the literature. Because of these features, the analysis of present methods of distribution cost analysis is focused on the latest works of Heckert and Miner and Longman and Schiff.

Present Methods Of Distribution Cost Analysis

As pointed out in Chapter I, the accounting department has traditionally provided two major information sources:

the profit and loss statement and the balance sheet. The interest of distribution cost analysts has centered on the reclassification and breakdown of the natural accounts provided by the accountants. Natural accounts, as mentioned in Chapter I, classify costs on the basis of what the expenditure secured. Salaries, Wages, and Commissions; Travel and Entertainment; Rent; Maintenance and Repairs; Taxes; Insurance; Heat, Light, Power, and Water; and Expense Materials and Supplies illustrate natural accounts for cost accumulation and recording. The first step of the distribution cost analysts is to get the accounting department to record the natural account expenses incurred by the marketing area, on the basis of the various marketing functions. For example, the wages, salaries, and commissions related to the marketing department would be broken down into direct selling expense, advertising and sales promotion expense, transportation expense, warehousing and handling expense, credit and collections expense, financial expense, and general distribution expense. This breakdown provides a functional classification of distribution costs and is an attempt to make distribution cost analysis comparable to the departmental classifications used for production cost analysis.[8]

The broad categories of functional expenses are then broken down into smaller components. For example, selling expense might be divided into: floor selling, telephone selling, mail orders, and outside selling. Each of these accounts would be assigned the salesmen's, sales office, sales supervision, and service expenses connected therewith. Once the expenses are allocated among the various functional accounts, the costs are reallocated to manners of application, i.e., by territories, products, customers, method of distribution, and order size.

Before functional costs can be assigned to products, customers, etc., the cost analyst must establish units of measurement for functional service and then divide these units into the total costs of an operation to arrive at a standard unit operating cost. Obviously the unit picked should have a relationship to cost variations, such as the following functional costs assigned to customers.

Expense	Unit of Measurement
Salesmen's salaries	number of calls or time per call
Salesmen's commissions	$ sales per customer or class

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[8] The functions identified above are used by J. Brooks Heckert and Robert B. Miner in Distribution Costs (New York: The Ronald Press Co., 1953), p. 18.

Expense	Unit of Measurement
General selling expenses	number of calls
Order processing	number of orders
Invoice preparation	number of invoice lines or number of invoices

Given the total of general sales expense and the total number of calls made on customers, the average general expense per call can be determined and used as the unit of measurement.

Now the allocation of general sales expense to various customers is simply a matter of determining the number of calls made on each customer and multiplying by the average cost of general sales expense per call. Therefore, by developing cost units for each cost factor, the allocation of expenses to each customer is performed by multiplying the value of the cost unit times the number of units the customer has required. The cost units are often referred to as standard costs since, once they are determined, they act as a standard for comparing actual future costs per unit for a given activity.

Limitations of Present Cost Analysis

Longman and Schiff, in Physical Distribution Cost Analysis, state, "It is not enough to record expenses according to their nature (natural accounts). They must also be classified according to their purpose--the function for which they are incurred."[9] In light of this statement it is unfortunate that the breakdown of natural accounts to the various marketing activities has been termed functional cost analysis. The use of the term function to describe the activities of marketing is not consistent with the nature of distribution costs presented earlier in the chapter where obtaining and servicing demand were listed as the functional costs of marketing.

The human heart beats. That is its activity; but its <u>function</u> is to supply blood to the body. Advertising represents nonpersonal mass persuasion, personal selling represents personal individualized persuasion, sales promotion represents special promotions on a noncontinuous basis, merchandising represents continuous adjustments to the products and services to fit changes in consumer tastes and habits. These are descriptions of their activities, but their common <u>function</u> is to obtain demand for the firm's products and services. The practice of labeling each activity a function of marketing has resulted in the independent analysis and separate control of each activity and the imperceptibility of the interrelated nature of their costs

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[9] Donald R. Longman and Michael Schiff, <u>Practical Distribution Cost Analysis</u> (Homewood, Ill.: Richard D. Irwin, Inc., 1955), p. 110.

in pursuit of their common function.

To fully realize long range benefits from the treatment of all marketing activities as a unified system, the organization must be supported by a cost analysis system that permits recognition, accumulation, and control of these costs. The marketing management concept must become an accounting as well as an organizational concept.

A second weakness of present methods of cost analysis lies in the inherent dangers of using standard costs (cost units). Since these are often derived from historical costs of a single or multiple periods, management must choose a period which is "typical." That is, the costs in the period cannot be extremely high or extremely low, but must represent a "normal" cost for performing an activity.

Another limitation of standard cost units is their construction as average unit costs for allocation of various expenses among customers and products. The presentation of expenses as averages may cause the standard unit to represent wide ranges of variations in the costs which are hidden. One author reports the case of a product sold at a uniform delivered price throughout the United States. The average cost of freight was computed at $.01 per pound. The normal gross profit was $.03 per pound. Further analysis showed actual freight ranged from $.002 to $.045 per pound. While overall marketing was profitable, certain sales areas were marginal or unprofitable.[10]

Finally, distribution cost analysts have tended to ignore geographic cost variations while concentrating on variations among products, customers, and order sizes. A leading text in the field reports the "nearly universal" relation of expenses in direct cost functions to product and customer characteristics. "Virtually all expenses incurred in these processes are influenced directly by the characteristics of products sold or customers served."[11] While the analysis of customer and product cost variations is important, the analysis of variations in direct cost functions on a geographic basis is equally important. The importance of geographic variability of costs has been recognized in the physical distribution literature as witnessed by the following statement. "If these variations within the average are neglected, then a standard uniform cost is assessed against all geographic markets. Neglecting the variations of spatially separated markets will mean that

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[10] H. G. Miller, "Accounting for Physical Distribution," Transportation and Distribution Management, December, 1961, p. 11.

[11] Longman and Schiff, Practical Distribution Cost Analysis, p. 177.

no market is accurately measured as to the precise cost of serving it."[12]

Overcoming the Limitations

It is important to note that the breakdown of natural accounts into functional accounts and the subsequent assignment of functional accounts by standard cost units to customers, products, etc., is not a continuous process and is made <u>after</u> the data have been accumulated rather than in connection with their accumulation. Herein lies the source of major limitations to present cost analysis. Production cost accounting has long recognized the necessity of collecting costs by activities at the specific location of its various operations. Through time and motion studies and other types of analysis of activities at each location, the variations in costs among different operations have been determined or closely estimated. The result has been a more precise control over costs than has occurred in distribution cost analysis. Therefore, where production cost analysis starts with multiple cost centers representing the source of costs and works toward aggregate costs, distribution cost analysis starts with the aggregate and works backwards toward the source. As illustrated above, the reallocation

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[12] Smykay, Bowersox, and Mossman, p. 77.

of aggregate costs results in a loss of accuracy in determining cost variations at their source.

It is felt that the application of the proposed geographic marketing information system to distribution cost accounting can significantly improve control. The small geographic units are used as collecting units for all direct costs of distribution in a specific area. Transportation, order processing and handling, personal selling, cooperative local advertising, localized sales promotion, and interest on pipeline inventories comprise the direct costs associated with a given geographic area. The coding by geographic units of the sales order, freight bill, order processing and handling work sheets, and advertising and sales promotion expense provides an information system which identifies the geographic variations in direct distribution costs. Since many of these documents also identify the customer and products involved, this permits geographic accounting for variations in direct costs by customer and product. The use of standard costs is not eliminated, but is replaced by geographic unit costs wherever it is practical and economically feasible to collect the costs by their geographic source.

Direct geographic costs should be collected in terms of the marketing activities comprising the functions of obtaining and servicing demand. This allows management to evaluate the cost trade-offs within and between the two functions in terms of the geographic, customer, and product variations in the costs. Therefore, the proposed geographic system of cost accounting more closely parallels manufacturing cost accounting by building the aggregate costs from the sources which cause cost variations.

CHAPTER IV

RESEARCH DESIGN

Introduction

Chapter II presented the need for and set the background necessary to develop a control unit for gathering marketing information on a geographically integrated basis. The nature of distribution costs and a review of the present method of analysis and its limitations were presented in Chapter III.

The objective in this chapter is to develop a geographic control unit for gathering marketing information which satisfies as many of the criteria for an ideal control unit as possible. After the information gathering system is completed, a method of distribution cost and revenue accounting is developed for the evaluation and control of marketing costs. These two systems are then combined into a research design to test their impact on: geographic evaluation of marketing activity, evaluation of the geographic variability of distribution costs, and establishment of distribution territories.

Developing The Geographic Control Unit

The summary evaluation of potential geographic control units presented in Chapter II shows that spherical grid units have the highest potential. This unit meets all the criteria for an ideal control unit except that it is not small and practical and, as a system, does not provide acceptable flexibility. Both of these deficiencies result from the large area contained in each block.

The proposed geographic control unit is basically a modification of the REA spherical grid discussed in Chapter II. It is helpful to recall that the grid quadrilaterals are constructed by the one degree latitude and longitude lines which cross the United States. Specifically, the United States is contained between the 49th and 25th latitudes north to south and the 66th and 125th longitudes east to west. The proposed control unit is derived by dividing each degree of latitude and longitude into sixteen parts. This yields 256 sub-blocks for each original one degree quadrilateral, with each sub-block control unit measuring 3.75 minutes latitude by 3.75 minutes longitude.

Characteristics of the Control Unit

The spherical grid control unit has certain characteristics which are important to understand before the unit is

used. Each quadrilateral is homogeneous in that all of its sides equal 3.75 minutes of latitude or longitude. However, the actual length of these lines varies depending upon the location on the earth's surface. This causes the areas within the quadrilaterals to vary in size. To illustrate the point, consider the quadrilateral formed by the 49° and 48° latitudes and the 125° and 124° longitudes. This is REA's block 100-1 and is illustrated in Figure 6. Each side of the quadrilateral equals 1° on the respective latitudes and longitudes. The length of each of the degrees of longitude equals 69.096 statute miles. However, the lengths of the degrees of latitude are not equal. One degree on the 49th latitude equals 45.469 statute miles, while on the 48th latitude it equals 46.376 statute miles. This happens because each longitude is a great circle--that is, a plane on the earth's surface passing through two points and the center of the earth--while the latitudes, except for the equator, are not great circles. Since the earth is not a perfect sphere, the length of one degree of longitude varies slightly from north to south, as shown in Table 3.

The maximum difference north to south in the United States equals .263 statute miles (69.096 - 68.833). Thus, average length can be used and individual variations ignored without significant error.

FIGURE 6

THE QUADRILATERAL FORMED BY THE 49° AND 48° LATITUDES AND THE 125° AND 124° LONGITUDES SUBDIVIDED INTO 256 SUB-BLOCKS FOR GEOGRAPHIC CONTROL UNITS (REA BLOCK 100-1)

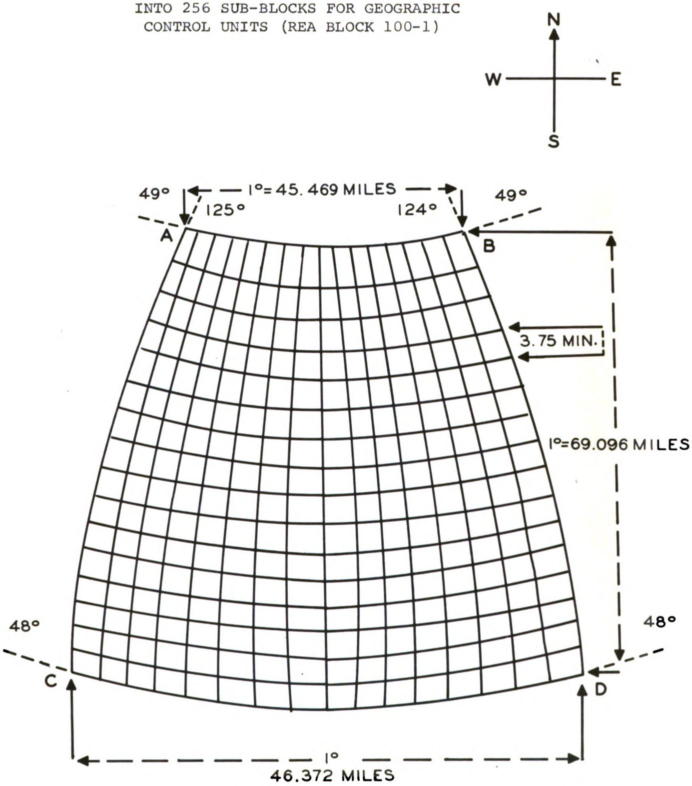


TABLE 3

LENGTHS OF A DEGREE OF LONGITUDE BETWEEN GIVEN DEGREES OF LATITUDE

Latitudes	Length of Longitude (In Statute Miles)
°	
48 - 49	69.096
47 - 48	69.084
46 - 47	69.072
45 - 46	69.060
44 - 45	69.047
43 - 44	69.035
42 - 43	69.023
41 - 42	69.011
40 - 41	68.998
39 - 40	68.986
38 - 39	68.974
37 - 38	68.962
36 - 37	68.951
35 - 36	68.939
34 - 35	68.928
33 - 34	68.916
32 - 33	68.905
31 - 32	68.894
30 - 31	68.883
29 - 30	68.873
28 - 29	68.862
27 - 28	68.852
26 - 27	68.842
25 - 26	68.833

Source: Smithsonian Geographical Tables, reprinted in Arthur H. Robinson, Elements of Cartography (New York: John Wiley & Sons, Inc., 1953), p. 224.

