AN ANALYSIS OF MILK PRICE RELATIONSHIPS INVOLVED IN DELINEATING SUPPLY AREAS FOR MILK MARKETS IN LOWER MICHIGAN

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A THESIS

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ABSTRACT

This study was concerned with the delineation of milk supply areas for the Detroit, Jackson, Battle Creek, Kalamazoo, Lansing, Grand Rapids, Muskegon, Bay City, Saginaw, and Flint, Michigan, consuming areas in such a way that total transport costs would be at a minimum. The nine areas include all counties having one or more cities with a population of 40,000 or more and contain 75.6% of the population in Lower Michigan.

Based on the per capita consumption in milk equivalents of 28.603 pounds for November, plus a 15% fluctuation allowance, the total fluid milk requirements for the nine areas was found to be 185,855,360 pounds.

Total milk production in Lower Michigan for November, 1959, was 363,831,640 pounds, of which 216,498,324 pounds were available to the marketing areas for fluid use. The remainder was used for non-fluid purposes and by people living outside the marketing areas.

To minimize total transport costs it was found that all supply area boundaries had to be defined by points of price indifference to the receiving stations in reference to the competing markets. These points of indifference form a hyperbolic function enclosing the smaller market. The

points on the boundary line were defined by the intersection of corresponding iso-price lines radiating from the competing markets.

The iso-price lines were set at ten mile intervals representing a change in price of $0.01. This amount reflects the added cost of moving a hundred weight of milk ten miles and is linear with distance.

Through a series of f.o.b. city plant price approximations the supply areas for the nine markets were simultaneously determined. All supply area boundaries common to more than one market were competitively defined over their entire range.

The price variation between the markets and the basing point was found to be influenced by the location of the market in reference to the surplus area, density of production, distance to the basing point and the number and location of competing markets.

To determine the degree of accuracy with which the ideal price variation could be predicted the above factors were quantified as independent variables in the formula $Y = b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4$. All the factors were found to be significant in determining price variation. A correlation coefficient of .99967 was obtained when the estimated price variations were tested against the observed, indicating a high degree of association between the desired prices and the independent variables.

To determine the savings which would result if the supply areas were organized in accordance with the theoretical model, a model was constructed representing the existing conditions. Price change with distance remained the same but the price variations among the market was taken to be equal to the location adjustments provided for in the Southern Michigan Marketing Order. When the models were compared it was found that the variable cost incurred to move the total market requirements of November, 185,855,360 pounds, was $120,967.88 in the existing model and $110,030.56 in the theoretical. The $10,937.32 decrease was the result of a $0.00588 decrease in the average total variable cost associated with transporting a hundred weight of milk. The average length of trip decreased from 65.1 miles in the model representing the existing conditions to 59.5 miles in the theoretical model making these savings possible.

The following general conclusions can be drawn from this study:

1. It is possible within the perfect market concept to develop a most efficient system of supply areas.
2. The correct price variation among the market will insure total cost minimization.
3. Price variation is a function of the characteristics of the market in relation to the basing point.
4. The f.o.b. city plant prices must be greater than the basing point price minus the variable cost of transportation between the basing point and the

market if the supply area boundaries are to be defined.

5. The fixed costs of transportation must be included in the f.o.b. city plant prices, leaving only the variable cost to determine a competitive boundary if supply areas are to reflect minimum cost.

6. The present system of supply areas does not insure maximization of the average price paid to all receiving stations and minimization of total costs to the city plants.

7. Total costs can be decreased if the present system of supply areas are reorganized through price variation adjustment in accordance with the model developed.

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CHAPTER I

INTRODUCTION

The allocation of a given supply of fluid milk among competing markets is a function of the price offered by those markets. Transportation costs, density of production, and market location must be considered in establishing these prices if the market supplies are to be adequate and secured in the most efficient manner.[1]

Objective and Problem

Southern Michigan, as any area encompassing a number of markets, is subject to supply area inefficiencies. These inefficiencies generally come about through a misallocation of the available supply. A major factor to be considered in rectifying these inefficiencies is the interrelationship of prices among the markets.

It is the objective of this study to devise a set of supply areas for nine Southern Michigan marketing areas which are consistent with the objective of adequately supplying each market with its fluid milk needs while minimizing

[1]For the purpose of this study efficiency is defined as securing an adequate supply of milk for all markets at the lowest total cost for all city plants and the highest average price for all receiving stations (producers). For further discussion of efficiency refer to Scitovsky, Tibor. Welfare and Competition. R.D. Irwin, Inc., 1951.

total transportation costs.

A further task is to determine the variables affecting price variation and to construct a formula in which they may be used in a price predicting capacity.

As an ultimate objective it is hoped that this study will be beneficial to all who have a general interest in orderly milk marketing.

Theoretical Framework

The interaction of the laws of supply and demand determine the market price of a commodity under conditions of perfect competition.[1]

If demand exceeds supply price will be bid up and the supply will tend to increase. Conversely if supply exceeds demand the price will tend to decrease. Eventually, through a series of price quantity adjustments, a point of balance between supply and demand will be reached. This is said to be the point of equilibrium.

The supply side may be affected by many factors.

Von Thunen early in the nineteenth century combined the place and form aspects of the perfect market model in an attempt to explain agricultural production about an isolated city. In essence his theory states that as one moves away from the city, production becomes less intensive and becomes increasingly devoted to production of items that are

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[1]For a detailed discussion of the Laws of Supply and Demand refer to R. H. Leftwich, The Price System and Resource Allocation, Rinehart and Company, Inc., New York, 1956, Chapter 3 pp. 23-48.

relatively less perishable and whose value is great enough to bear the cost of transportation.[1]

Milk being convertible into many forms serves as a good illustration of his principle. If the principle holds we would expect to find the more perishable and bulky products produced near the centers of population. On the basis of bulk alone we would expect fluid milk to come from the nearby areas and butter from the most distant. If perishability is the primary concern we would again expect to find fluid milk produced in the nearby areas with condensed milk coming from the most distant areas. These tendencies become evident when looking at local markets or the United States as a whole. The Detroit metropolitan area secures more than eighty percent of its fluid milk from twelve surrounding counties but relies on the large surplus areas of the midwest for much of its butter, cheese and condensed milk. The production on the East Coast is similarly devoted to fluid production as population in that area is intense and again relies on the midwest surplus area for most of its manufactured products.[2]

Diagrammatically Von Thunen's Principle looks as follows:[3]

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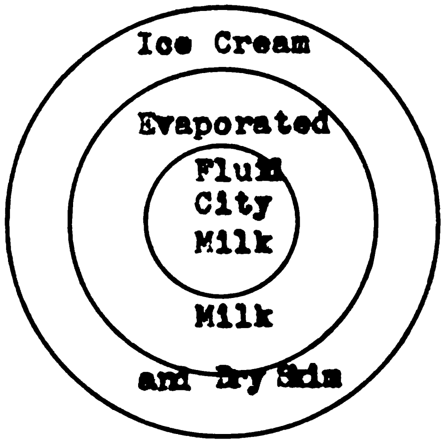
[1] G. Quackenbush, "The Perfect Market, Von Thunen's Principle, Fetter's Law of Markets," Michigan State University, Agricultural Economics Department, mimeograph, 1958.

[2] *Ibid.*, p. 4.

[3] John M. Cassels, *A Study of Fluid Milk Prices*, Harvard University Press, 1937, p. 20.



The boundary line between two areas is defined by the formula $P_1 - T_1R = P_2 - T_2R$ where P_1 equals the price of one hundred pounds equivalent of milk made into product 1, T_1 = transportation rate for product 1, P_2 = city price for one hundred pounds equivalent of the original product made into product 2 and T_2 = the associated transportation rate. The equation is solved for R.

When considering the milk industry several modifying factors must be kept in mind when discussing Von Thunen's thesis:

1) Natural boundaries
2) Overlapping metropolitan areas
3) Health regulations
4) Competition of manufactured products from distant surplus areas.[1]

In discussing location theory with reference to two markets Fetter's Law of Markets is useful. In brief Fetter's Law states that the boundary line between geographically competing markets or territories is a hyperbolic curve. At any given point on the boundary line the dif-

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[1] G. M. Beal and H. H. Bakken, Fluid Milk Marketing, Mimir Publishers Inc., Madison, Wisconsin, 1956, pp. 51.

ference in transfer costs is just equal to the difference in market price.[1] From this it can be seen that prices in different markets determine the location of the boundary line between them.