Since latitudes are not great circles, their lengths between degrees of longitude vary significantly, as shown in Table 4. The maximum difference in length from north to south equals 17.26 statute miles (62.729 - 45.469), and the greatest difference between any two adjacent latitudes is .903 statute miles between the 49° and 48°. The difference of the differences between the lengths of any two adjacent latitudes, as shown in Table 4, is reasonably uniform and therefore permits linear interpolation of the differences for determining the sub-block sizes. Thus, to determine the length of the latitude sides of sub-block quadrilaterals for any given 1° quadrilateral, one-sixteenth of the total difference between its northern and southern boundary lines has been added for each 3.75 minute movement north to south. For example, the difference in length between the northern and southern boundaries of the quadrilateral shown in Figure 6 is .903 statute miles. One-sixteenth of this difference equals .0564 miles. To compute the length of the longitude line 3.75 minutes south of the 49° parallel, all that is required is to add .0564 to the length of the parallel (45.469 + .0564 = 45.5254). One sixteenth of 45.469 miles and 45.5254, respectively, equals the lengths of the northern and southern boundaries of the first row of sub-blocks, while one-sixteenth of 69.096 equals the length of

TABLE 4

LENGTHS OF A DEGREE OF LATITUDE
(IN STATUTE MILES)

Latitude	Line Distance	Differences	Difference of Differences	N^o + 30' ÷ 16 Linear Interpolation	Great Circle Distances
o					
49	45.469				45.335
		.903			
48	46.372		.014	2.8700	46.233
		.889			
47	47.261		.014	2.9260	47.108
		.875			
46	48.136		.016	2.9811	47.995
		.859			
45	48.995		.014	3.0353	48.858
		.845			
44	49.840		.016	3.0886	49.699
		.829			
43	50.669		.015	3.1409	50.528
		.814			
42	51.483		.016	3.1922	51.345
		.798			
41	52.281		.016	3.2426	52.146
		.782			
40	53.063		.016	3.2920	52.923
		.766			
39	53.829		.016	3.3404	53.694
		.750			
38	54.579		.018	3.3877	54.443
		.732			
37	55.311		.016	3.4341	55.180
		.716			
36	56.027		.018	3.4793	55.894
		.698			
35	56.725		.016	3.5235	56.596
		.682			
34	57.407		.018	3.5666	57.276
		.664			
33	58.071		.019	3.6087	57.943
		.645			
32	58.716		.016	3.6496	58.588
		.629			
31	59.345		.018	3.6894	59.222
		.611			
30	59.956		.019	3.7281	59.832
		.592			
29	60.548		.018	3.7657	60.431
		.574			
28	61.122		.020	3.8022	61.006
		.554			
27	61.676		.018	3.8374	61.559
		.536			
26	62.212		.019	3.8715	62.100
		.517			
25	62.729				62.619

the eastern and western boundaries. Hence, the size of the first row of sub-blocks of the quadrilateral in Figure 6 equals 2.8418 miles on the northern boundary (45.469 ÷ 16) by 4.3185 miles on the eastern and western boundaries (69.096 ÷ 16) by 2.8453 miles on the southern boundary (45.5245 ÷ 16).

This procedure for each row of sub-blocks from the northern to the southern boundary of the United States provides a very close approximation of the actual size of the sub-blocks used for geographic control units. Table 5 presents the area contained in each original 1^{o}quadrilateral and the <u>average</u> area and <u>average</u> length of sides of the 3.75 minute sub-blocks for each 1^{o} quadrilateral.

Another characteristic of the control unit caused by the spherical shape of the earth is the difference between the lengths of the latitude north and south boundaries and airline distances over the boundaries. The latitude and longitude intersections are labeled A, B, C, and D in Figure 6. While the boundary line distance between A and B is 45.469 miles and between C and D equals 46.372 miles, these are not the shortest (airline) distances between the points. This is true because the shortest distance between two points on a sphere is a great circle and the latitudes are not great circles. Since the sides of the quadrilaterals

TABLE 5

AREA OF QUADRILATERALS ON EARTH'S SURFACE OF 1° EXTENT IN LATITUDE AND LONGITUDE COMPARED TO THE AVERAGE AREA OF 3.75 MINUTES EXTENT IN LATITUDE AND LONGITUDE

Lower Latitude of Quadrilateral	1° Area In Square Miles	3.75 Minute Average Areas In Square Miles	Avg. Length Of Sides of Sub-blocks In Statute Miles		
			Longitude		Latitude
°					
48	3173.04	12.3941	4.3185	x	2.8700
47	3234.39	12.6336	4.3177	x	2.9260
46	3294.71	12.8506	4.3170	x	2.9811
45	3354.01	13.1010	4.3162	x	3.0353
44	3412.26	13.3285	4.3154	x	3.0886
43	3469.44	13.5520	4.3147	x	3.1409
42	3525.54	13.7708	4.3139	x	3.1922
41	3580.54	13.9860	4.3132	x	3.2426
40	3634.42	14.1964	4.3134	x	3.2920
39	3687.18	14.4025	4.3116	x	3.3404
38	3738.80	14.6040	4.3109	x	3.3877
37	3789.26	14.8013	4.3101	x	3.4341
36	3838.56	14.9937	4.3094	x	3.4793
35	3886.67	15.1817	4.3087	x	3.5235
34	3933.59	15.3649	4.3080	x	3.5666
33	3979.30	15.5434	4.3072	x	3.6087
32	4023.79	15.7174	4.3066	x	3.6496
31	4067.05	15.8862	4.3059	x	3.6894
30	4109.06	16.0502	4.3052	x	3.7281
29	4149.83	16.2098	4.3046	x	3.7657
28	4189.33	16.3643	4.3039	x	3.8022
27	4227.56	16.5131	4.3032	x	3.8374
26	4264.51	16.6575	4.3026	x	3.8715
25	4300.17	16.7971	4.3021	x	3.9044

Source: (For 1° quadrilaterals) Smithsonian Geographical Tables, reprinted in Arthur H. Robinson, Elements of Cartography, (New York: John Wiley & Sons Inc., 1953), p. 225.

are composed of longitudes which are great circles, the line (boundary) distances and airline distances from A to C and B to D are equal. The last column in Table 4 shows the airline distances for each degree of latitude. Because of the differences in line (boundary) and airline distances, the control units cannot be used directly to compute milages between the centers of any two units without a special program. This problem is discussed in Appendix I.

Control Unit Identification

Having constructed the spherical grid for the United States, the next step requires an identification numbering system for the blocks. The original REA grid system was chosen as the origin for the new numbering system for two reasons. First, it has been in existence for many years and several studies have been made using the system. Second, the REA has extensive data relating to its grid system. Therefore, it seemed appropriate to make the system used in this study compatible with data generated by the other sources.

Figure 4 on page 52 shows the REA grid system and the identification numbers used for the blocks. As shown in the figure, the vertical coding system consists of the numbers 100 through 2400 north to south, while the horizontal system consists of 1 through 58 west to east. To identify a cell which contains an area of interest, it is necessary to determine the vertical and horizontal numbers which correspond to the cell's vertical and horizontal position on the scales. For example, the cell containing Milwaukee, Wisconsin, is located at 600 on the vertical scale and 38 on the horizontal scale. Therefore, cell 600-38 identifies the area of interest. Specifically this cell is the quadrilateral formed by the 88° and 87° longitude lines and the 44° and 43° latitude lines.

Using the original REA numbering system as the origin, the following procedure was used to develop the numbering system for the sub-block control units:

(a) Change the REA vertical scale numbers from 100 through 2400 to 1 through 24. This provides smaller numbers for identification.

(b) Multiply the horizontal and new vertical REA scale numbers by 16.

(c) Subdivide each original REA block into sixteen parts on both the vertical and horizontal axes.

(d) Number the sub-blocks starting with the sub-block in the upper left hand corner with the numbers 0 through 15 on both the vertical and horizontal axes.

(e) Add to the vertical and horizontal scale numbers computed in (b) above the vertical and horizontal sub-block numbers. The result is an identification number for each sub-block used.

Referring back to the quadrilateral containing Milwaukee, the conversion would be:

(a) Original block number equaled 600-38. (note: the vertical scale number is always given first.)

(b) Convert the original number to 6-38.

(c) Multiply each scale number by sixteen. 6 x 16 and 38 x 16 = 96-608, the new main block number.

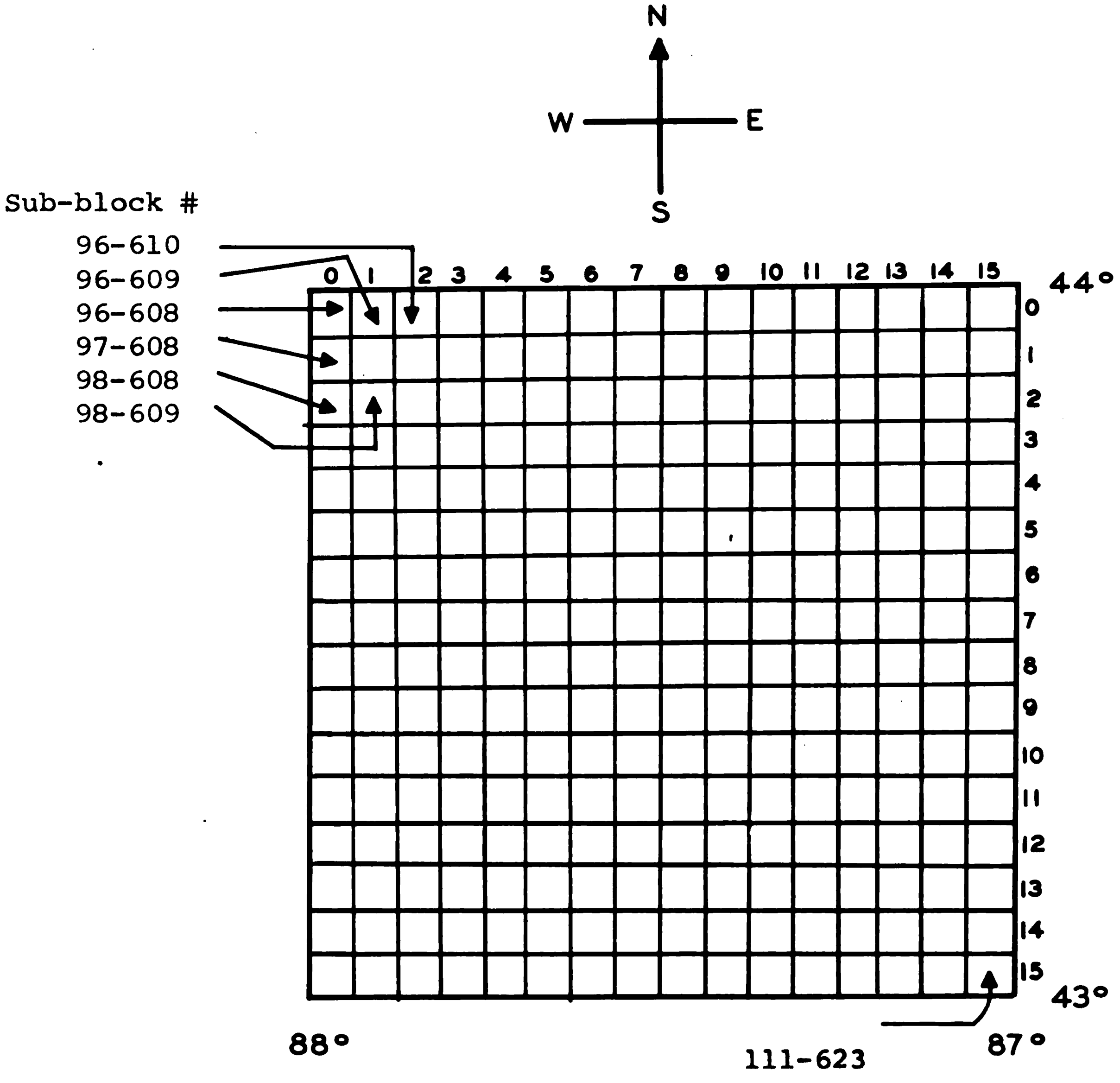
(d) Now, for any sub-block within block 96-608 add the appropriate vertical and horizontal scale numbers of the sub-block.

Figure 7 shows the conversion for the Milwaukee quadrilateral. The upper left hand control unit is now main block 96-608, sub-block 0-0. Therefore, its identity number is 96-608. The control unit immediately to its right is main block 96-608, sub-block 0-1, or control unit number 96-609. The lower right hand corner control unit is 96-608, sub-block 15-15, or control unit 111-623.

The conversion was computerized to print out a block book which shows the main block number, sub-block number, and final identification number of each control unit in

FIGURE 7

REA BLOCK NUMBER 600-38 SUBDIVIDED INTO 256 SUB-BLOCKS AND RESCALED TO MAIN BLOCK 96-608*



*This figure was drawn to illustrate the derivation of the numbering system for control units and does not portray the actual configuration of the quadrilateral. The actual configuration is similar to Figure 6.

every one degree quadrilateral for the United States. Since the control unit numbers are based on latitude and longitude, they not only serve to identify the area contained within a unit, but also can be used to compute the airline distances between the centers of any two units. The use of control unit numbers for distance computations is shown in Appendix I.

In order to determine the control unit or units within which a city, section of a city, town, or village is located, a set of plexiglass templates was constructed. The templates divide each one degree quadrilateral into the 256 sub-block control units on any Lambert Conic Conformal Projection with a scale of 1:1,000,000 inches. By placing the template on a map, the appropriate control unit numbers needed to identify an area are determined.

The Control Unit And Marketing Records

The use of the control unit for geographic analysis of market activities requires that the records of activities show the control units in which the activities took place. Therefore, the control unit location number of each customer, distribution, and manufacturing point must be determined and reported on the various marketing records.

The application of the control unit to the marketing activities of the company described in Chapter I consisted of identifying the control unit location for all the customers in eighteen states, as well as all distribution and manufacturing points. After identification, the control unit numbers were matched with customer, warehouse, and manufacturing points involved on each sales order and freight invoice. This provided geographic coding of all the data shown on the two documents. In the case of the studied company, the information available on the documents was as follows:

Sales Order

1. Origin of shipment (manufacturing or distribution point)
2. Destination of shipment (customer address)
3. Territory
4. Company order number
5. Assigned shipping date
6. Date shipped
7. Carrier name
8. Quantity ordered (in pounds)
9. Product description
10. Number of containers
11. Container size
12. Quantity shipped
13. Unit price
14. Market code number (shows sales division and department, customer type, and salesman's number)

Freight Invoice

1. Origin of shipment
2. Destination of shipment
3. Date of invoice
4. Name of carrier
5. Partial or full shipment
6. Number of pieces (by product)

7. Product description
8. Weight by product
9. Shipping rate by product by cwt.
10. Charges by product
11. Total charges

Hence, the geographic analysis of marketing activities relies on the information obtained from existing company records once it has been classified in terms of the geographic control units within and between which the activities took place.