When placing the milk industry into Fetter's context we are confronted with a centripetal market or one that is characterized by the movement of goods toward the market.[2]

When considering a single market Fetter's Law says that price will vary from the base price at the market center only by the cost of procuring the product.[3] When two markets are considered the law would read that the prices received in either market cannot vary by more than the cost of transportation between them or, in other words, price differences can be only less or equal to the differenses in transportation costs.[4]

Based on Fetter's analysis it can then be said that the size of a given supply area is a function of the market base price relative to its geographical competitors or that the supply area of competing markets is a function of the differences in freight costs, base price remaining constant.

The boundary curve will change in location and in shape with changes in price but will always be curved around the market with the lower price and away from that with the

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[1]Frank A. Fetter, The Masquerade on Monopoly, Harcourt, Brace and Company, New York, 1931, p. 283.

[2]Ibid., p. 279.

[3]Ibid., p. 283.

[4]Ibid., p. 284.

higher price.[1]

It should be noted that even if freight rates are not constant per unit the concept will hold altering only the shape of the curve.

HYPOTHESIS

Within the above framework the basic hypothesis of this study can be stated: The efficiency with which given populations acquire their supply of fluid milk is determined by the interrelationship of the prices existing in the individual market.

Various hypotheses concerning these price relationships and the factors which influence them will be stated in later sections of this study.

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[1] *Ibid.*, p. 235.

CHAPTER II

REVIEW OF LITERATURE

Introduction

A number of studies have been made concerning fluid milk supply areas for various cities. Likewise there are a number of published works concerning single market and inter-market pricing of milk. Works combining these two along with the applications of general location theory have been few. The study of these earlier works, however, gives the broad basis on which this study has been built.

Literature Review

According to Cassels, fluctuations in the size of market supply areas for a given commodity can be directly correlated with fluctuating supply and demand equilibrium points.[1] These changing equilibrium points are felt to be the results of those in the market seeking the best possible market outlet, thus forcing prices that will equalize the advantages and disadvantages of the different outlets.[2]

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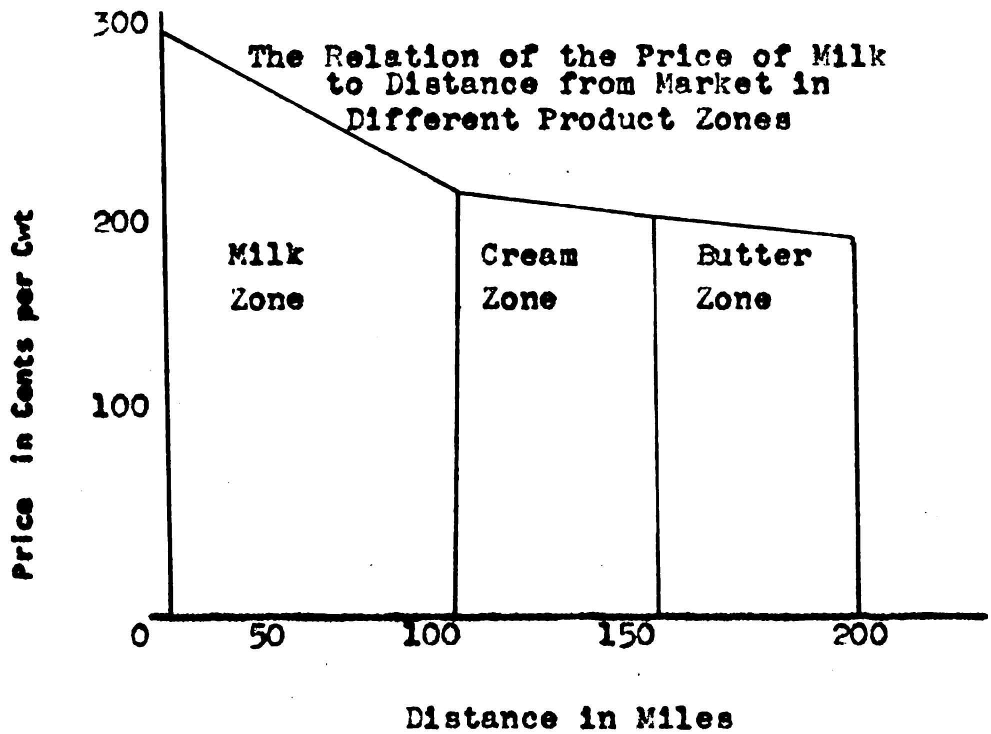
[1] *Op. cit.*, John M. Cassels, p. 19.

[2] *Ibid.*, p. 18.

Based on a Von Thunen type analysis, Cassels sets up the following model.[1]



Price itself depends on the interaction of supply and demand. The supply depends on the area enclosed by the zone boundary. On this basis it can be seen that a change in any one of the factors influencing the equilibrium point would cause a readjustment of the marketing area.

Cassels' consideration of two markets reverts back to a Fetter type analysis. Market size, being affected by the supply and demand equilibrium point, will be equal and the two markets will be separated by a straight line if their prices are equal. Equal changes in price will bring about a similar adjustment in both markets, the boundary line

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[1] John M. Cassels, Op.cit., p. 21.

remaining straight and any point on it will be an equal distance from the center of either market.[1]

Where prices differ between markets we have a hyperbolic curve as a boundary line. Each point on the boundary will have an a-b=x (x being constant) relationship between the two markets. The market area changes as does the price thus altering the shape of the hyperbola. The hyperbola always tends to be convex toward the higher priced market enclosing the lower price market.[2]

Rojko, like Cassels, when considering an isolated market believes specialized zones of production are created based on economies obtainable from shipping concentrated dairy products long distances.[3]

Where dairy products move between several markets their prices tend to differ by transfer costs, the largest being transportation. Where regional movement occurs, as with manufactured dairy products, prices are said to be determined on a national market and prices among markets are closely related.[4]

Rojko's model illustrating the above is as follows:[5]

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[1]John M. Cassels, op.cit., pp. 27-30.

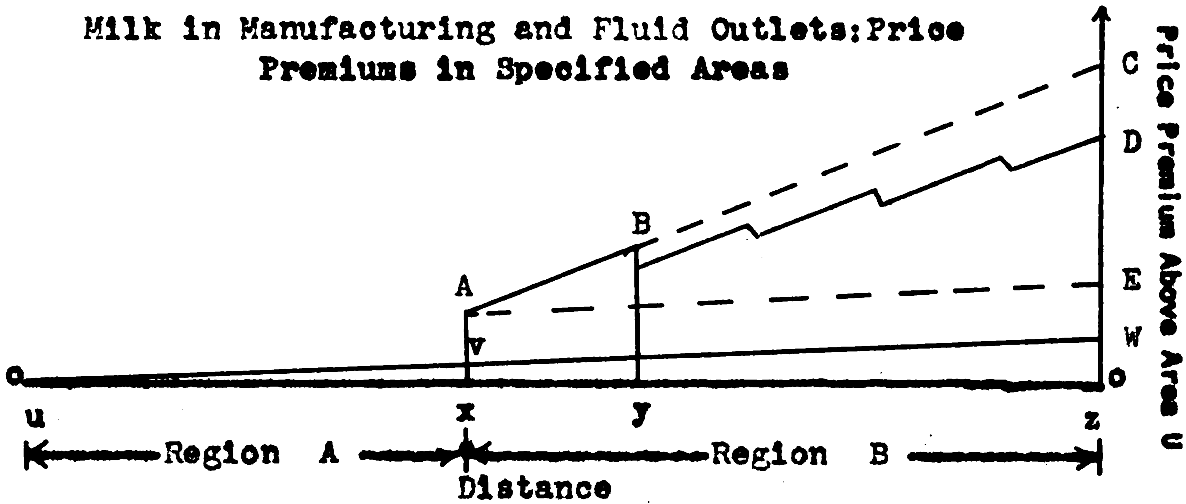
[2]Ibid., p.30.

[3]Anthony S. Rojko, The Demand and Price Structure for Dairy Products, (Washington, D.C.: U.S.D.A.) Technical Bulletin No. 1168, 1953. p.201.

[4]*Ibid.*, pp. 201-204.

[5]*Ibid.*, p.202.

Milk in Manufacturing and Fluid Outlets: Price Premiums in Specified Areas



The base line u z represents any number of producing areas and consuming centers. The elevation of u w from u z is the amount over u manufacturing milk is worth at any given point.

Prices of fluid milk are closely related among regions only when interregional movement of fluid milk products can or could occur. As noted earlier, fluid milk prices are related directly to manufacturing prices in an isolated market. Rojko states that when several consuming centers compete with one another for milk from several common producing areas, prices of milk for fluid use in each market may not be directly related to prices of milk for manufacturing outlets. Instead, prices are determined by the supply and demand for fluid milk in the local market and by prices of milk produced primarily for fluid use in competing or nearby markets. Based on this, only those markets at the edge of the surplus area would be directly related to manufacturing milk prices.[1]

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[1] Anthony S. Rojko, op. cit., p. 203.

On the previous graph x is the point of indifference between producing manufacturing milk and fluid milk, and v - A is the added premium needed to produce fluid milk. If there were a close relationship between markets, the price of fluid milk would take the form of ABC throughout region B. This is equal to the price at A plus the transportation cost to other points on the line. If the supply demand relationships between the markets are not interregional then a line such as ABD would represent the prices received.[1]

Hoover, also drawing from Fetter's concepts, says that the area supplying a market will be determined by the product cost plus minimum transportation costs.[2] He uses the concentric ring concept to illustrate loci of different points of equal cost, (product and transportation). When two markets are considered, the boundary line represents the locus of all points of equal cost and will be either a straight line or hyperbolic curve depending upon the price relationship.

Andes,[3] also concerned with market areas and boundaries, stated that as the amount of fluid milk consumed in a market is rather constant while costs of transporting different dairy products vary with the product, distance be-

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[1] Ibid., p. 204.

[2] E.M. Hoover, Location Theory and the Shoe and Leather Industry, Cambridge, Massachusetts, Harvard University Press, 1948.

[3] James Andes, Problems in the Base Surplus Plan in the Philadelphia Milkshed, (University of Pennsylvania: Unpublished M.S. Thesis, 1937) pp. 11-12.

comes a factor in determining price, and that price determines the milk shed or supply area.

Hoover describes the basing point system as establishing price patterns in which delivered prices of all sellers or buyers grade up or down according to freight rates from a designated basing point. The basing point is usually located in a large production area if it's a sellers market or in a large consumption area if it's a large buying market such as with fluid milk.[1] Hoover says that the economies of long hauls make boundary lines sharper curves than hyperbolas and also account for the fact that one market or supply area may completely surround another.[2]

One of the first applications of location theory in developing supply areas for fluid milk for a given area was done in Connecticut by Hammerberg, Parker, and Bressler.[3]

They defined a market as a population or area subject to the same general economic forces. The most efficient supply areas for a combination of these markets would be derived as a result of competitive bidding for the available milk supply. This in turn would equate supply and demand and determine the various price relationships between the

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[1] Edgar M. Hoover, The Location of Economic Activitie , (New York: McGraw Hill Book Company, Inc, 1948) p. 56.

[2] Ibid., p. 61.

[3] D.O. Hammerberg, L.W. Parker, and R.G. Bressler, Jr., Efficiency of Milk Marketing in Connecticut, (Storrs, Connecticut: Agricultural Experiment Station) Part 1, Bulletin, No. 237, 1942

markets.[1]

It was noted that market population and density of production will determine the size of the supply area needed and that in turn these should affect the prevailing market prices.[2]

The major conclusion drawn from the study was that it is possible to allocate producing areas to milk markets in a manner that will minimize the costs of moving milk from farms to markets.

Bredo's and Rojko's study in Massachusetts in 1952 was directed along similar lines.[3] Answers were sought to the following questions: 1) how efficient are price relationships between milk markets, 2) how adequate is the adjustment in the location of milk supply areas in these markets, and 3) what is the amount and process of adjustment in milk prices and supply areas among Northeastern markets under varying economic conditions.[4]

The results of the study showed interregional and intermarket movements were hindered by varying quality standards. This in turn was found to hinder the efficiency of the resulting milksheds in most of the regions.[5] It was

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[1] Ibid., p. 4-6.

[2] Ibid., p. 17.

[3] W. Bredo and Anthony S. Rojko, Prices and Milksheds of Northeastern Markets, Massachusetts Agricultural Experiment Station, Bulletin No. 470, 1952.

[4] Ibid., p. 8.

[5] Ibid., p. 71.

found that small deviations in price were all that were required between cities to insure efficient supply areas. On this basis it was felt that by eliminating the costs of price and market uncertainty the theoretical and observed intermarket prices would be approximately the same and provide for an efficient supply area.[1]

Prices in and among markets are often predetermined by Federal Milk Marketing Orders.[2]

Federal Orders establish a minimum f.o.b. price at the basing point of the marketing area. Prices paid or received in other markets within the marketing area are then influenced by the location adjustment applicable to their location. The resulting price in any of the markets is equal to the f.o.b. basing point price minus the location differential.

The purpose of these differentials is to make possible the procurement of milk throughout the supply area at a uniform cost to all handlers.[3]

The location differentials are based primarily on transportation costs although convenience, certainty, seasonal uniformity, etc., are also considered. The differentials fall generally into two categories: 1) those

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[1] W. Bredo and Anthony S. Rojko, _op.cit_., p. 71.

[2] "Regulations Affecting the Movement and Merchandizing of Milk," Market Research Report, No.98, U.S.D.A. Agricultural Marketing Service, 1955.

[3] _Ibid_., p. 61.

extending over an infinite area, and 2) those that reach out only a given radius. The latter in particular, if not properly adjusted to the supply requirements of the market, serves as a barrier to milk movements into the market.[1]

The above studies all represent valuable contributions toward a better understanding of the problem at hand.

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[1] *Ibid.*, p. 61.

CHAPTER III

METHODOLOGY AND PROCEDURE

Study and Setting

Ten cities in Michigan's lower peninsula were selected for detailed study. These were Bay City, Battle Creek, Detroit, Flint, Grand Rapids, Jackson, Kalamazoo, Lansing, Muskegon, and Saginaw. These cities and their metropolitan areas contain 75.6 percent of the population in Lower Michigan and thus provide the primary outlet for fluid milk and cream.[1]

The cities and their metropolitan areas have been combined into nine marketing areas, as shown in Figure 3-1. In all cases the marketing areas are the same as the metropolitan areas except for the Bay City and Saginaw areas which are combined because of their proximity.

To achieve the objective of maximizing efficiency based on the criteria set forth in the previous chapters,

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[1]The definition of a metropolitan area as used in this study is any county within which a city of 40,000 or more persons is located. Where two or more continuous counties satisfy this condition they may or may not be considered as one metropolitan area depending on the location of the major population concentration and other characteristics of the area.