The use of standardized geographic coding of marketing records results in a geographically integrated marketing information system for internal records and, thus, makes it possible to merge the records of various activities.

Electronic data processing of the coded information found on the various documents provides flow information for distribution and sales analysis. Under most existing information systems, information is not collected on a continuous basis, primarily because of prohibitive costs. Continuous information, data flowing in through time, provides an important advantage--the ability to recognize changes and trends as they occur. By using the source documents of marketing activities, continuous analysis is available instead of comparative statistics. Comparative statistics do not permit evaluation of activities between points in time, except by ex post facto methods.

Equally important to flow data in the temporal dimension are flow data in the spatial (geographic) dimension. The use of the geographic control units to identify the origins and destinations of all shipments and sales provides geographic flow data. When such data are provided, it is possible to determine any geographic changes in the patterns of physical distribution. Once these patterns have been determined and evaluated, management is able to make more valid decisions concerning the location of plant and distribution facilities, the modes of transportation to be used, and the allocation of sales and promotional efforts. Therefore, the use of geographic control unit identification on the source documents of marketing activities results in an information system which supplies flow data in both the spatial and temporal dimensions.

Applications Of The Geographic Control Unit System

Location Theory

The shortcomings of current quantitative methods used to determine ton-center, mile-center, ton-mile-center, cost-ton-mile-center, or cost-time-ton-mile-center stem from the use of arithmetic grids, discussed in Chapter II. The error in calculations is minimal if all shipments are relatively short distances; however, a national distributor locating regional warehouses or plants incurs a significant amount of error. The use of the spherical grid control units eliminates the errors from assuming that the earth is flat and that constant lengths anywhere on the earth's surface represent equal distances. Spherical grid blocks, however, are not completely free from error in computing the weighted distribution centers. Shipments to each control unit are assigned to the center of each spherical block, and distances are also computed from the centers of the blocks. If all of the shipments in a control unit happened to occur in one corner of the block, the ton mile weighting of the block would be in error by the distance from the center of the block to the corner. The largest possible error in this situation occurs in the largest control unit, which is 4.3 x 3.9 miles, and could result in an error of 2.8 miles in weighting the block.

A marketing information system based on geographic control units affords a natural basis for location analysis. Since it provides information on origin and destination of shipments, time required for processing, handling, and shipping, and costs of transportation, the various types of weighted centers are easily computed.

The procedure for computing a ton mile center from control unit information requires the following steps:

(a) Determine the total number of tons shipped to each control unit.

(b) Compute the milages from the centers of the various control units.

(c) Pick an initial control unit from inspection which appears to be close to the center.

(d) Use the control units as East-West and North-South vectors for movement, starting with the East-West vector.

(e) Compute the ton mile value for the initial control unit picked.

(f) Move from the initial control unit by one control unit to the east. Possible results are ton miles increase or ton miles decrease.

(g) If ton miles increase, back up and move westward until ton miles stop decreasing. If ton miles decrease, continue moving east until they increase; then back up one unit.

(h) Now move north from the established east-west unit. If ton miles increase, stop and move south until they stop decreasing. If ton miles decrease, keep on moving north until they increase; then back up one unit.

(i) Repeat the procedure for a new east-west vector at the new north-south point, finding a new east-west point.

(j) Repeat the procedure for a new north-south vector at the new east-west point in the second east-west vector.

(k) Repeat steps (g) and (h) until it is impossible in both vectors to move either direction without increasing the ton mile total. The resulting cell is the ton mile center of the shipments.

A possible pattern of movements from the procedure outlined above is shown in Figure 8.

Area Determination

A second application of the System[1] consists of using the control units to identify an area. Because the control unit is based solely on geographic considerations rather than on political, social, or economic, it allows management to delineate an area on the basis of the data being analyzed. That is, by analyzing a given type of data within the control units, the geographic characteristics of the data are revealed.

Typically marketing management constructs sales

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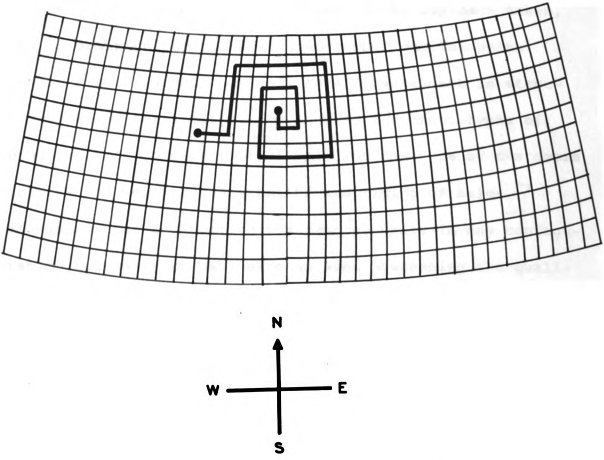
[1] As in Chapter I, the word System is used to refer to the integrated internal marketing information system based on the geographic control unit developed in this chapter.

FIGURE 8

**A POSSIBLE PATTERN OF VECTOR MOVEMENTS IN COMPUTING
THE TON-MILE CENTER OF SHIPMENTS
FROM CONTROL UNIT DATA**



territories in order to control and coordinate salesmen's activities, promotional efforts, and other marketing activities. The determination of sales territories depends upon how the company wishes to structure the areas and what relative weights it places on the variables it chooses to consider. While some companies wish to structure overlapping multiple territories by product divisions or by type of customers and use multiple sales forces, other companies may use a single sales force to sell the entire product line to all types of customers. Regardless of the approach taken, the information structured by geographic control units should provide a valuable tool to aid management in structuring sales territories. [By knowing the exact types of products sold in each control unit and the type of customers involved as well as the quantity and timing of sales,] management can agglomerate the control units in any configuration necessary to delineate an area possessing the qualities it desires in the sales territories. For example, management may decide that each sales territory should be within a given range of physical size and yield a sales volume within a given range for a certain group of products or for all products. Since the size of the control units and the type and quantity of products sold within each unit are known, the units can be combined in the manner necessary to meet management's criteria. Hence, the System identifies market areas without the use of political divisions such as cities, county lines, or state lines. Although the marketing profession has long recognized that markets normally know no political boundaries, little has been done to provide an alternative method of describing a market area. It is the author's belief that if market areas were delineated in the manner described above, marketing managers would be able to tailor their promotional and selling efforts to a far greater extent than at present. Specifically, local newspaper, radio, and point-of-purchase promotions could be especially tailored to the unique product mix, customer types, or both contained in a unique market area.

Distribution territory analysis becomes important when a firm operates multiple distribution points. As defined in Chapter I, a distribution territory refers to a definable area based on analysis of the physical flow of products in terms of minimizing the transportation, warehousing, order handling and processing costs, and interest cost on pipeline inventory consistent with a speed of delivery which allows the company to be competitive. Therefore, the boundary line between any two distribution territories occurs where:

(a) regardless of which distribution point is used, identical costs are required and identical service can be given (a point of indifference, between the costs of two distribution points)

(b) on one side of the line minimum costs are realized from shipping from one distribution point, while on the other side of the line minimum costs are realized from another distribution point.

In a multi-product firm it is highly probable that distribution territories based on costs and speed of service are not the same for all products or all sizes of shipments. The use of the System to identify distribution territories requires the analysis of the supply costs of each product for each control unit, together with the time required to supply the products from each potential distribution point. The boundary line for a distribution territory is established between the adjacent blocks which meet condition (a) or (b) above. Thus, the System identifies distribution territories by agglomerating the necessary control units on the basis of economic considerations (supply costs) and service considerations (time requirements).

Accounting for Geographic Variable Costs

The third application of the System relates to its use in determining the geographic efficiency of marketing activities. By using the control units as cost centers for identifying all direct distribution costs and for reporting the revenues realized from each control unit, a geographic yardstick is provided for measuring, comparing, and controlling marketing efficiency.

The information gathered on the basis of the System can be combined with an accounting system that is designed for the control of distribution activities by measuring the profit contribution of various combinations of marketing strategies used in each "market area" defined by the grid system.

Donald W. Drummond, in an article entitled "A Marketing Yardstick," presents an accounting system for the control of marketing activities.[2] He reports that the result the first year after inaugurating the system in a division of Olin Mathieson Chemical Corporation was a 95 percent increase in net profits with only a 5 percent increase in sales. This was accomplished without drastic reduction in selling costs or the introduction of new products. It was accomplished because the analysis revealed situations and transactions which diluted the net profits, and permitted management to take the appropriate action.

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[2] Donald W. Drummond, "A Marketing Yardstick," <u>Transportation and Distribution Management</u>, Feb., 1962, pp. 13-16.

One of the major features of the system inaugurated by the division of Olin Mathieson involves the starting point from which costs are deducted. Drummond calls attention to the shortcomings of the current method of using "net sales" as the initial figure from which cost of sales is deducted. The use of "net sales" results in the loss of important cost information, in that this figure omits deductions for [illegible] freight equalization or allowances, price allowances, cash discounts, and other activity costs. In place of "net sales" he suggests that a "gross sales" figure be used. Gross sales he defines as the top dollar that could possibly be realized for the product. Although this is a loose definition, it appears that what he means is that a realistic list price should be established for each product and then "gross sales" computed by multiplying the units sold times the list price for each product in the line.

The system of accounting used to determine profit and loss and for income tax purposes must, by the nature of its objectives, concentrate on the actual dollars exchanged and actual costs which required dollar outflows by the firm. It is because of this orientation that such "costs" as freight equalization or allowances, price allowances, cash discounts, and others are not recorded as costs of making a particular sale. These "costs" represent opportunity costs, since the only reason for granting such concessions should be that the sale would not have been made without them. Therefore, it seems reasonable to assume that such concessions are valid "costs" of making a particular sale for, even though no dollars flowed out of the company, fewer dollars flowed in. Thus, by adopting Drummond's concept of "gross sales" as the starting point for distribution cost analysis, a more complete picture is obtained for distribution cost control. The advantage of the "gross sales" accounting method is that any time the actual price realized is lowered due to granting special allowances, discounts, or concessions, the difference between the list price and the actual price realized must be identified as a cost to the marketing activity or activities granting the difference.

Using the gross sales for a geographic distribution cost control system, the procedure is as follows:

(1) Subtract from Gross Sales the sum of the Manufacturing Costs up to the loading platform for all products sold. Manufacturing Costs are defined as all costs incurred in producing the good until the good comes off the end of the production line.

(2) Subtract all direct costs of Servicing Demand from (Gross Sales minus Manufacturing Costs).

Direct costs of Servicing Demand include all costs of storage and movement from the end of the production line to the buyer's location which can be directly allocated to product sales in a given geographic control unit.

(3) From (Gross Sales minus Manufacturing Costs and direct costs of Servicing Demand) subtract all direct costs of Obtaining Demand. Direct costs of Obtaining Demand are defined as all the costs of the activities which possess the common function of obtaining demand for the firm and can be allocated to sales in a given geographic control unit.

(4) From the results in (3) above, subtract any General Marketing Expenses which are directly allocable to a specific geographic control unit.

(5) The resulting figure is a measure of distribution efficiency in each geographic area, and it serves as a basic geographic indicator of performance.

When the system above is applied to products and customers in individual markets (identified by an agglomeration of control units), meaningful information is obtained to measure distribution efficiency. Such an application allows management to answer the question, "What is the difference in the contribution to profit and overhead if product C is sold in market A rather than in market B?" This is possible because the starting point, "gross sales," was defined as the highest dollar that could possibly be realized for each product and because the geographic nature of direct costs is identified at its source. The control system does not start with the dollar inflow which did occur, but from one which is realized in the optimum situation. Hence, the method accounts for opportunity costs as well as actual costs (i.e., the difference between selling the product in market A which produced $1.75 in net contributions, and selling it in market B which would have produced $2.00 in net contributions). The results of the method provide an approximation of a geographic marginal approach to the allocation of marketing costs. The economic solution to the geographic variations in contributions to profit and overhead would be to allocate more marketing activities (costs) to those areas having higher contributions until the contribution of the next unit sold in all areas would be equal to the costs required to sell the unit.

Although economic theory provides a guideline for allocation of marketing activities among the control units, it would provide only a short run answer. Certainly many considerations beyond costs must be included in long range marketing plans which affect short range allocation of marketing activities. However, the basic geographic indicator of marketing performance can serve as a useful tool to analyze the geographic impact on the costs of marketing activities and functions.

Testing The System

After development of the geographic control unit and the method for geographic accounting, the System is now ready to be applied to the company data for an empirical test of its impact in various areas. The empirical testing of the System consists of the following:

1. Geographic evaluation of marketing activities. The purpose of geographic evaluation of marketing activities is to determine the geographic variability of product flows and revenues generated. At present the studied company uses the state unit as the smallest geographic unit in classifying distribution activities. The impact of the control unit in determining geographic variability of activities will be measured by taking the states of New York and Georgia and first looking at these states as the geographic control units, then looking at the System units which collectively make up the states as the geographic control units. The

comparison of the state units to the grid control units for measuring geographic variability of marketing activities in New York and Georgia will be based on the following:

(a) Total Dollar Sales by state unit
by grid block

(b) Total Pound Sales by state unit
by grid block

(c) Compute:

(i) Average sales per grid block (by dollars and product) by dividing total sales in the state by the number of grid blocks in the state.

(ii) The variance of block sales.

The objective of testing the grid blocks against the state unit is to determine if the grid block system can provide a more significant breakdown of marketing flows and activities at their source and thus provide a better basis for decisions involving marketing effort.