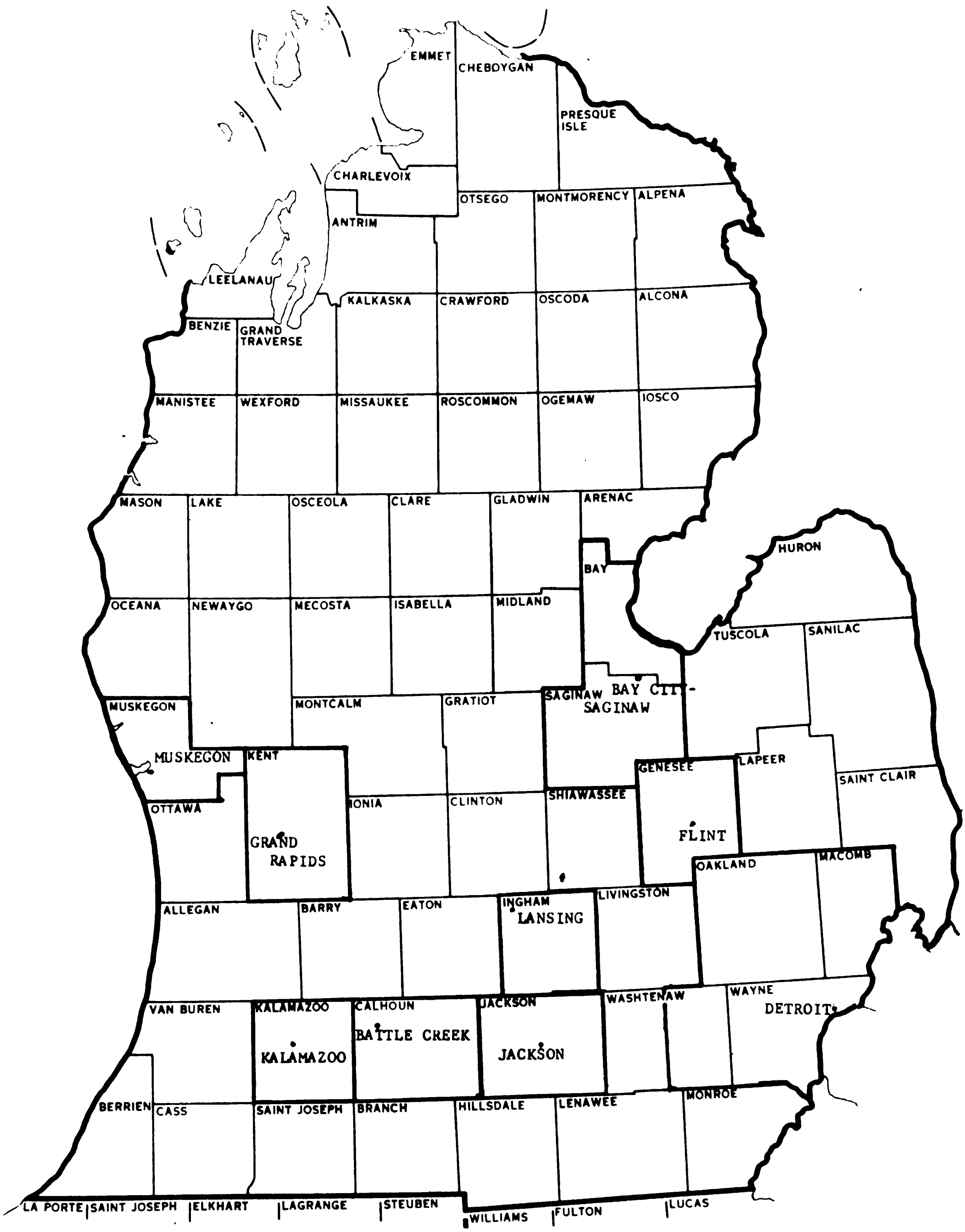

Figure 3-1

Marketing Areas in Michigan, 1959

Each Marketing Area is composed of one or more Metropolitan Areas. A Metropolitan Area is defined as a county containing one or more cities with a population of 40,000 or more. Population data based upon the 1960 census.

certain assumptions concerning the operational characteristics of the markets must be made.

It is assumed that producers will want to maximize the price they receive for their product and thus ship to the market paying the highest price. Handlers will act in a way which will minimize their costs of procurement and thus purchase the product as near to the market as possible.

A second necessary assumption is that of absence of price makers in the market. Under this condition neither the producer nor dealer can influence prices received for their products or prices paid for inputs used in producing the final products.

The Theoretical Model

The model is constructed on the basis of data for 1959. Supply areas are set up on the basis of supply and demand data for November of that year. November is chosen as it is usually the month of lowest total production. Because of this, supply areas that are applicable during November will also be of sufficient size to supply the market requirements during the remainder of the year. As noted in Appendix A, there is a significant difference in total milk production between the high production month of June and the low production month of November.

Market Requirement

The amount of fluid milk required to fulfill the needs of a market is a function of the number of people in that

market and their per capita consumption. In the model 1960 census data are used to determine the population of the markets. Consumption is determined on the basis of the 1959 per capita consumption of fluid milk and cream in milk equivalent. Fifteen percent is added to this amount to allow for variations in consumption and production.

Market Supply

The available supply of fluid milk for the marketing areas is based on total milk production data. Total milk production is determined for each county and is based upon average production and the number of cows in the county. Deductions are made from the total to take into account milk produced which is not of fluid quality, milk used on the farm for other than human consumption, and that milk which is consumed by persons living outside the marketing areas. From the above net figures the total supply of milk of fluid quality available to the marketing areas is determined by adjusting the data for net exports or imports and making an allowance for deficit counties outside the marketing areas.

Supply Areas and Market Prices

With the available supply determined and the market requirement known, supply areas for the markets are simultaneously determined. In essence, the procedure is that of successive approximations until supply and demand are equated for all markets. As will be discussed and illustrated in Chapter IV, these supply areas involve no cross hauling or

overlapping and the total transportation costs involved are minimized.

When the supply areas are determined the exact market price and price relationships among the markets are also determined as each must be such as to secure the appropriate supply. Prices and price variation among the markets are in relation to a base price f.o.b. city plant, Detroit. The Detroit market is used because it is the most distant market from the surplus area of those being considered. It also contains 67.7 percent of the population under consideration, and thus has the largest demand, and as will be seen in Chapter IV, is the market which must travel the greatest distance to satisfy its requirements.

Price Variation Formula

A formula expressing the price variation found to be consistent with efficient supply areas is constructed in Chapter IV. The variables used in the formula are those found to have been important in determining the supply areas. They are density of production, population, distance to basing point, and relationship with the surplus area. Coefficients for the variables are determined by regression analysis. The coefficients are then applied to the variables to obtain estimates of the price variation. By comparing the estimated price variation with those found in the model the formula is tested for accuracy. This formula can then be used to predict the correct price variations for the given

markets, though time as the values of the variables change.

Under the Southern Michigan Marketing Order price variation among the markets is essentially fixed by the applicable location adjustments set forth in the order for the county in which the market is located. In Chapter V a set of supply areas is constructed using the same procedures as in the model except market prices are taken to be those indicated by the Federal order. In section 2 of that chapter a comparison of the two sets of supply areas is made.

CHAPTER IV

Analysis

The objectives of this thesis, as stated previously, are to determine the most efficient supply areas for nine centers of population located in Michigan's lower peninsula and to construct a formula which will reflect and can be used to compute price variation among these markets.

The first section of the analysis deals with the construction of a model in which the supply areas for the nine markets are determined. In developing the model, population, market requirements, milk production and transportation costs are taken into account.

In section two the price variation formula is developed. The variables considered include the density of production, the relative size of the population centers, the relationship between the market and the surplus area, and the distance to the basing point.

Section 1

Population

According to the 1960 census there were 7,778,200 people living in Michigan, of which 96 percent were located in the Lower Peninsula.[1]

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[1]United States Department of Commerce, Bureau of the

Theoretically every source of demand regardless of size has a corresponding supply area. In the case of a self sufficient unit, the supply area consists of the area devoted to producing the product. In the case of villages, towns and cities the supply areas consist of the location from which the product is secured. To make a manageable and perhaps meaningful analysis of an area, however, the number of markets to be considered must be limited to those which are of a dominant size.

As indicated in Table 4-1, there are twenty-two cities in Lower Michigan with a population of 40,000 or more.[1] Seven of these cities and their respective counties comprise seven of the marketing areas under study. (See Table 4-1) Bay City and Saginaw and the counties in which they are located comprise the eighth area. The ninth area is the Detroit market which encompasses the remaining thirteen cities and the counties in which they are located. The exception to the above is Washtenaw county of which only half is considered a part of the Detroit marketing area.

The nine areas described above composed of about 13 counties include 75.6 percent of the total population in the lower peninsula and all areas of population concentration of greater than 40,000 persons. They constitute the dominant demand forces in Lower Michigan. The remaining 24.4 percent

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Census, Preliminary Reports, Populations Counts for States PC (PI) - 24 August, 1960, p. 1.

[1] Op.cit., Preliminary Reports, Population Counts for States, pp.3-5.

TABLE 4-1

CITIES IN MICHIGAN WITH A POPULATION OF 40,000 OR MORE BASED ON THE 1960 CENSUS

City	Population 1960 1/	County in Which City is Located	Marketing Areas to Which City Belongs
Ann Arbor	67,547	Washtenaw	Detroit
Warren	88,766	Macomb	Detroit
Roseville	50,676	Macomb	Detroit
Pontiac	81,651	Oakland	Detroit
Detroit	1,654,125	Wayne	Detroit
Dearborn	111,077	Wayne	Detroit
East Detroit	45,925	Macomb	Detroit
Lincoln Park	53,225	Wayne	Detroit
Livonia	68,539	Wayne	Detroit
Royal Oak	81,140	Oakland	Detroit
St. Clair Shores	77,879	Macomb	Detroit
Wyandotte	42,214	Wayne	Detroit
Wyoming	45,712	Wayne	Detroit
Battle Creek	44,003	Calhoun	Battle Creek
Bay City	53,247	Bay	Bay City
Saginaw	97,031	Saginaw	Saginaw
Flint	194,958	Genesee	Flint
Muskegon	45,925	Muskegon	Muskegon
Grand Rapids	175,344	Kent	Grand Rapids
Lansing	108,128	Ingham	Lansing
Jackson	50,244	Jackson	Jackson
Kalamazoo	81,823	Kalamazoo	Kalamazoo

1/ United States Department of Commerce, Bureau of Census, Preliminary Reports, Population Counts for States, Pc(PI) -24, August, 1960, pp. 3-5.

of the population in the state is much less concentrated.

Market Area Requirements

The average per capita consumption of fluid milk and cream (on a milk equivalent basis) for the United States is used to determine the market requirements. In 1959 this was 348 pounds.[1] This is equivalent to 28.603 pounds per person for the month of November. The market requirements for the nine areas for November, 1959, are shown in Table 4-2.

To allow for fluctuations in market receipts and consumption fifteen percent of the normal per capita consumption is added to each market. This allowance for fluctuations is consistent with the allowances made under most Federal Marketing Orders.

Milk Available to the Market Areas

The amount and location of milk available to the consuming centers is derived from total production figures on a county basis. Table 4-3 shows the computation of the total available milk supply.

The number of cows and heifers two years old or older by county are indicated in column 1 of the table. To determine the total number of cows producing milk a deduction must be made from the number of two year olds and over for those which are not producing. To make this allowance the Michigan Crop Reporting Service' data relating to number of

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[1]Michigan Department of Agriculture, Michigan Agricultural Statistics, July, 1960, p. 5?.

TABLE 4-2

FLUID MILK AND CREAM REQUIREMENTS IN MILK EQUIVALENTS FOR THE NINE MARKETING AREAS IN MICHIGAN FOR NOVEMBER 1959

Marketing Area	Population 1960 1/	Fluid Milk & Cream Requirements for November 1959 2/ (lbs.)	Total Market Requirements including 15% allowance 3/ (lbs.)
Battle Creek	138,378	3,958,026	4,551,730
Bay City-Saginaw	294,831	8,433,051	9,698,009
Flint	370,303	10,591,777	12,180,544
Muskegon	148,950	4,260,417	4,899,480
Grand Rapids	360,574	10,313,498	11,860,522
Lansing	211,634	6,053,367	6,961,372
Jackson	130,948	3,745,506	4,307,332
Kalamazoo	169,151	4,838,226	5,563,960
Detroit	3,825,455	109,419,489	125,832,412
Total	5,650,224	161,613,357	185,855,360

1/ United States Department of Commerce, Bureau of the Census, Preliminary Report, Population Counts for States PC (PI) - 24 August 1960, p. 1.

2/ Population of Marketing area times 28.603, the per capita consumption of fluid milk and cream for November, 1959.

3/ Fluid milk and cream requirements for November, 1959, plus 15% of that amount.

TABLE 4-3

TOTAL MILK PRODUCTION IN LOWER MICHIGAN BY COUNTY, 1959

District and county	Number of cows 2 years and over January 1, 1960 1/	Percent of cows 2 years and over by county 1959 2/	Average number of milk cows on farms by district 1959 3/	Number of milk cows on farms by county 4/	Average production per cow by district 1959 5/ (pounds)	Milk production per county 1959 6/ (pounds)	November 1959 production by county (pounds)
	Column 1	Column2	Column 3	Column 4	Column 5	Column 6	Column 7
District 2							
Antrim	3,800	10.5	32,780	3,442	6,325	21,770,650	1,567,487
Benzie	900	2.5	"	820	"	5,186,500	373,428
Charlevoix	4,500	12.5	"	4,097	"	25,913,525	1,365,773
Emmet	4,600	12.8	"	4,196	"	26,539,700	1,910,858
G. Traverse	3,400	9.4	"	3,081	"	19,487,325	1,403,087
Kalkaska	2,000	5.6	"	1,835	"	11,606,375	835,659
Leelanau	2,700	7.5	"	2,459	"	15,553,175	1,119,829
Manistee	3,000	8.3	"	2,721	"	17,210,325	1,239,143
Missaukee	7,000	19.5	"	6,392	"	40,429,400	2,910,917
Wexford	4,100	11.4	"	3,737	"	23,636,525	1,701,829
Total	36,000	100.		32,780		207,333,500	14,928,010
District 3							
Alcona	3,900	10.8	32,780	3,540	6,398	22,648,920	1,630,722
Alpena	6,400	17.8	"	5,839	"	37,357,922	2,689,770
Cheboygan	3,700	10.3	"	3,376	"	21,599,648	1,555,175
Crawford	200	.6	"	197	"	1,260,406	90,749
Iosco	3,100	8.6	"	2,819	"	18,035,962	1,298,589
Montmorency	2,000	5.6	"	1,836	"	11,746,728	845,764
Ogemaw	6,800	18.9	"	6,193	"	39,622,814	2,852,842
Oscoda	1,700	4.7	"	1,540	"	9,852,920	709,410
Otsego	2,500	6.9	"	2,262	"	14,472,276	1,042,004
Presque Isle	5,300	14.7	"	4,818	"	30,825,564	2,219,441
Roscommon	400	1.1	"	360	"	2,303,280	165,836
Total	36,000	100.		32,780		209,726,440	15,100,302

Page 2 of TABLE 4-3

TOTAL MILK PRODUCTION IN LOWER MICHIGAN BY COUNTY, 1959

District and county	Number of cows 2 years and over January 1, 1960 1/	Percent of cows 2 years and over by county 1959 2/	Average number of milk cows on farms by district 1959 3/	Number of milk cows on farms by county 4/	Average production per cow by district 1959 5/ (pounds)	Milk production per county 1959 6/ (pounds)	November 1959 production by county (pounds)
	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7
District 4							
Lake	2,100	5.5	35,015	1,926	6,841	13,175,766	948,655
Mason	9,300	24.5	"	8,579	"	58,688,939	4,225,603
Muskegon	7,000	18.4	"	6,443	"	44,076,563	3,173,513
Newaygo	12,000	31.6	"	11,064	"	75,688,824	5,409,595
Oceana	7,600	20.0	"	7,003	"	47,907,523	3,449,342
Total	38,000	100.		35,015		239,537,615	17,246,708
District 5							
Clare	5,200	6.0	79,715	4,783	6,834	32,687,022	2,353,466
Gladwin	6,300	7.2	"	5,739	"	39,220,326	2,823,863
Gratiot	14,500	16.7	"	13,313	"	90,981,042	6,550,635
Isabella	15,600	17.9	"	14,349	"	98,061,066	7,060,397
Mecosta	11,500	13.2	"	10,523	"	71,914,182	5,177,821
Midland	4,800	5.5	"	4,384	"	29,960,256	2,157,138
Montcalm	19,500	22.4	"	17,856	"	122,027,904	8,786,009
Osceola	9,600	11.0	"	8,768	"	59,920,512	4,314,277
Total	87,000	99.9		79,715		544,772,310	39,223,606
District 6							
Arenac	6,000	4.7	117,710	5,533	7,422	41,065,926	2,956,747
Bay	11,000	8.6	"	10,123	"	75,132,906	5,409,569
Huron	25,000	19.5	"	22,953	"	170,357,166	12,265,716
Saginaw	19,000	14.8	"	17,421	"	129,298,662	9,309,503
Sanilac	44,000	34.4	"	40,492	"	300,531,624	21,638,277
Tuscola	2,310	18.0	"	21,188	"	157,257,336	11,322,528
Total	128,000	100.		117,710		873,643,820	62,902,340