2. Evaluating geographic variability of costs. Throughout earlier sections the importance of the geographic variability of costs has been emphasized. In this particular section the geographic variability of costs is studied by the following procedure:

(a) Pick two products of the firm which are very different in their physical characteristics.

(b) Pick a standardized shipment for each product.

(c) Determine an east-west vector composed of adjacent grid block control units across a state.

(d) From a given warehouse determine the cost of each standard shipment to each block in the east-west vector. The cost includes warehousing, order processing and handling, transportation costs, and an interest cost on the shipment while it is in the pipeline.

(e) Compare the average block costs for each standardized shipment to the actual block costs and determine the variance.

Although the analysis includes only the costs of servicing demand, the methodology would be the same for costs of obtaining demand. By determining the direct costs per control unit for each demand-obtaining activity, the geographic variance of their costs is uncovered.

3. Establishing distribution territories. This section tests the ability of the control units to establish the costs of servicing demand and to subsequently identify distribution territories based on the geographic variability of costs. The design of the test follows.

(a) Select two patterns of distribution, one direct from a factory to customer and the other from a distribution point to the customer.

(b) Identify an east-west vector of control units which lies between the two points.

(c) Pick two products which are very different in their physical characteristics.

(d) Develop a standardized shipment for each product.

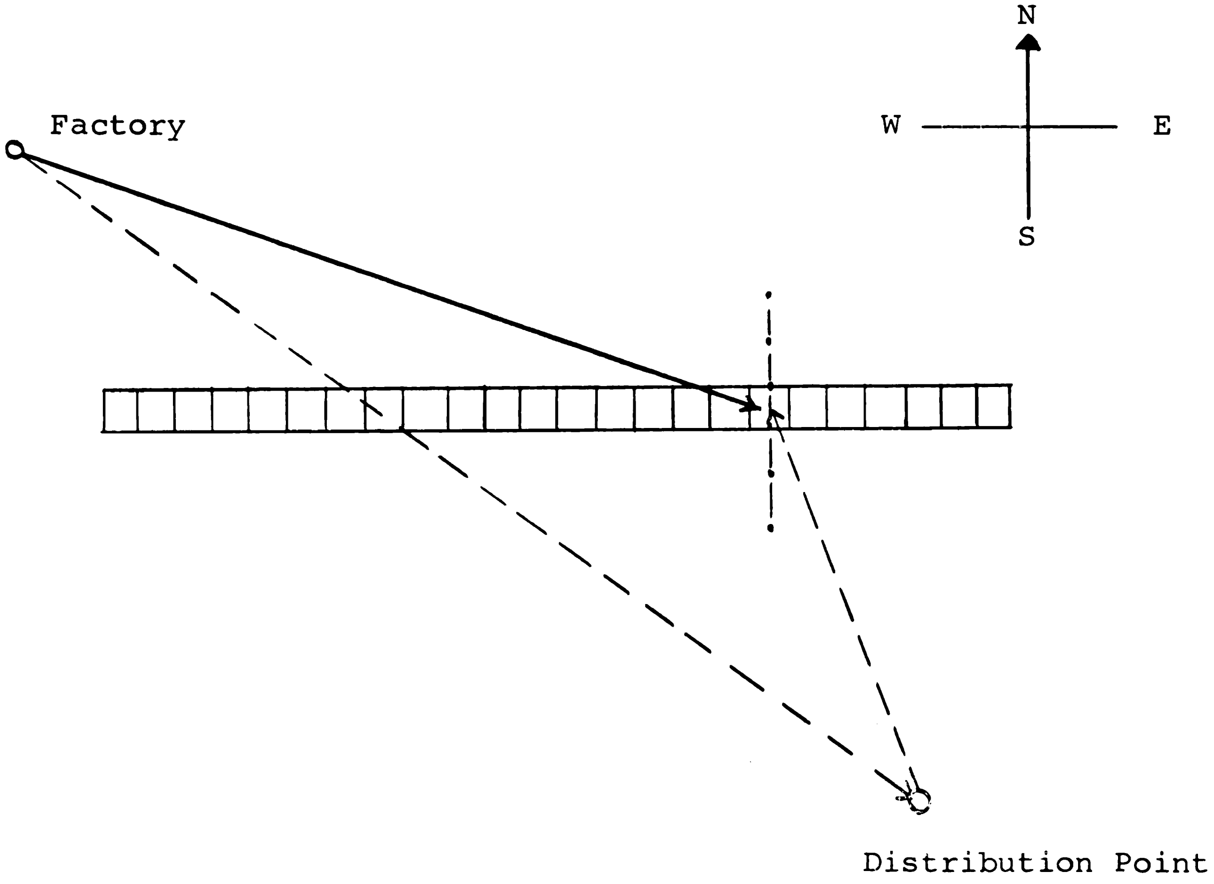
(e) Compute the costs of servicing demand in each control unit of the east-west vector for both the direct shipments from the factory to the customer and from the factory to the distribution point to the customer.

(f) Determine the adjacent block numbers in which the costs of both patterns of shipments are equal or where one block favors one pattern and the adjacent block favors the other pattern. The costs included for comparison are the transportation, order processing and handling, warehousing, and pipeline inventory costs for each pattern of shipment in each block.

Figure 9 portrays the location of the factory, distribution point, and the east-west vector.

FIGURE 9

THE LOCATION RELATIONSHIP BETWEEN THE FACTORY, DISTRIBUTION POINT, AND VECTOR USED TO ILLUSTRATE DISTRIBUTION TERRITORY DETERMINATION



——→ Direct shipment from plant to customer

- - - → Shipment to distribution point and then to customer

—·—·—· Line of equal costs between methods of shipment or line where adjacent blocks favor different methods

CHAPTER V

FINDINGS

Introduction

In this chapter the results from applying the System to the corporation's records are presented. The first section reports the results from comparing the state to the spherical block as the control unit for geographic evaluation of marketing activities. The second section presents the application of the System for evaluating the geographic variability of costs. The third section deals with the findings from using the System to determine distribution territories.

Geographic Evaluation Of Marketing Activities

As mentioned in Chapter IV, the studied company currently uses states as the geographic control units to analyze marketing activities. For this reason the analysis of marketing activities was first determined using the states of New York and Georgia and then using the spherical control units which collectively covered the two states. The objective of the test is to determine if the grid block system can provide a more meaningful analysis of revenues generated and the flow of goods and thus provide a better basis for decisions involving the allocation of marketing effort.

The first step involved identifying the vertical and horizontal scale numbers for all of the spherical grid control units contained within the two states. This identification was performed by using for each state a set of maps on which the grid system had been drawn to scale. Because the scale of the maps was so low (1:1,000,000), it was impossible to reduce the New York and Georgia maps for illustration here without losing a significant amount of detail. Therefore, the New Hampshire-Vermont map is provided in Appendix II as an example.

A problem arises when a particular control block lies across a state line and contains parts of two states. Since the company studied used state identification on the original records, it was possible to determine which shipments in a control block containing two states belonged to each respective state. If a company desiring to incorporate the System wishes to know the division of marketing activities by states as well as by the control units, it would necessitate a two-digit state identification number on the respective records as well as the six-digit grid block identification number. Identification of the states of New York and Georgia in terms of the grid blocks produced 3,647 control units in New York and 3,571 control units in Georgia. After placing the specific control unit identification number for the point of origin and destination on the various company records, it was possible to identify the sales and shipments in the respective states by the specific grid blocks involved. This identification involved reading all the cards onto a tape and then using a tape sort program to sort the sales and shipments by point of origin, point of destination, by product, and by other variables of interest.

Appendix III contains a reproduction of a page of the computer print-out when the sort routine called for a sort by origin block to the destination block showing the dollars, pounds, products, container code, and customer for each shipment. The next sort was made by destination block and showed the total dollar sales and pounds shipped to each destination block without considering the origin blocks of the shipments. From the sort by origin block complete information was obtained concerning where a shipment originated, where it went, to whom it went, what products were in the shipment, and what respective quantities as well as container sizes were involved for each product shipped. The sort by destination block provided the total annual sales in each grid block in terms of total revenue realized from each block and total pounds shipped to each block.

There are several ways the dollar and pound sales figures or other types of data for the two states can be geographically analyzed. The analysis could proceed by using the entire state as the unit of comparison, as the company is currently doing. Another method is to use the total number of grid blocks contained in each state and compute the mean average dollar and pound grid block sales within each state together with the standard deviation and coefficient of variation of the block sales. The standard deviation is a measure of the dispersion of the respective block sales around their mean value. If the standard deviations of sales from two states are compared to each other, the result is a comparison of their absolute variations from their means and provides insight into the absolute uniformity of sales between states. The significance of difference between the standard deviations need not be tested, since the data for each state are not samples and any observed difference is significant. The coefficient of variation measures the relative variability of a series. Therefore, when the coefficients of variation from two series are compared, a measure of relative variability between the two series is achieved. The typical symbol for the coefficient of variation is V. The computation is made by dividing the standard deviation of each series by its respective mean. Hence, the measure of uniformity (standard deviation) becomes relative to the size of the mean of the series being studied.

A third method of analysis is to compute the mean average, standard deviation, and coefficient of variation on the basis of including only those grid blocks within a state which actually contain sales. The rationale of this method lies in recognizing that it was not the entire state, but only certain parts of the state that produced the sales.

The final method of analysis is to completely drop the state as a unit and view each grid block as the relevant unit of analysis by making individual comparisons among the blocks.

Each of the analytical methods presented is computed and evaluated in the following sections. The evaluation considers the relative ability of each method to evaluate marketing activities on a geographic basis. Whether the analysis is based on gross dollar and pound sales or sales by product, customer type, or container size, the ability to pinpoint marketing activities geographically provides feedback information important to marketing management for allocating time, men, and money in the proper relationship among widely dispersed areas of sales.

Geographic Analysis Using State Units

Comparison of the marketing activities of the company based on state control units led to the following analysis for one year's sales in New York and Georgia.

Total Dollar Sales
New York: $4,073,912.40
Georgia : $ 542,451.00

Total Pound Sales
New York: 1,706,770
Georgia : 343,057

A basic analysis of these totals leads to the conclusion that the New York market generated approximately seven and one-half times the gross dollar sales of the state of Georgia from shipments of less than five times the pounds shipped to Georgia. Obviously the company would also wish to analyze exactly what products were purchased in each state, by whom, and in what quantities. However, the evaluation of the gross dollar sales and pounds sold will suffice to illustrate the difference in the methods of analysis.

Geographic Analysis Based on Total Number of Grid Blocks Within A State

Using the total number of grid blocks within which each state is contained results in the following analysis.

Average grid block dollar sales
New York: \$4,073,912.40/3647 = \$1,117.06
Georgia : \$ 542,451.00/3571 = \$ 151.90

Average grid block pound sales
New York: 1,706,770/3647 = 467.99 or 468 lbs.
Georgia : 343,057/3571 = 96 lbs.

In order to determine the dispersion of the individual block dollar and pound sales around the mean averages, the respective standard deviations were computed with the following results.

Standard Deviation of Dollar Sales
New York: \$13,540.80
Georgia : \$ 3,786.75

Standard Deviation of Pound Sales
New York: 6,241.3
Georgia : 2,073.8

The coefficients of variation (relative measure of dispersion) of the two dollar series are:

$$\text{New York: } V = \frac{\$13,540.80}{\$\ 1,117.06} = 12.12$$

$$\text{Georgia : } V = \frac{\$3,786.75}{\$\ \ 151.90} = 24.93$$

The rationale underlying the preceding calculation is the belief that the comparison of marketing activity in each state is best accomplished by analyzing state data on the basis of the total area of each state in terms of its total number of grid blocks. This philosophy produces the following comparison of New York and Georgia. The average block dollar sales in New York is a little more than 7.3 times the average in Georgia, while the average pounds shipped per block in New York equals approximately 5.4 times the average in Georgia. The reason these calculations are so close to the figures computed when the entire state was used as the unit of comparison is because of the small difference in the total number of grid blocks within the two states. Had the comparison been made between New York and Rhode Island, the two sets of data would have been significantly different.

An analysis of the uniformity of sales between the two states shows an extreme difference. Comparison of the standard deviations of the two states shows that there is approximately 257 percent greater <u>absolute</u> variation in the grid block dollar sales in <u>New York</u> than in Georgia. However, comparison of the coefficients of variation reveals that there is approximately 106 percent greater <u>relative</u> variation in <u>Georgia's</u> grid block dollar sales than in New York's. Therefore, Georgia possesses greater absolute uniformity in grid block dollar sales, while New York possesses greater relative uniformity. It is important to determine the variation in a series of data in order to establish how well the mean describes the series. The greater the variation of a series, the further the individual values vary from the mean, which causes the mean to be a poor description of the individual values. Since Georgia possesses the smaller standard deviation, its mean describes the individual values more closely than does New York's mean.

Comparison of the standard deviations for pound sales reveals that New York has approximately 201 percent greater absolute variation than Georgia in block pound sales.

The respective coefficients of variation for block pound sales are:

$$\text{New York:} \quad V = \frac{6,241.3}{468} = 13.34$$

$$\text{Georgia :} \quad V = \frac{2,073.8}{96} = 21.60$$

A comparison of the coefficients shows that although New York has approximately 201 percent greater absolute variation in pounds sold per grid block, Georgia has almost 62 percent greater relative variation. Hence, the analysis of pound sales per block parallels the dollar sales per block, with Georgia having greater absolute uniformity and New York having more relative uniformity. Further analysis reveals that the average grid block dollar sales in New York is $965.16 greater than in Georgia, while the average pound sales in New York is 372 pounds greater than in Georgia.

State Geographic Analysis Using Only Grid Blocks Containing Sales

An alternative procedure to using all the grid blocks within a state consists of evaluating each state by considering only the blocks which contained sales. The logic of this procedure stems from the ability to identify the specific blocks and their location within the state where sales occurred.

The analysis of sales in New York and Georgia using only the grid blocks which contained sales produced the following data.