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TOTAL MILK PRODUCTION IN LOWER MICHIGAN BY COUNTY, 1959

District and county	Number of cows 2 years and over January 1, 1960 1/	Percent of cows 2 years and over by county 1959 2	Average number of milk cows on farms by district 1959 3	Number of milk cows on farms by county 4/	Average production per cow by district 1959 5/ (pounds)	Milk production per county 1959 6/ (pounds)	November 1959 production by county (pounds)
	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7
District 7							
Allegan	20,000	21.3	87,910	18,725	7,430	139,126,750	10,017,126
Berrien	7,600	8.1	"	1,121	"	52,909,030	3,809,450
Cass	6,500	6.9	"	6,066	"	45,076,380	3,245,067
Kalamazoo	8,200	8.7	"	7,648	"	56,824,640	4,091,374
Kent	23,000	24.5	"	21,538	"	160,027,340	11,521,968
Ottawa	19,000	20.2	"	17,757	"	131,934,510	9,499,285
Van Buren	9,700	10.3	"	9,055	"	67,278,650	4,844,063
Total	94,000	100.		87,910		653,171,3[illegible]	47,023,333
District 8							
Barry	13,000	7.1	166,880	11,848	7,641	90,539,568	6,513,201
Branch	16,400	9.0	"	15,019	"	114,760,179	8,262,733
Calhoun	16,400	9.9	"	15,019	"	114,760,179	8,262,733
Clinton	17,000	9.9	"	16,521	"	126,236,961	9,089,061
Eaton	19,900	10.4	"	17,356	"	132,617,196	9,548,433
Hillsdale	18,500	10.3	"	17,189	"	131,341,149	9,456,563
Ingham	18,000	9.9	"	16,521	"	126,236,961	9,089,061
Ionia	18,400	10.1	"	16,855	"	128,789,055	9,272,312
Jackson	15,500	8.5	"	14,185	"	108,337,585	7,803,906
St. Joseph	9,300	5.1	"	8,511	"	65,032,511	4,682,344
Shiawassee	19,500	10.7	"	17,856	"	136,437,696	9,823,514
Total	182,000	100.		166,880		1,217,510,080	91,309,366

TOTAL MILK PRODUCTION IN LOWER MICHIGAN BY COUNTY, 1959

District and county	Number of cows 2 years and over January 1, 1960 1/	Percent of cows 2 years and over by county 1959 2/	Average number of milk cows on farms by district 1959 3/	Number of milk cows on farms by county 4/	Average production per cow by district 1959 5/ (pounds)	Milk production per county 1959 6/ (pounds)	November 1959 production by county (pounds)
	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7
District 9							
Genesee	15,000	10.1	134,845	13,619	7,786	106,037,534	7,634,702
Lapeer	24,000	16.2	"	21,846	"	170,092,956	12,246,693
Lenawee	18,000	12.1	"	16,316	"	127,036,376	9,146,619
Livingston	14,500	9.7	"	13,080	"	101,840,880	7,332,543
Macomb	15,500	10.4	"	14,024	"	109,190,864	7,861,742
Monroe	6,800	4.6	"	6,203	"	48,296,558	3,477,352
Oakland	11,300	7.6	"	10,248	"	79,790,928	5,744,947
St.Clair	22,000	14.6	"	19,687	"	153,282,982	11,036,375
Washtenaw	19,000	12.8	"	17,260	"	134,386,360	9,675,818
Wayne	2,900	1.9	"	2,562	"	19,947,732	1,436,237
Total	149,000	100.		134,845		1,049,903,170	75,593,028
Grand Total						4,995,598,035	363,831,640

1/ Michigan Department of Agriculture, Michigan Agricultural Statistics, July 1960, pp. 30-31
2/ Number of cows per county divided by total number in the respective districts.
3/ Based on number of milk cows on farms, Michigan Department of Agriculture, Michigan Agricultural Statistics, July 1960, p. 16
4/ Column 2 times column 3
5/ Based on average production by district in 1959. Projections are shown in Appendix B.
6/ Column 4 times column 5
7/ Column 6 times 7.2%. Seven and two-tenths percent is the proportion of total production produced in November, based on a ten year average

milking cows is used.[1] It is assumed that the ratio of cows two years old and over to the number of milk cows is constant. The percent of the total cows two years old and over in each district is determined and that percentage applied to the number of total milk cows. This approximation of milk cows per district is shown in column 3 of the table. In a similar manner the percent of cows two years old and over in each county is determined and that figure applied to the total milk cows per district to determine the milk cow numbers in each county, as shown in column 4 of the table.

Production per cow was found to vary by district in 1951.[2] The variation ranged from 5664 pounds per cow in district two to 6973 pounds per cow in district nine. It is assumed that a similar variation has existed since that time. Based on the above the percent variation from the overall average in 1951 is computed for each district and that percentage applied to the 1959 average production to determine the average production per cow in each district. These figures are shown in column 5, Table 4-3. The computations of the averages are shown in appendix B. Total production per county can now be computed as in column 6 by multiplying the number of milk cows in each county by the average

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[1] Op.cit., Michigan Agricultural Statistics, p. 37.

[2] Michigan Department of Agriculture, Dairy Trends in Michigan, June, 1955, p. 16.

production per cow for the appropriate district.

As discussed earlier, the theoretical model is constructed on the basis of the November 1959 supply and demand. As noted in Appendix A based on a ten year average November production has averaged 7.2% of the yearly production. When this percentage is applied to the total production figures for 1959 the November production per county is determined. These figures are shown in column 7 of Table 4-3.

To determine the amount of fluid milk that is available to the marketing areas certain deductions must be made from the total milk produced. These deductions are shown in Table 4-4.

The deduction that is made for milk utilized on the farm as livestock feed and in producing butter amounts to 3.4% of the total production.[1] The net figures on a county basis are shown in column 2, Table 4-4.

It is also necessary to adjust the production figures for that milk which is not of fluid quality or for milk produced for manufacturing purposes only. A study conducted in 1957 indicated that the volume of milk produced for manufacturing purposes was decreasing at the rate of 13.7% per year.[2] A more recent study conducted in October

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[1] Michigan Department of Agriculture, Op.cit., Michigan Agricultural Statistics, p. 37.

[2] G. McBride and W.H. Blanchard, Changes in Michigan's Manufacturing Milk Industry, Michigan State University, Department of Agricultural Economics, Special Bulletin 427, 1959, pp. 18-19.

TABLE 4-4

FLUID MILK AVAILABLE TO THE NINE MARKETING AREAS IN MICHIGAN, NOVEMBER 1959

Districts and counties	November production by county 1959 1/ (pounds)	November production less 3.4 percent 2/ (pounds)	Estimated production of manufacturing milk November 1959 3/ (pounds)	Milk available for fluid use November 1959 4/ (pounds)	Milk consumed outside marketing areas November 1959 5/ (pounds)	Milk available for fluid use including allowance for non-market area consumption (pounds) 6/	Adjustment for excess exports and deficit producing counties (pounds) 7/	Fluid milk supply available to market areas November 1959 8/ (pounds)	Square miles in county 9/	Density per square mile of available fluid milk November 1959 10/ (pounds)
	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10
District 2										
Antrim	1,567,487	1,514,192	892,500	621,692	295,412	326,280	- 78,327	247,953	477	520
Benzie	373,428	360,731	212,500	148,231	219,070	70,839	+ 70,839	0	316	0
Charlevoix	1,865,773	1,802,337	1,062,500	739,837	378,017	361,820		361,820	414	874
Emmet	1,910,858	1,845,889	1,088,000	757,889	447,522	310,367		310,367	461	673
G. Traverse	1,403,087	1,355,382	799,000	556,382	948,018	391,636	+391,636	0	464	0
Kalkaska	835,659	807,247	476,000	331,247	124,223	207,024	-177,107	29,917	564	53
Leelanau	1,119,829	1,081,755	637,500	444,255	263,434	180,821	-131,456	49,366	348	141
Manistee	1,239,142	1,197,012	705,500	491,512	539,910	48,398	+ 48,398	0	558	0
Missaukee	2,910,917	2,811,946	1,657,500	1,154,446	191,154	963,292	- 19,360	943,932	565	1,671
Wexford	1,701,829	1,643,967	969,000	674,967	520,060	154,907	-112,493	42,414	563	75
Total	14,926,010	14,420,458	8,500,000	5,920,458	3,926,820	1,993,638	-	1,985,768	-	-
District 3										
Alcona	1,630,722	1,575,277	162,000	1,413,277	179,055	1,234,222		1,234,222	677	1,823
Alpena	2,689,770	2,598,318	267,000	2,331,318	822,536	1,508,782		1,508,782	568	2,656
Cheboygan	1,555,175	1,502,299	154,500	1,347,799	406,677	941,122		941,122	725	1,298
Crawford	90,749	87,664	9,000	78,664	140,641	61,977	+ 61,977	0	563	0
Iosco	1,298,589	1,254,437	129,000	1,125,437	463,740	661,697		661,697	547	1,210
Montmorency	845,764	817,008	84,000	733,008	125,910	607,098		607,098	555	1,094
Ogemaw	2,852,842	2,755,845	283,500	2,472,345	274,331	2,198,014	- 19,360	2,178,645	574	3,796
Oscoda	709,410	685,290	70,500	614,790	96,907	517,883	- 20,452	497,431	565	880
Otsego	1,042,004	1,006,576	103,500	903,076	214,837	683,239	- 21,073	667,116	530	1,259
Presque Isle	2,219,441	2,142,990	220,500	1,923,430	367,692	1,555,788		1,555,788	654	2,379
Roscommon	165,836	160,198	16,500	113,698	202,366	58,668	+ 58,668	0	521	0
Total	15,100,302	14,586,892	1,500,000	13,086,892	3,294,692	9,792,200	-	9,851,960	-	-

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FLUID MILK AVAILABLE TO THE NINE MARKETING AREAS IN MICHIGAN, NOVEMBER 1959

Districts and counties	November production by county 1959 1/ (pounds)	November production less 3.4 percent 2/ (pounds)	Estimated production of manu-facturing milk November 1959 3/ (pounds)	Milk available for fluid use November 1959 4/ (pounds)	Milk consumed outside marketing areas November 1959 5/ (pounds)	Milk available for fluid use including allowance for non-market area consumption (pounds) 6/	Adjustment for excess exports and deficit producing counties (pounds)	Fluid milk supply available to market areas November 1959 8/ (pounds)	Square miles in county 9/	Density per square mile of available fluid milk November 1959 10/ (pounds)
	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10
District 4										
Lake	948,655	916,401	71,500	844,901	151,024	693,877	- 15,971	677,906	572	1,185
Mason	4,225,603	4,081,932	318,500	3,763,432	620,656	3,142,776	- 15,971	3,126,805	493	6,342
Muskegon	3,173,513	3,065,614	239,200	2,826,414	-	2,826,414		2,826,414	504	5,608
Newaygo	5,449,595	5,264,309	410,800	4,853,509	684,784	4,168,725		4,168,725	857	4,864
Oceana	3,449,342	3,332,064	260,000	3,072,064	469,461	2,602,603		2,602,603	836	3,113
Total	17,246,708	16,660,320	1,300,000	15,360,350	1,925,925	13,434,395	-	13,402,453	-	-
District 4										
Clare	2,353,466	2,273,448	1,118,000	1,085,448	330,622	754,826	- 9,974	744,852	572	1,302
Gladwin	2,823,862	2,727,852	1,425,600	1,302,252	304,622	977,630	-155,883	841,747	503	1,983
Gratiot	6,550,635	6,327,913	3,306,600	3,021,313	1,056,480	1,964,833	- 48,636	1,961,197	566	3,386
Isabella	7,060,397	6,820,344	3,544,200	3,276,144	1,008,256	2,267,888	-194,545	2,073,343	572	3,625
Macosta	5,177,821	5,001,775	2,613,600	2,388,175	600,692	1,787,483		1,787,483	563	3,175
Midland	2,157,138	2,083,795	1,089,000	944,795	1,463,158	468,363	+468,363	0	520	0
Montcalm	8,786,009	8,487,285	4,435,200	4,052,085	1,011,974	3,040,111		3,040,111	712	4,270
Osceola	4,314,277	2,178,000	1,989,592	1,989,592	388,200	1,601,392		1,601,352	581	2,756
Total	39,223,606	37,890,004	19,780,200	18,109,804	6,164,004	11,945,800	-	12,005,125	-	-
District 6										
Arenac	2,956,747	2,856,218	930,600	1,925,618	280,281	1,645,337		1,645,337	368	4,471
Bay	5,409,569	5,225,644	702,800	4,522,844	-	4,522,844	- 72,955	4,449,889	446	9,977
Huron	12,265,716	11,848,682	3,861000	7,987,682	967,125	7,020,557		7,020,557	822	8,541
Saginaw	9,309,503	8,992,980	2,930,400	6,062,580	-	6,062,580	- 24,318	6,038,262	812	7,436
Sanilac	21,638,277	20,902,576	6,811,200	14,091,376	918,242	13,173,143		13,173,143	916	13,708
Tuscola	11,322,528	10,937,562	3,564,000	7,373,562	1,194,576	6,178,986		6,178,966	816	7,572
Total	62,902,340	60,763,662	18,800,000	41,963,662	3,360,224	38,603,438	-	38,506,165	-	-

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FLUID MILK AVAILABLE TO THE NINE MARKETING AREAS IN MICHIGAN, NOVEMBER 1959

Districts and counties	November production by county 1959 1/ (pounds)	November production less 3.4 percent 2/ (pounds)	Estimated production of manu-facturing milk November 1959 3/ (pounds)	Milk available for fluid use November 1959 4/ (pounds)	Milk consumed outside marketing areas November 1959 5/ (pounds)	Milk available for fluid use including allowance for non-market area consumption (pounds) 6/	Adjustment for excess exports and deficit producing counties (pounds)	Fluid milk supply available to market areas November 1959 8/ (pounds)	Square miles in county 9/	Density per square mile of available fluid milk November 1959 10/ (pounds)
	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10
District 7										
Allegan	10,017,126	9,676,544	2,066,100	7,610,444	1,641,984	5,968,460		5,968,460	828	7,208
Berrien	3,809,450	3,679,929	785,700	2,894,229	4,256,498	1,362,269	+1,362,269	0	580	0
Cass	3,245,067	3,134,735	669,300	2,465,435	1,047,156	1,418,279	- 681,135	737,144	488	1,511
Kalamazoo	4,091,374	3,952,267	843,900	3,108,367	-	3,108,367	- 253,355	2,855,012	567	5,035
Kent	11,521,968	11,130,221	2,376,500	8,753,721	-	8,753,721		8,753,721	862	10,155
Ottawa	9,499,285	9,176,309	1,959,400	7,216,909	2,813,448	4,403,461		4,403,461	607	7,339
Van Buren	4,844,063	4,679,365	999,100	3,680,265	1,374,660	2,305,605	- 681,134	1,624,471	607	2,676
Total	47,028,333	45,429,370	9,700,000	35,729,370	11,133,746	24,595,624	-	19,938,308	-	0
District 8										
Barry	6,518,201	6,296,582	1,036,600	5,259,982	903,512	4,356,470		4,356,470	549	7,935
Branch	8,262,733	7,981,300	1,314,000	6,667,800	996,614	5,671,186	-1,017,826	4,653,360	506	9,196
Calhoun	8,262,733	7,981,300	1,314,000	6,667,800	-	6,667,800	- 253,355	4,414,445	709	9,047
Clinton	9,089,261	8,780,033	1,445,400	7,334,633	1,083,053	6,251,580		6,251,580	571	10,948
Eaton	9,548,438	9,223,791	1,518,400	7,705,391	1,426,918	6,278,473		6,278,473	567	11,073
Hillsdale	9,456,563	9,135,040	1,503,800	7,631,240	989,807	6,641,433	- 264,241	6,377,192	601	11,051
Ingham	9,089,061	8,780,033	1,445,400	7,334,633	-	7,334,633		7,334,633	559	13,121
Ionia	9,272,812	8,957,536	1,474,600	7,482,936	1,225,610	6,257,326		6,257,326	575	10,882
Jackson	7,803,906	7,538,573	1,241,000	6,297,573	-	6,297,573	- 1,620	6,295,953	705	8,930
St. Joseph	4,682,344	4,523,144	744,600	3,778,544	1,206,761	2,571,783	- 253,355	2,318,428	508	4,564
Shiawassee	9,823,514	9,489,514	1,562,200	7,927,314	1,521,508	6,405,806		6,405,806	540	11,863
Total	91,809,366	88,687,846	14,600,000	74,087,846	9,353,783	64,734,063	-	62,943,666	-	-