	New York	Georgia
Total blocks within the state	3647	3571
Number of blocks containing sales	274	62
Percentage of blocks containing sales	7.45%	1.74%

Average dollar sales per block for blocks containing sales:

New York: $\frac{\$4,073,912.40}{274} = \$14,868.29$

Georgia : $\frac{\$542,451.00}{62} = \$8,749.00$

Average pound sales per block for blocks containing sales:

New York: $\frac{1,076,770}{274} = 6,229$

Georgia : $\frac{343,057}{62} = 5,533$

Range of dollar sales:

New York: $462,714.50 to $10

Georgia : $205,318.80 to $5.20

Range of pound sales:

New York: 251,210 to 1

Georgia : 106,950 to 1

Standard deviation of dollar sales:

New York: \$47,345.85

Georgia : \$27,398.70

Standard deviation of pound sales:

New York: 21,968.4

Georgia : 14,752.4

Coefficient of variation of dollar sales:

New York: $V = \frac{\$47,345.85}{\$14,868.29} = 3.18$

Georgia : $V = \frac{\$27,398.70}{\$\ 8,749.} = 3.13$

Coefficient of variation of pound sales:

New York: $V = \frac{21,968.4}{6,229} = 3.53$

Georgia : $V = \frac{14,752.4}{5,533} = 2.67$

Evaluation of the data above provides some new data of importance and reveals some drastic changes from the data provided by comparing the states on the basis of all the blocks contained within each state.

The new data are provided by determining what percentage of the total area within each state (the total number of grid blocks in a state) actually contained sales. As shown in the data above, New York had the highest percentage, 7.45, while Georgia had only 1.74 percent. Within these areas New York had the largest range of both dollar and pound sales.

It may be recalled that the comparison of the states based on all the grid blocks showed the average dollar sales per block in New York was a little more than 7.3 times the average in Georgia, while the average pounds sold per block in New York equaled almost 5.4 times the average in Georgia. Using the data based solely on the blocks containing sales within each state, the comparison shows that New York's average sales per block is approximately 1.7 times as great as in Georgia, while average pound sales per block in New York is approximately 1.1 times Georgia's average. The drastic reduction in these ratios from the earlier ratios based on all the grid blocks within each state occurred because of the larger relative number of grid blocks in Georgia which contained no sales. When these blocks containing no sales were included in the basis of comparison, they lowered Georgia's average dollar and pound sales per block.

The comparison of uniformity between the two states was also affected by the inclusion of so many blocks having no sales when all grid blocks within a state were considered. Using only the blocks within each state which contained sales, the data above show that New York has only 72 percent greater absolute variation in dollar sales than Georgia, compared to 257 percent greater absolute variation when all blocks were considered. Absolute variation in block pound sales dropped from New York's 201 percent greater variation than Georgia to 49 percent greater variation than Georgia. The drastic reduction resulted from omitting all the blocks in both states which had no sales. Since Georgia contained a greater number of these blocks and they are completely uniform--all having zero sales, the standard deviation of Georgia's sales was increased more than New York's and the relative difference between the two standard deviations was narrowed.

A comparison of the relative variations of dollar and pound sales from the data above shows a complete reversal of relationships from those found when all grid blocks within a state were analyzed. Comparison of the coefficients of variation for the data including only blocks having sales within each state reveals that New York has almost 16 percent greater relative variation in grid block dollar sales than Georgia and 32 percent greater relative variation in block pound sales. This contrasts with Georgia's 106 percent greater relative variation in block dollar sales and 62 percent greater relative variation in block pound sales when all grid blocks within the state were included. Therefore, the viewpoint of a market analyst in determining what the appropriate unit shall be for comparing marketing activities between states has a major impact on the data he uses for evaluation and, as shown above, can drastically change or even completely reverse the relationships between states.

Geographic Analysis by Individual Grid Block

While all of the methods of evaluation thus far have viewed the state in various ways as the relevant unit for geographic analysis of marketing activity, the present method views each individual grid block as the relevant unit of analysis. The fundamental reason for this view is that markets normally do not follow political boundaries.

Although the method initially evaluates each grid block as a separate unit, the next step is to combine adjacent blocks or blocks having a close proximity to each other in order to delineate present sales "areas." These areas can, and often will, cross state boundaries. The marketing activities analysis using this method includes not only gross dollar and pound sales, used to illustrate the method here, but also individual product's sales, sales by customer type, size of orders, and other meaningful information needed for planning and controlling marketing effort.

Individual comparison of the New York and Georgia grid blocks resulted in the ranking of grid blocks on the basis of total dollar sales and pounds sold within each block. Tables 6 and 7 show the comparisons for the top twenty-one grid blocks. These rankings represent the top twenty-one blocks from the 336 blocks which contained sales in the two states.

Inspection of the tables shows that Georgia contained the fourth, seventeenth, and twenty-first ranked grid blocks in terms of block dollar sales. In terms of block pound sales Georgia contained the fifth, fourteenth, eighteenth, and twentieth ranked grid blocks. Ranking the grid blocks for evaluation and comparison is justified because the units are basically homogeneous in size.

The data derived from individual block comparisons provide greater ability to pinpoint marketing activity. All of the various aggregate state methods showed New York as having the highest average dollar and pound block sales. Although this is true, the individual block comparison showed that Georgia contained the fourth most important grid block in terms of dollar sales per block. The analysis by

TABLE 6

THE TOP TWENTY-ONE GRID BLOCKS FROM NEW YORK AND GEORGIA BASED ON GROSS DOLLAR SALES

Rank	State	Block Number	Dollar Sales
1	New York	139-849	$462,714.50
2	" "	147-832	347,655.10
3	" "	113-754	328,974.80
4	Georgia	262-669	205,318.80
5	New York	114-832	203,281.60
6	" "	149-833	181,026.30
7	" "	109-774	176,316.00
8	" "	131-853	155,223.30
9	" "	112-791	128,960.80
10	" "	141-843	109,465.70
11	" "	110-780	93,688.00
12	" "	132-833	90,267.40
13	" "	110-796	80,869.10
14	" "	144-832	74,245.00
15	" "	148-834	66,740.10
16	" "	143-839	62,784.20
17	Georgia	243-656	60,242.30
18	New York	108-808	49,229.00
19	" "	143-832	49,090.60
20	" "	146-832	48,028.10
21	Georgia	287-718	47,443.60

TABLE 7

THE TOP TWENTY-ONE GRID BLOCKS FROM NEW YORK AND GEORGIA BASED ON GROSS POUNDS SOLD

Rank	State	Block Number	Pound Sales
1	New York	147-832	251,210
2	" "	139-849	139,736
3	" "	114-832	117,505
4	" "	113-754	115,528
5	Georgia	262-669	106,950
6	New York	149-833	97,977
7	" "	110-811	60,692
8	" "	143-832	55,483
9	" "	109-774	50,535
10	" "	146-834	39,574
11	" "	141-843	34,810
12	" "	148-834	33,838
13	" "	131-853	33,244
14	Georgia	271-655	31,684
15	New York	110-780	31,101
16	" "	108-808	30,944
17	" "	144-832	30,669
18	Georgia	243-656	26,992
19	New York	143-839	24,581
20	Georgia	287-718	24,512
21	New York	112-791	23,447

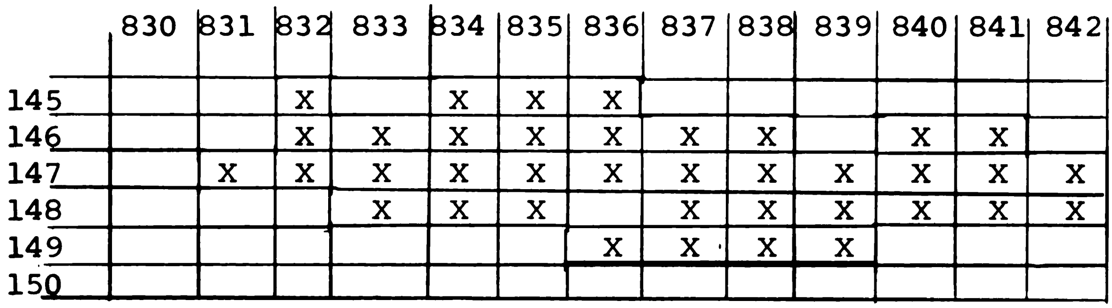
individual block not only allows relative ranking of basically homogeneous units (in size) but also identifies the exact location where the activities took place. Therefore, individual block analysis yields superior means of pinpointing marketing activity and hence provides a better basis for evaluating and allocating marketing activities than do the aggregate methods based on averages and measures of dispersion. The superiority of individual unit analysis stems from its ability to account for the exact differences by location in grid block marketing activity rather than simply measuring them by means of a standard deviation or coefficient of variation.

Admittedly the division of a company's marketing activities by grid blocks is partially arbitrary. To overcome this limitation the next step is to combine adjacent blocks possessing the activity being studied to determine activity "areas." For example, if a certain product's sales are being evaluated, then adjacent blocks containing the sales of the product would be combined to form the sales "areas" of the product.

To illustrate the procedure the dollar block sales were combined to identify certain sales areas. The most important area in New York appeared on the grid scale as shown in Figure 10. The dollar sales generated from this area

FIGURE 10

DELINEATION OF A SALES "AREA" USING ACTUAL DOLLAR BLOCK SALES FOR ADJACENT BLOCKS



Vertical Scale Number	Horizontal Scale Number												
	830	831	832	833	834	835	836	837	838	839	840	841	842
145			X		X	X	X						
146			X	X	X	X	X	X	X		X	X	
147		X	X	X	X	X	X	X	X	X	X	X	X
148				X	X	X		X	X	X	X	X	X
149							X	X	X	X			
150													

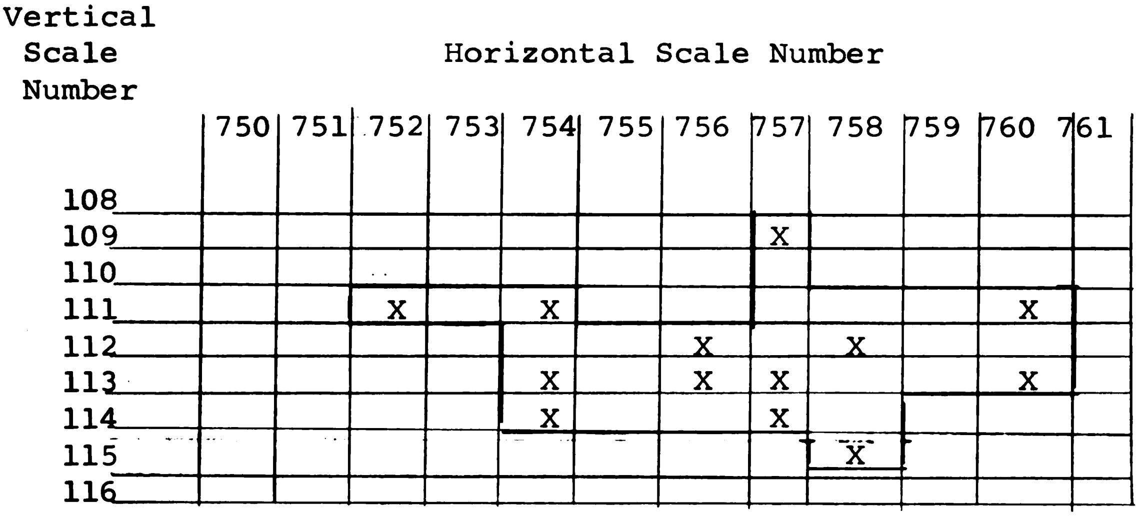
X = a block containing sales
___ = boundary line of the area

containing 38 grid blocks equal $720,667.80, or almost 18 percent of the total sales within the state. This sales area is wholly contained in Long Island and would not have been a difficult task for a company to uncover without the grid blocks because of its geographic configuration. However, the second "area" would be difficult since it is not a distinctive geographic area. In the second area the blocks were aggregated on the basis of having a close proximity to each other. Figure 11 shows the blocks and corresponding area delineated.

The area in Figure 11 contains 13 of the 274 blocks in New York which had sales. The total sales in the area equal $354,295.10, which is equivalent to almost 9 percent of the total sales within the state.

FIGURE 11

DELINEATION OF A SALES AREA USING ACTUAL DOLLAR
BLOCK SALES FOR BLOCKS IN CLOSE
PROXIMITY TO EACH OTHER



Vertical Scale Number	750	751	752	753	754	755	756	757	758	759	760	761
108												
109								X				
110												
111			X		X						X	
112							X		X			
113					X		X	X			X	
114					X			X				
115									X			
116												

In the same manner that sales "areas" were delineated above for gross sales, other areas based on sales by product or by customer type, etc., can also be determined. The determination of these areas would be extremely helpful in planning promotional campaigns, buying local radio time, routing salesmen, and other activities where geographic selectivity could help maximize the efficiency per dollar spent.

Determining Geographic Variability Of Costs

In several parts of this dissertation the geographic variability of marketing costs has been discussed. The purpose of this section is to use the grid block control units as geographic cost centers for marketing cost accounting. The application which follows deals with the use of the grid blocks as cost centers for determining the marketing costs of servicing demand. The coding of the various internal corporate records by the destination grid block numbers provides a large amount of cost information on each block serviced. For example, the coding of the freight invoices supplies information concerning the carriers which have been used, costs sustained in using the carriers, and different transit times for shipments. Therefore, the geographic variability of transportation costs and interest cost on inventory in transit to a specific block location is automatically provided by coding the freight invoice. It is important to note that from any given distribution point the transportation cost and pipeline inventory costs comprise the total costs which vary geographically.

Although the coding of the corporate shipping records provides current information on geographic variable costs of servicing demand, this information is available only for shipments from a given origin to the actual blocks receiving shipments. Ideally the cost should be available for all blocks so that the costs of servicing demand can be determined for blocks in which future sales may occur. This requires the construction of a generalized cost accounting system based on the actual cost data available. It seems appropriate to determine the total costs of servicing demand in each block rather than account for only the geographic variable costs. Therefore, the generalized accounting system was constructed as follows.

Distribution Point

The major distribution point of the company was picked as the point of origin for the customer block shipments. It shall be referred to as Point A.

Destination Points

The destination points were determined by choosing an east-west vector of grid block units across the state of New York, which included block 126-741 through block 126-839. Thus, the vector represents 99 cost centers. It is interesting to note that the company had sales in 37 of the blocks contained in the vector.

Products

Two products were selected from a list of the top ten products in dollar sales. The shipment costs for each product were based on a container size of 440 pounds. For the container selected, Product A has a value of $2,090 and

Product B's value is $255.20. The products were selected purposely for their different values in order to have different pipeline inventory costs.

Total Costs

The total costs of each product from the distribution point to a specific block included the following:

Costs from Factory to Distribution Point

Transportation Costs (per unit)		$2.24
Storage Cost at the Factory (per unit)		.50
Handling Costs (per unit)		1.00
Packing List Costs (per unit)		.03
Order Processing Costs (per unit)		.06
Pipeline Interest Costs	Product A	1.57
	Product B	.17
Total Cost to Distribution Center	Product A	5.40
	Product B	4.00

Distribution Center Costs

Transportation Costs to the Block	$variable
Storage Charges (per unit)	.45
Handling Charges (per unit)	.90
Packing List Charges (per order)	.25
Order Processing Charges (per order)	.50
Pipeline Interest Costs	variable
Total Cost to the Block	

The costs from the factory to the distribution point were obtained from cost analysis of the current shipments to the distribution point. Currently the company does not account for a pipeline interest cost on inventory in transit.

Therefore, the pipeline interest cost was computed by determining that the transit time from the factory to the distribution point equaled four days and then charging a 6 percent interest rate on inventory. Since the distribution point is a public warehouse, all of the costs except transportation and pipeline interest costs are covered by contract.

Transportation Costs to the Blocks

Although the transportation costs to the 37 blocks containing sales were available, a method was needed to determine the transportation costs to the 62 blocks without sales. Since the company ships to customers by truck, the following procedure was used to study motor carrier freight rates. The main factory and two distribution points were selected. From each of the points vectors were established in north-south, east-west, northeast-southwest, and northwest-southeast directions. Various cities in each vector, multiple distances from the points of origin, were identified and the tariffs were used to determine the rates. The rates were recorded for 29 freight classifications for each weight break. A linear regression line was then fit to the rates for each freight classification and each weight break. This procedure allowed the regression line to describe the association between transportation costs and miles, given the knowledge of what freight class and weight break were involved in the shipment. Three hundred forty-three regressions were computed with the coefficients of correlation ranging from .999806 to .973945 and coefficients higher than .99 occurring in 297 of the blocks. The high coefficients of correlation established that motor carrier rates are basically linear. This linearity permitted the use of the linear equations computed for determining transportation costs on the basis of the miles being shipped, given the freight classification of the product and weight involved in the shipment. Appendix IV shows a page of the computer output from the linear regression analysis of motor carrier freight rates.

Determining the Highway Miles to the Control Blocks

The use of the regression equations for determining transportation costs requires that the highway distances from the origin point to each specific block be known. For the 37 blocks which contained sales, this information was available. The major problem consisted of determining highway miles which show the highway distances from the distribution point for blocks not having past records. One possible solution was to use The Household Goods Carriers' Bureau Milage Guide which reports the highway milages among

775 key shipping points in the United States. Two disadvantages to the use of the milage guide are that it requires a manual look-up, which is time consuming, and only 775 points are reported.

Because the grid control units are based on latitude and longitude measurements, the airline distances between the centers of blocks are readily computed by using the computer program presented in Appendix I. The next problem involves determining if there is some relationship and conversion which can be made to translate the airline milages between blocks into highway milages. Donald E. Church, Chief of the Transportation Division, Bureau of the Census, reports the use of standard conversion factors by the Bureau. The air miles are increased by factors of 25 percent for determining short-line rail miles and 15 percent for highway direct route distances.[1] Because of the vast differences in topography and directness of highways between points in various areas of the country, the Bureau's standard factor was tested against the 37 blocks with known highway milages. First, the airline miles were computed from distribution point A to all 99 blocks in the vector. Next, the airline

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[1] Donald E. Church, PICADAD--A System for Machine Processing of Geographic and Distance Factors in Transportation and Marketing Data (Washington: U.S. Department of Commerce, Bureau of the Census, June 6, 1961).

miles were compared to the known highway miles for the 37 blocks which contained sales. The comparison consisted of computing the ratio of the actual highway miles to the airline miles for each of the blocks and then computing the ratio of total highway miles to total airline miles for all the blocks. The ratios appear in Table 8.

TABLE 8

A COMPARISON OF ACTUAL HIGHWAY MILAGES TO AIRLINE MILAGES FROM DISTRIBUTION POINT A TO 37 BLOCKS IN THE NEW YORK VECTOR

Block Number	Highway Miles (to the town)	Airline Miles (to center of block)	Ratio
126-743	388	294.229	131.87
126-744	383	291.167	131.54
126-745	379	288.109	131.55
126-746	375	285.055	131.55
126-747	372	282.005	131.91
126-748	370	278.959	132.63
126-749	367	275.918	133.01
126-758	342	248.766	137.47
126-759	339	245.777	137.93
126-760	334	242.794	137.56
126-761	330	239.818	137.60
126-762	323	236.849	136.37
126-763	316	233.886	135.11
126-765	310	227.985	135.97
126-766	304	225.045	135.08
126-768	297	219.192	135.50
126-773	284	204.723	138.72
126-777	265	193.343	137.06
126-780	253	184.945	136.80
126-781	250	182.174	137.23

TABLE 8--Continued

Block Number	Highway Miles (to the town)	Airline Miles (to center of block)	Ratio
126-787	226	165.906	136.22
126-788	222	163.262	135.977
126-789	220	160.639	136.95
126-790	216	158.039	136.67
126-791	215	155.464	138.30
126-795	185	145.426	127.212
126-797	183	140.586	125.46
126-799	178	135.882	131.00
126-800	173	133.586	129.50
126-801	171	131.330	130.21
126-809	153	114.979	133.07
126-816	136	103.911	130.88
126-827	120	95.221	126.02
126-832	112	95.496	117.28
126-833	116	95.879	120.10
126-834	119	96.370	123.48
126-839	141	100.368	135.99
Totals	9467	7073.083	133.845

Clearly the conversion ratio of 1 to 1.15 reported by Church could not be used to convert airline miles into highway miles for the New York vector. Possibly the topography and means of highway construction in New York caused the higher ratios than the national average reported by Church.

In evaluating the individual ratios for each block, it is important to remember that the airline distances were computed from the <u>center</u> of the origin block containing distribution point A to the center of each block in the vector, while the highway miles were measured from the actual distribution point to a specific town within each block. In most cases the towns were not located at the center of their blocks, which resulted in comparing highway and airline miles to different points. The difference between points measured to compare airline and highway miles, combined with the small incremental differences in miles between two adjacent blocks, undoubtedly caused the ratios to fluctuate and appear less stable than they really are. The average difference between highway miles to specific cities and airline miles to the center of each corresponding block equaled 6.28 miles, with a standard deviation of differences of 3.03 miles. Unfortunately, highway distances to the center of each block were not available, for the majority of blocks did not contain highways which passed through their centers. The lack of a common base for comparing the two measurements undoubtedly caused the average difference and standard deviation of differences to be higher than the figures which would have resulted from a common basis of comparison. However, the comparison provides illuminating information for determining how closely the generalizing of distances by using measurements to the center of the blocks can come to estimating distances to specific points within a block. The distances of shipments to the 37 blocks ranged from 394 miles to 112 miles. Therefore, the percent of error in using airline miles to estimate highway miles was not extremely large.

The estimated highway miles from the center of the block containing distribution point A to the center of each block were computed. The ratio used (1.33845) represented the ratio of total highway to total airline miles for the 37 blocks in the New York vector which contained sales. The estimated transportation costs for a 440-pound shipment of Product A based on the estimated highway miles to the center of each block were then compared to the actual transportation costs to the specific town within each block. Table 9 presents the comparisons.

The differences between the estimated costs to the center of each block and actual costs of shipping to the specific towns in each block were calculated as a percentage of the actual costs. If these percentages are considered as the relative error in estimating actual costs of specific shipments by using the transportation cost regression equations and highway miles estimated from airline miles, then the range of error for the 37 blocks is from a little less than 3 percent to a little more than .2 of 1 percent. The average "absolute" error (signs neglected) is slightly more than .96 of 1 percent.

TABLE 9

A COMPARISON OF ACTUAL TRANSPORTATION COSTS TO ESTIMATED TRANSPORTATION COSTS, USING ESTIMATED HIGHWAY MILES, FOR THE 37 BLOCKS IN THE NEW YORK VECTOR CONTAINING SALES (BASED ON A 440-POUND SHIPMENT OF PRODUCT A)

Block Number	Estimated Cost	Actual Cost	Difference	Difference As A % of Actual
126-743	$13.85	$13.75	.10	.727
126-744	13.78	13.67	.11	.805
126-745	13.71	13.60	.11	.808
126-746	13.64	13.53	.11	.813
126-747	13.57	13.48	.09	.667
126-748	13.50	13.44	.06	.446
126-749	13.43	13.39	.04	.298
126-758	12.81	12.96	-.15	1.157
126-759	12.74	12.91	-.17	1.316
126-760	12.67	12.83	-.16	1.247
126-761	12.60	12.76	-.16	1.253
126-762	12.53	12.64	-.11	.870
126-763	12.47	12.52	-.05	.399
126-765	12.33	12.41	-.08	.644
126-766	12.26	12.31	-.05	.406
126-768	12.13	12.19	-.06	.492
126-773	11.80	11.97	-.17	1.420
126-777	11.53	11.64	-.11	.945
126-780	11.34	11.44	-.10	.874
126-781	11.28	11.39	-.11	.965
126-787	10.91	10.97	-.06	.546
126-788	10.85	10.91	-.06	.549
126-789	10.79	10.87	-.08	.735
126-790	10.73	10.80	-.07	.648
126-791	10.67	10.79	-.12	1.112

TABLE 9--Continued

Block Number	Estimated Cost	Actual Cost	Difference	Difference As A % of Actual
126-795	$10.44	$10.27	.17	1.655
126-797	10.33	10.24	.09	.878
126-799	10.22	10.15	.07	.689
126-800	10.16	10.06	.10	.994
126-801	10.11	10.03	.08	.797
126-809	9.74	9.72	.02	.205
126-816	9.48	9.43	.05	.530
126-827	9.28	9.16	.12	1.310
126-832	9.29	9.02	.27	2.993
126-833	9.30	9.09	.21	2.310
126-834	9.31	9.14	.17	1.859
126-839	9.40	9.52	-.12	1.260
Totals	$424.98	$424.99		35.622

As shown in Table 9, the difference between the total actual and estimated costs for shipments to all 37 blocks is only one cent. On the basis of the analysis above, the regression equation for transportation costs and the estimation of highway miles from airline miles were accepted as reasonable estimates for determining geographic variability of transportation costs.

Pipeline Inventory Costs to the Blocks

The transit time from the distribution point to the various blocks was determined by the company's past experience, when available, and by the carrier's estimate for those blocks where there was no past experience. The in-transit times from the distribution point to the various blocks used for computing the pipeline interest cost for less-than-truckload shipments were as follows:

Pipeline Time (in days)	Blocks	Pipeline Inventory Costs	
		Product A	Product B
5	126-741 to 126-749	$1.95	$.21
4.5	126-751 to 126-758	1.57	.19
4	126-759 to 126-768	1.39	.17
3.5	126-769 to 126-779	1.22	.15
3	126-780 to 126-794	1.05	.13
2.5	126-795 to 126-808	.87	.11
2	126-809 to 126-823	.70	.08
1.5	126-824 to 126-830	.52	.06
1	126-831 to 126-839	.35	.04

The large differences in pipeline inventory interest costs stem from the vast difference in the values of 440 pounds of the two products, as mentioned earlier. It should be recalled that product A has a value of $2,090, while product B has a value of $255.20.

Determining the Total Physical Distribution Costs to Each Block

The final estimate of total distribution costs per block included the specific costs shown in the earlier section, "Total Costs," together with the pipeline interest costs above and the transportation costs derived from the regression equations and estimated highway miles. A partial listing of total costs per block appears below.

Block Number	Total Physical Distribution Costs	
	Product A	Product B
126-741	$23.44	$17.58
126-742	23.37	17.52
126-743	23.30	17.47
126-744	23.23	17.41
. . .	. . .	. . .
. . .	. . .	. . .
126-837	17.21	13.76
126-838	17.23	13.77
126-839	17.25	13.79

The costs decline at first and then rise again because the majority of the vector lies west of the distribution point, but part of the vector is east of the distribution point. Therefore, minimum costs occur in the control block directly above the distribution point and begin to increase again with movements east of the minimum cost block.

The two components of total costs which vary geographically (by block) are the transportation and pipeline inventory costs. It is important to note that in this study these two costs represented more than half of the total costs of physical distribution to each block. For example, in block 126-741 for product A transportation costs equaled $13.99 and pipeline inventory costs equaled $1.95. The sum of these two costs represents 68 percent of total costs. The lowest percentage of total costs attributed to these two costs was 56 percent for product A and 51 percent for product B.

Determining Distribution Territories

The preceding section presented a method of accounting for total costs of physical distribution and estimating those costs which vary geographically. The grid blocks served as cost centers for determining the total costs and geographically variable costs. Given the control objective of minimizing the costs of servicing demand, this section deals with a method of using the geographic cost information to establish minimum cost distribution territories.

The procedure involved the same New York vector of 99 grid blocks used in the previous section. The analysis consisted of comparing the total costs of shipping 440 pounds of products A and B to each block from distribution point A to the total costs of the same shipments made directly from the factory. Figure 9 in Chapter IV approximates the location relationship of the factory and distribution points to the New York vector. The factory is located approximately 250 miles northwest of the west end of the vector, while distribution point A is south and approximately one-tenth of the total vector distance west of the east end of the vector.

With the block cost patterns already established from the distribution point, the datum needed for evaluation is the corresponding cost pattern from the factory. The costs from the factory to each block consisted of the following:

Transportation Cost		$variable
Storage Cost (per unit)		.50
Handling Cost (per unit)		1.00
Packing List Cost		.26
Order Processing Cost		3.74
Pipeline Inventory Cost	Product A	variable
	Product B	variable
Total Costs per block		

The transportation cost was determined by the same procedure used for the distribution point in the previous section. However, the ratio was 1.4817 for converting airline to highway miles from the factory to the blocks. The higher ratio from the factory resulted from the indirect nature of the route necessary to reach the vector blocks. Therefore, the factory data also serve to illustrate the necessity of determining the conversion ratio from studying the specific areas of the country involved in the shipments.

The coefficients of correlation between transportation costs from the factory and miles to the specific blocks equaled .998376 for product A and .99820 for product B, given their freight classifications and the weight break involved in the shipment. Here again, the high coefficients of correlation permitted the computation of transportation costs from the regression equation.

The in-transit times from the factory to the blocks were:

Blocks	Days In Transit
126-741 to 126-772	3.0
126-772 to 126-798	3.5
126-798 to 126-812	4.0
126-812 to 126-840	4.5

The relatively shorter in-transit times from the factory across the vector blocks reflects the difference in routing and the number of stops made by less-than-truckload carriers used by the factory compared to the carriers used at the distribution point.

The total cost pattern for the two products from the factory to the vector blocks is shown below for selected blocks.

For factory shipments the geographically variable costs (transportation and pipeline interest costs) represented from 60 percent to 76 percent of the total block costs. The

Block Number	Total Cost Product A	Product B
126-741	$16.79	$13.94
126-742	16.84	13.98
126-743	16.90	14.03
126-744	16.96	14.07
. . .	. . .	. . .
. . .	. . .	. . .
126-836	22.94	18.34
126-837	23.01	18.39
126-838	23.07	18.43
126-839	23.13	18.48

higher proportion of variable to total costs for factory shipments occurs because the distribution costs from the factory to the distribution point were not considered as geographically variable in determining the proportion of geographically variable costs from the distribution point. The transportation and pipeline inventory interest costs from the factory to the distribution point are geographically variable costs only when a change in the location of the factory or distribution point is under consideration. When the location of distribution and production facilities are studied, these costs become geographically variable and their proportion of total costs from distribution point would rise. This comparison of the cost patterns from the factory and distribution point to the vector blocks considered the locations of the factory and distribution point as fixed. Therefore, the transportation and pipeline inventory costs from the factory to distribution point are not variable.

Table 10 contains a comparison of the total block cost patterns for direct factory and distribution point A shipments for 440-pound shipments of products A and B. Block 126-741 lies at the western end of the vector. In this location direct shipments from the factory cost $6.65 less than from the distribution point for the shipment of product A and $3.65 less for product B. As the shipments move eastward across the vector blocks, the factory continues to enjoy the lowest total block costs through blocks 126-777 for product B and 126-785 for product A. However, at blocks 126-788 for product B and 126-786 for product A distribution point A begins to have the lowest total block costs. The in-transit times to blocks 126-777 and 126-778 equal 3.5 days from both the factory and distribution point A. However, the factory shipments require 3.5 days to reach block 126-785, while the distribution point shipments take only 3 days. Therefore, on the basis of grid block distribution costs, the decision rules to minimize physical distribution costs would be:

(a) For all 440-pound orders of product A from the New York vector, ship from the factory through

TABLE 10

A COMPARISON OF THE TOTAL PHYSICAL DISTRIBUTION BLOCK COSTS FOR DIRECT FACTORY AND DISTRIBUTION POINT A SHIPMENTS (BASED ON 440-POUND SHIPMENTS OF PRODUCTS A AND B)

Block Number	Total Cost For Product A		Total Cost For Product B	
	Factory	Distribution Point	Factory	Distribution Point
126-741	$16.79	$23.44	$13.94	$17.58
126-742	16.84	23.37	13.98	17.52
126-743	16.90	23.30	14.03	17.47
126-744	16.96	23.23	14.07	17.41
. . .	. . .	. . .	. . .	. . .
. . .	. . .	. . .	. . .	. . .
126-775	18.93	20.39	15.48	15.68
126-776	18.99	20.32	15.52	15.63
126-777	19.05	20.25	15.57	15.58
126-778	19.11	20.19	15.62	15.53
126-779	19.17	20.13	15.66	15.48
. . .	. . .	. . .	. . .	. . .
. . .	. . .	. . .	. . .	. . .
126-783	19.41	19.70	15.84	15.26
126-784	19.47	19.64	15.89	15.21
126-785	19.52	19.58	15.94	15.16
126-786	19.58	19.52	15.98	15.11
126-787	19.64	19.46	16.03	15.07
126-788	19.70	19.40	16.07	15.01
. . .	. . .	. . .	. . .	. . .
. . .	. . .	. . .	. . .	. . .

block number 126-785. Ship from distribution point A all orders from blocks 126-786 through 126-839.

(b) For all 440-pound orders of product B from the

New York vector, ship from the factory through block 126-777. Ship from distribution point A all orders from blocks 126-778 through 126-839.

The decision rules above illustrate how the geographic control blocks are used first to identify geographic cost patterns, and from these patterns decision rules are established to minimize physical distribution costs. The next step consists of using the decision rules to determine the configuration of distribution territories around the shipping points. The analysis above dealt with a single vector of control units, while the delineation of distribution territories would require that all relevant control units between alternate shipping points be considered. The recommended procedure for delineating distribution territories is:

(a) Select a vector of control units between the two alternative shipping points.

(b) Compute the total block costs from the two shipping points to each control unit, as described in the previous section.

(c) Determine the blocks in the vector where the minimum cost in one block favors one pattern of shipment and in the adjacent block favors the alternative point of shipment.

(d) Draw a line between the two blocks identified in (c).

(e) Now move to the vectors above and below the original vector studied.

(f) Identify the block numbers of the five grid blocks on either side of the line drawn in step (d).

(g) Compute the costs to the blocks identified in (f).

(h) Repeat step (c) based on the costs found in each of the new vectors.

(i) Continue the above process until the boundaries of the distribution territory are complete.

The above procedure constructs the boundary lines of distribution territories from the lines which separate two adjacent blocks whose minimum costs favor different shipping points (factory vs. distribution point).

CHAPTER VI

SUMMARY, CONCLUSIONS, AND IMPLICATIONS

Summary

In Chapter I the fundamental uniqueness of marketing was identified as the problem of overcoming spatial influences in both the demand-obtaining and order-servicing activities. As a result, certain marketing costs vary geographically. Since several of marketing's costs and all of its revenues and profits are generated outside the firm's centralized operations, the marketing manager is faced with controlling geographically dispersed activities, costs, and profits. Therefore, it was postulated that the integration of internal marketing records into an information system based on meaningful geographic control units would provide marketing management with data needed to evaluate and control geographically dispersed activities. The specific nature of distribution costs and cost control was discussed in Chapter III.

In Chapter II the spherical grid block was selected as having the best potential of the various geographic units available. The restructuring of the spherical grid for control unit blocks was developed in Chapter IV.

Conclusions And Implications

The conclusions and implications of the study are derived from the findings in Chapter V. The conclusions are divided into three sections, corresponding to the three applications of the System.

Geographic Analysis of Marketing Activities

The evaluation of marketing activities using individual grid block comparisons provided the ability to pinpoint geographic variations in marketing activities, which was not provided by aggregate methods of analysis. Furthermore, collecting marketing data by grid blocks permits the identification of current "areas" of marketing activity as well as determination of the relative importance of the areas and their sizes. Use of the grid blocks for "area" determination based on total sales, products shipped, and sales by product or customer type provides marketing management with a tool for evaluating and controlling geographically dispersed activities.

Geographic Variability of Costs

From the findings in Chapter V the following conclusions can be drawn from applying the grid system to determine the geographic variability of costs.

(a) The use of regression line equations by freight class and weight break yields a very close approximation of actual transportation costs.

(b) Airline miles can be converted into a reasonable approximation of highway miles, provided the conversion ratio is determined by taking a sample of actual highway miles and airline miles to specific points <u>in the area studied</u>.

(c) Physical distribution costs which have been computed for a grid control unit as a cost center can generalize the costs of serving specific points contained in the block with minimal error.

(d) The geographic variability of order-servicing costs can be determined with a margin of error which is acceptable in most cases.

(e) Costs which vary geographically are probably the largest component of the total costs of servicing demand. For the company studied, these costs accounted for the majority of the total order-servicing costs, and it is probable that the same relationship is true for other companies.

Determining Distribution Territories

A company using multiple distribution points faces decisions concerning which of the points should be used for each type of shipment to a given location. Ideally, the decisions should result in minimum costs, consistent with a competitive delivery time. The findings from applying the grid blocks to delineate distribution territories suggest that:

(a) Once the geographic variability of distribution costs is determined, it is possible to construct decision rules to minimize the costs of servicing demand and determine the corresponding in-transit time required.

(b) Determination of geographically variable distribution costs also permits the construction of distribution territories based on minimum costs of servicing demand within the area, consistent with a competitive delivery time.

From the findings it is concluded that marketing management can benefit from an internal information system which provides geographic analysis of marketing activities, provided their markets are dispersed and computerization of internal records is feasible.

Suggested Areas For Further Research

This study has concentrated on the spherical grid system's ability to account for and evaluate the costs of *servicing* demand. Analyzing the system's ability to account for and evaluate the costs of *obtaining* demand is equally important. If the costs of obtaining demand can be accounted for with the grid units, then possibly the two types of marketing costs could be combined within each block, resulting in a geographic cost and revenue accounting system.

It is also suggested that experimentation be undertaken to determine if airline miles can be converted into rail miles within a reasonable amount of error.

The current research was limited to an industrial goods company. Therefore, the analysis should be expanded to other types of companies in order that comparative costs and cost behavior can be analyzed.

APPENDIX I

MILAGE ESTIMATION

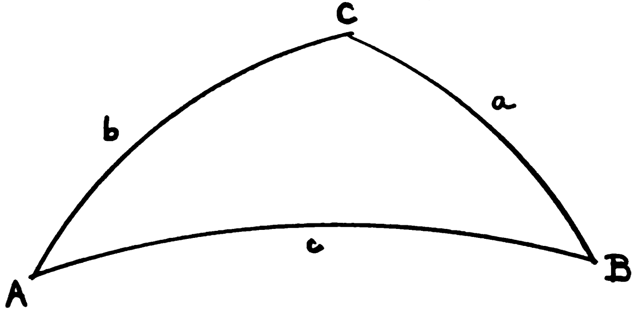
The computation of airline miles between the centers of any two grid blocks requires the methodology and computer program presented in this appendix.

The base point for all calculations is grid block 16-16, located in the upper left-hand corner of the northwestern part of the grid blocks which cover the United States. This location corresponds to the first spherical grid block on the vertical and horizontal scales.

The center of spherical grid block 16-16 is located at 48.96875 degrees of latitude and 124.96875 degrees of longitude. Since the distance between the centers of any adjacent grid blocks always equals 3.75 minutes or .0625 degrees, the difference between the grid numbers can be converted into latitude and longitude differences between points. For example, the center of grid block 18-19 represents a movement of two grid blocks south and three grid blocks east of base block 16-16. This is equivalent to moving .1250 (.0625 x 2) degrees south and .1875 (.0625 x 3) degrees east of the base block. The number of unit movements from the base block in each direction is found by subtracting the base block scale number from the block number being studied. In the example above, the calculation would be (18-19) - (16-16) = 2-3, which shows the 2-unit movement south and 3-unit movement east of the base block.

The formula for computing the airline distance between centers of blocks is a standard spherical trigonometry formula which solves side c of a polar triangle.[1] A polar triangle is illustrated below.

Polar Triangle



Angle C is formed at the north pole and the side opposite is side c, which represents the airline distance in degrees or radians between points A and B. The points at angles A and B represent the centers of the two grid blocks

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[1] For a basic understanding of solving for side c of a polar triangle, see Chapter XV of H. L. Riety, J. F. Reilly and Roscoe Woods, <u>Plane and Spherical Trigonometry</u> (New York: The Macmillan Co., 1950).

between which the airline distance is being computed. Arc CB equals side a and arc AC equals side b, while arc AB equals side c.

Arc AC (side b) equals 90° minus the latitude of point A. Arc BC (side a) equals 90° minus the latitude of point B. Angle C equals the longitude of point A minus the longitude of point B.

Solving the above equations results in a spherical triangle with a known angle C and known sides a and b. Using John Napier's analogies as simultaneous equations and the law of sines, angles A and B and side c may be solved for as follows:

Simultaneous Equations

$$\text{I.}\quad \tan\frac{A-B}{2} = \frac{\sin\frac{a-b}{2}}{\sin\frac{a+b}{2}}\cot\frac{C}{2}$$

$$\text{II.}\quad \tan\frac{A+B}{2} = \frac{\frac{\cos a-b}{2}}{\frac{\cos a+b}{2}}\cot\frac{C}{2}$$

Equation for side c

$$\sin c = \frac{\sin b \sin C}{\sin B}$$

Once side c is computed in terms of degrees or radians, it is converted into minutes and multiplied by 1.1515, which

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[2] *Ibid.*, p. 179.

converts the minutes of a great circle into miles. The computerization of the distance calculation is simplified if formulas are solved in terms of radians rather than degrees. The conversion ratio is one degree equals .0174532925 radians.

The final computer program for distance measurement using grid block numbers is:

(a) Latitude of block B = 48.96875 - (the vertical scale number of block B - 16 x .0625)

(b) Longitude of block B = 124.96875 - (the horizontal scale number of block B - 16 x .0625)

(c) Latitude of block A = 48.96875 - (the vertical scale number of block A - 16 x .0625)

(d) Longitude of block A = 124.96875 - (the horizontal scale number of block A - 16 x .0625)

(e) Radian = .0174532925

(f) Side a = (90.0 - latitude of block B) x radian

(g) Side b = (90.0 - latitude of block A) x radian

(h) Angle C = (longitude of block A - longitude of block B) x radian

(i) Equation #1 ((sin of ((Side a - Side b)/2.0)) / (sin of ((side a + side b/2.0))) x (1.0/tan of (Angle C/2.0))

(j) Equation #2 ((cos of ((side a - side b)/2.0)) / (cos of ((side a + side b)/2.0))) x (1.0/ tan of (angle C/2.0))

(k) Equation #1 = the arc tan of (Equation #1)

(l) Equation #2 = the arc tan of (Equation #2)

(m) Angle A = Equation #1 + Equation #2

(n) Angle B = Angle A - (2.0 x Equation #1)

(o) Sin of c = (sin of (side b) x sin of (Angle C) / sin of (Angle B)

(p) Side c = arc sin of (sin c)

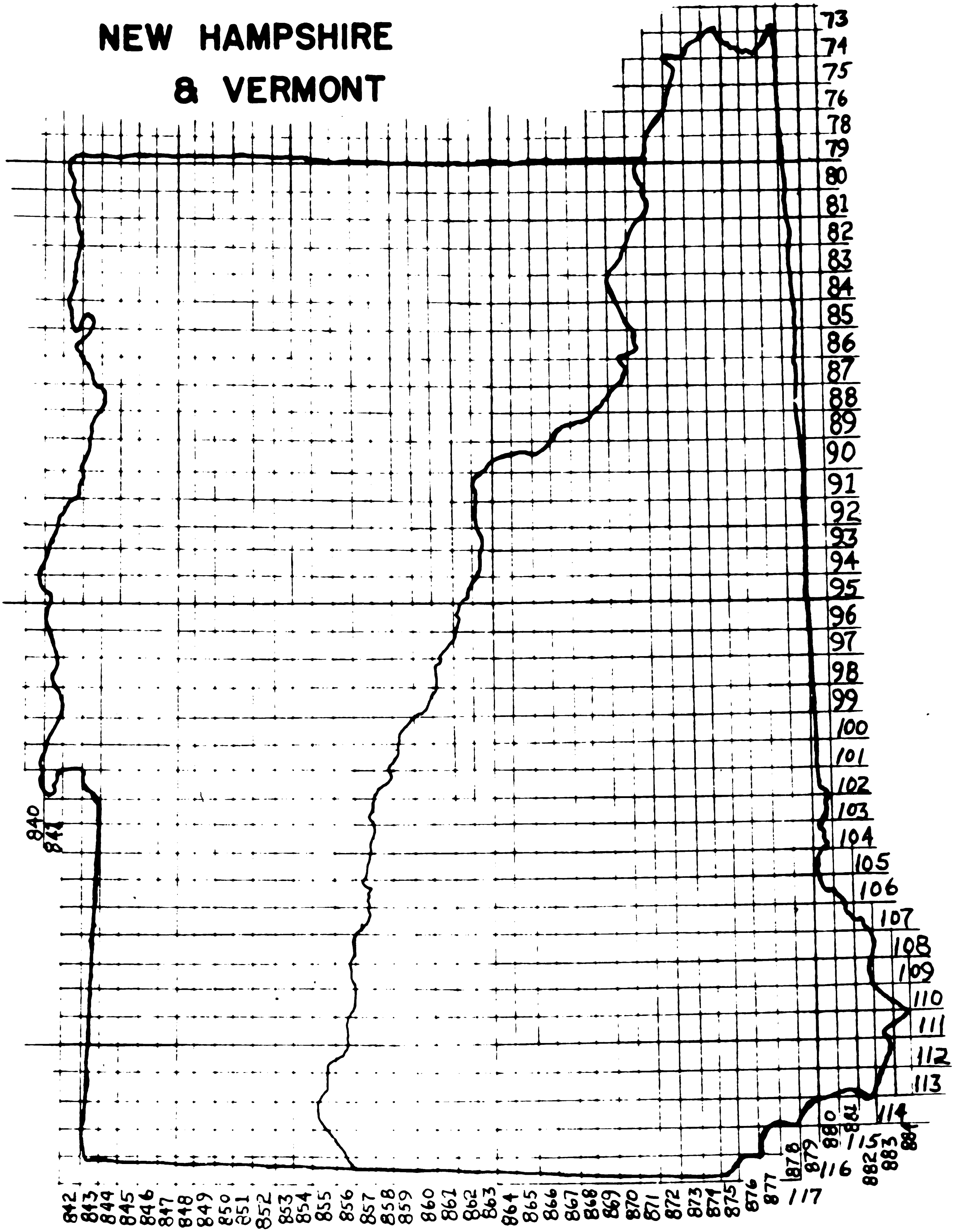
(q) Side c in degrees =(Side c x 57.2957795) x 60.0

(r) Distance in miles of side c = side c in degrees x 1.151515

APPENDIX II

MAP OF NEW HAMPSHIRE AND VERMONT

The map of New Hampshire and Vermont came from the set of maps which were constructed for this study. The original scale was 1:1,000,000 inches before it was reduced for reproduction here. The maps are used to plot the various data which are identified by grid blocks, such as sales areas and distribution territories.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APPENDIX III

COMPUTER OUTPUT OF GEOGRAPHIC MARKETING INFORMATION

This appendix contains a reproduction of one of the computer output pages from the sort by origin of shipments to the various destination blocks. The output is read in the following manner. All of the data on the page consist of sales which were shipped from a given origin block Y to the destination blocks shown. The fourth destination block shown (control unit 314-599) received a total of 400 pounds, which generated $503.50 in gross revenue. The individual sales and shipments consisted of the following:

(a) A 144-pound shipment in container code 27 of product number 20025 sold to customer number 701580 which produced $247.50 of gross revenue.

(b) A 200-pound shipment in container code 21 of product 10302 sold to customer 419151 which produced $200.00 of gross revenue.

(c) A 56-pound shipment in container code 20 of product 10302 sold to customer number 419151 which produced $56.00 of gross revenue.

```
             DESTINATION BLOCK      CONT CODE      PROD NO                CUSTOMER NO
               [illegible],          71,           [illegible],           [illegible],
POUNDS =              12,                  12,            12,                     12,
$ SALES =          34.20              34.20        34.20                  34,20

                                                   PROD NO                CUSTOMER NO
                                                   94120,                 277424,
POUNDS =                                                  77,                     77,
$ SALES =                                        1075.90                1075,90

                                                   PROD NO                CUSTOMER NO
                                                   94100,                 277424,
POUNDS =                                                   5,                      5,
$ SALES =                                         120.00                 120,00

             DESTINATION BLOCK      CONT CODE      PROD NO                CUSTOMER NO
               315506,               60,           94104,                 277424,
POUNDS =              80,                  80,             6,                      6,
$ SALES =         1253,50           1253.50        57.60                  57,60

                                    CONT CODE      PROD NO                CUSTOMER NO
                                     11,           20016,                 202310,
POUNDS =                                   10,            10,                     10,
$ SALES =                             47.50        47.50                  47,50

             DESTINATION BLOCK      CONT CODE      PROD NO                CUSTOMER NO
               314709,               10,           20191,                 202310,
POUNDS =              22,                  12,            12,                     12,
$ SALES =          89.50              42.00        42.00                  42,00

                                    CONT CODE      PROD NO                CUSTOMER NO
                                     27,           20025,                 701500,
POUNDS =                                  144,           144,                    144,
$ SALES =                            247.50       247.50                 247,50

                                    CONT CODE      PROD NO                CUSTOMER NO
                                     21,           10302,                 419191,
POUNDS =                                  200,           200,                    200,
$ SALES =                            200.00       200.00                 200,00

             DESTINATION BLOCK      CONT CODE      PROD NO                CUSTOMER NO
               314599,               20,           10302,                 419191,
POUNDS =             400,                  56,            56,                     56,
$ SALES =         503,50              56.00        56.00                  56,00

                                    CONT CODE      PROD NO                CUSTOMER NO
                                     71,           20126,                 756300,
POUNDS =                                   48,            48,                     48,
$ SALES =                            153.60       153.60                 153,60

                                                   PROD NO                CUSTOMER NO
                                                   30014,                 977763,
POUNDS =                                                   6,                      6,
$ SALES =                                          20.50                  20,50

             DESTINATION BLOCK      CONT CODE      PROD NO                CUSTOMER NO
               313619,               11,           20126,                 977763,
POUNDS =              64,                  16,            18,                     18,
$ SALES =         245.10              91.50        63.00                  63,00

                                    CONT CODE      PROD NO                CUSTOMER NO
                                     41,           20126,                 419040,
POUNDS =                                   12,            12,                     12,
$ SALES =                             13,40        13.40                  13,40

                                                   PROD NO                CUSTOMER NO
```

APPENDIX IV

A PAGE OF COMPUTER OUTPUT FROM THE LINEAR REGRESSION ANALYSIS TESTING THE ASSOCIATION BETWEEN MOTOR CARRIER COSTS AND MILES SHIPPED

The page of computer output in this appendix was taken from the total output of regression equations for the factory and two distribution points. The coefficients of correlation show the "goodness of fit" of a straight line association between transportation costs of motor carriers and miles shipped for given freight classifications and weight breaks. For example, the last line shows the coefficient of correlation equals .995220 for freight classification 26 and weight break 6,000 to 22,999 pounds in the New York vector for shipments from distribution point A. The regression equation shows that Y (transportation costs) = 68.985 cents + .32730 cents times the miles being shipped.

When the coefficient of correlation equals +1 or -1, a straight line has a perfect fit to the data (perfect association). A value of 0 for the coefficient of correlation indicates that a straight line does not fit the data and there is no linear association. Therefore, the high coefficients of correlation found in the output show an almost perfect linear relationship between motor carriers' costs and miles shipped.

```
 CORRELATION COEFFICIENT = .994582        Y=   74.587+  .35324(MILES)         WHSE NO =1      WHSE IS  PN
VECTOR IS  KYSTAT           CLASSIF NO =11          WGT BREAK = 6000 TO  22999 LBS

 CORRELATION COEFFICIENT = .995375        Y=   80.454+  .37858(MILES)         WHSE NO =1      WHSE IS  PN
VECTOR IS  KYSTAT           CLASSIF NO =12          WGT BREAK = 6000 TO  22999 LBS

 CORRELATION COEFFICIENT = .995109        Y=  113.371+  .54189(MILES)         WHSE NO =1      WHSE IS  PN
VECTOR IS  KYSTAT           CLASSIF NO =13          WGT BREAK = 6000 TO  11999 LBS

 CORRELATION COEFFICIENT = .995222        Y=  105.256+  .50084(MILES)         WHSE NO =1      WHSE IS  PN
VECTOR IS  KYSTAT           CLASSIF NO =14          WGT BREAK = 6000 TO  15999 LBS

 CORRELATION COEFFICIENT = .995220        Y=   68.985+  .32730(MILES)         WHSE NO =1      WHSE IS  PN
VECTOR IS  KYSTAT           CLASSIF NO =15          WGT BREAK = 6000 TO  22999 LBS

 CORRELATION COEFFICIENT = .995375        Y=   80.454+  .37858(MILES)         WHSE NO =1      WHSE IS  PN
VECTOR IS  KYSTAT           CLASSIF NO =16          WGT BREAK = 6000 TO  22999 LBS

 CORRELATION COEFFICIENT = .995375        Y=   80.454+  .37858(MILES)         WHSE NO =1      WHSE IS  PN
VECTOR IS  KYSTAT           CLASSIF NO =17          WGT BREAK = 6000 TO  22999 LBS

 CORRELATION COEFFICIENT = .995375        Y=   80.454+  .37858(MILES)         WHSE NO =1      WHSE IS  PN
VECTOR IS  KYSTAT           CLASSIF NO =18          WGT BREAK = 6000 TO  22999 LBS

 CORRELATION COEFFICIENT = .994582        Y=   74.587+  .35324(MILES)         WHSE NO =1      WHSE IS  PN
VECTOR IS  KYSTAT           CLASSIF NO =19          WGT BREAK = 6000 TO  22999 LBS

 CORRELATION COEFFICIENT = .995375        Y=   80.454+  .37858(MILES)         WHSE NO =1      WHSE IS  PN
VECTOR IS  KYSTAT           CLASSIF NO =20          WGT BREAK = 6000 TO  22999 LBS

 CORRELATION COEFFICIENT = .995685        Y=   63.639+  .29798(MILES)         WHSE NO =1      WHSE IS  PN
VECTOR IS  KYSTAT           CLASSIF NO =21          WGT BREAK = 6000 TO  22999 LBS

 CORRELATION COEFFICIENT = .995685        Y=   63.639+  .29798(MILES)         WHSE NO =1      WHSE IS  PN
VECTOR IS  KYSTAT           CLASSIF NO =22          WGT BREAK = 6000 TO  22999 LBS

 CORRELATION COEFFICIENT = .995685        Y=   63.639+  .29798(MILES)         WHSE NO =1      WHSE IS  PN
VECTOR IS  KYSTAT           CLASSIF NO =23          WGT BREAK = 6000 TO  22999 LBS

 CORRELATION COEFFICIENT = .995375        Y=   80.454+  .37858(MILES)         WHSE NO =1      WHSE IS  PN
VECTOR IS  KYSTAT           CLASSIF NO =24          WGT BREAK = 6000 TO  22999 LBS

 CORRELATION COEFFICIENT = .995274        Y=   97.617+  .45972(MILES)         WHSE NO =1      WHSE IS  PN
VECTOR IS  KYSTAT           CLASSIF NO =25          WGT BREAK = 6000 TO  15999 LBS

 CORRELATION COEFFICIENT = .995220        Y=   68.985+  .32730(MILES)         WHSE NO =1      WHSE IS  PN
VECTOR IS  KYSTAT           CLASSIF NO =26          WGT BREAK = 6000 TO  22999 LBS
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