FLUID MILK AVAILABLE TO THE NINE MARKETING AREAS IN MICHIGAN, NOVEMBER 1959

Districts and counties	November production by county 1959 1/ (pounds)	November production less 3.4 percent 2/ (pounds)	Estimated production of manu-facturing milk November 1959 3/ (pounds)	Milk available for fluid use November 1959 4/ (pounds)	Milk consumed outside marketing areas November 1959 5/ (pounds)	Milk available for fluid use including allowance for non-market area consumption (pounds) 6/	Adjustment for excess exports and deficit producing counties (pounds) 7/	Fluid milk supply available to market areas November 1959 8/ (pounds)	Square miles in county 9/	Density per square mile of available fluid milk November 1959 10/ (pounds)
	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10
District 9										
Genesee	7,634,202	7,375,122	282,800	7,092,322	-	7,092,322		7,092,322	644	11,013
Lapeer	12,246,693	11,830,305	453,600	11,376,705	1,203,471	10,173,234		10,173,234	659	15,437
Lenawee	9,146,619	8,835,634	338,800	8,496,834	2,211,040	6,285,794	- 36,026	6,249,766	754	8,289
Livingston	7,332,543	7,083,236	271,600	6,811,636	1,084,025	5,727,611		5,727,611	571	10,031
Macomb	7,861,742	7,594,443	291,200	7,303,243	-	7,303,243		7,303,243	481	15,183
Monroe	3,477,352	3,359,122	128,800	3,230,322	2,888,331	341,991	- 8,100	333,891	562	594
Oakland	5,744,947	5,549,619	212,800	5,336,819	-	5,336,819		5,336,819	877	6,085
St. Clair	11,036,375	11,240,738	408,800	10,831,938	3,043,245	7,788,693		7,788,693	740	10,525
Washtenaw	9,675,818	9,346,840	358,500	8,988,440	2,460,087	6,528,353	- 3,758	6,524,595	716	9,113
Wayne	1,436,237	1,387,405	53,200	1,334,205	-	1,334,205		1,334,205	607	2,198
Total	75,593,028	73,602,404	2,800,000	70,802,464	12,890,199	57,912,262	-	57,864,379	-	-
Grand Totals	363,831,640		76,980,200		52,049,393		-	216,498,324	-	-
		352,041,016		275,060,816		223,011,423				

1/ Seven and two-tenths percent of the total production (Table 4-3)
2/ Allowance for milk used on the farm for other than fluid consumption, Michigan Department of Agriculture, Michigan Agricultural Statistics July 1960, p. 37
3/ Estimates based on 1955-57 production. Computation shown in Appendix C
4/ Column 2 minus column 3
5/ Population per county times the per capita consumption of fluid milk and cream in milk equivalents (28.603)
6/ Column 4 minus column 5
7/ As determined in Appendix D
8/ Column 6 minus column 7
9/ Michigan State University, Michigan Statistical Abstract, Bureau of Business and Economic Research, Third Edition 1960, pp. 47-48
10/ Column 8 divided by column 9

of 1960 indicated a continuation of that trend at approximately the same rate.[1] When this percentage is applied to the amount of manufacturing milk produced in 1957 an estimate of production in November of 1959 is obtained. This estimate is shown in column 3 of Table 4-4.[2]

Making the above deductions from the total amount of milk produced gives us an estimate of the total fluid milk available in the Lower Peninsula as shown in column 4 of Table 4-4.

To determine the portion of this amount available to the marketing areas further deduction must be made for persons living in counties other than those included in the marketing areas, for deficit producing counties, and for the net difference between exports and imports. The amount of these deductions are shown in columns 5, 6, and 7 of Table 4-4.

Deductions for those counties outside of the marketing areas are based on the population of those counties and their per capita consumption of fluid milk and cream.

The Cleveland, Toledo, South Bend, and Chicago markets are the sizable markets located near Michigan. The amount of milk of fluid quality moving to or from the Chicago and South Bend markets was found to be negligible and thus

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[1]G. McBride and W.B. Hellegas, Fewer Producers of Manufacturing Milk, Michigan Farm Economics, No. 216, January, 1961, Department of Agricultural Economics, Michigan State University.

[2]Refer to Appendix C for computation of estimate.

is not considered.[1] That moving to and from the Cleveland and Toledo markets, however, is significant and consequently its effect on the total supply available must be taken into account.[2] As noted in Table 4-5 in both cases exports from Michigan exceed imports. The excess of exports is deducted from the total available supply as follows.[3] In the case of Toledo the counties from which the milk originated and the percent of each county's contribution to the total is published in the Market Administrator Report.[4] These percentages are used to determine the amount of the net export which comes from each county and this amount in turn is deducted from the available milk in that county. In the case of Cleveland no such figures are available. The amount by which exports exceed imports in this market are allocated to the area in which the Cleveland receiving stations are located. The allocation is based on the amount of milk available in the county in which the station is located and those surrounding it. The allocations are shown in Appendix D and the amount is again shown in column 7 of Table 4-4.

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[1] Based on discussions with Mr. G. A. Swanson, Michigan Cooperative Crop Reporting Service and information received from plants which ship to these markets from time to time.

[2] Data obtained from the Toledo, Detroit, and Cleveland Market Administrators and the plants which are involved in exporting and importing of milk of fluid quality.

[3] See Appendix D for allocation to counties.

[4] Toledo, Ohio Marketing area, Analysis of Producers Receipts, for months of January, June, and December, 1959.

TABLE 4-5

FLUID MILK IMPORTS AND EXPORTS,
MICHIGAN, NOVEMBER, 1959

Marketing Area	Milk imported to Michigan from the area in November 1959 (pounds)	Milk exported to the area from Michigan November 1959 (pounds)	Exports from Michigan in excess of imports to Michigan November 1959 (pounds) 1/
Cleveland	387,142	2,413,982	2,026,840
Toledo	301,775	366,575	64,800
South Bend	2/	2/	-
Chicago	2/	2/	-

1/ For allocations of deductions see Appendix D.

2/ Negligible

Source: Personal interview with Mr. G.A. Swanson of the Michigan Cooperative Crop Reporting Service, September, 1960. Personal letters from Mr. George Irvine, Market Administrator, Southern Michigan Marketing Order, September 30, 1960, Mr. R.J. Quaintance, Deputy Market Administrator, Toledo Milk Marketing Area, September 20, 1960, Mr. A. W. Wolgamood, Manager, Constantine Cooperative Creamery Company, September, 30, 1960, and Mr. A. Wiersma, Manager, Mead Johnson and Company, September 30, 1960.

A final adjustment must be made for those counties which do not produce enough milk to cover the above deductions. It is assumed that these counties will obtain milk from neighboring counties to take care of their deficits. The allocation of the deficit to neighboring counties is shown in appendix D. These counties as noted in column 8 of Table 4-4 have no excess milk from which the marketing area may draw.

Column 8 of Table 4-4 indicates the amount of fluid milk by county available to the market areas being examined. In column 9 of that table the relative density per square mile is shown.

Transportation Costs

To determine the most efficient supply areas for the nine markets, it is necessary to again set forth the assumptions upon which this analysis is being made. It is assumed that the receiving stations (representing the producers) will sell to the point of highest return and that the city plants will purchase from the points of lowest procurement cost. Under the perfect market concept the cost of moving milk from one point to another then becomes the logical basis on which competitive choice is made.

Maximum efficiency is reached when the total costs of transportation for all markets is minimized. It should be noted that this is not necessarily consistent with minimizing the transportation costs of any one of the markets. With

transportation costs minimized the receiving station in total will receive the highest average price for their milk, and the city plants when all markets are considered will be paying a minimum amount to secure the milk.

To minimize the cost of transportation it is necessary to determine how total transportation costs vary with distance. Total costs, or costs per mile times miles traveled, are relevant for our purposes as it is these costs which must be minimized.

The total cost of transportation is broken down into three classes, fixed costs, fixed costs of operation and variable costs.

Fixed Costs - Fixed costs are those which cannot be varied within the time period being considered. They are composed of costs such as depreciation allowances, licenses, insurance, etc.

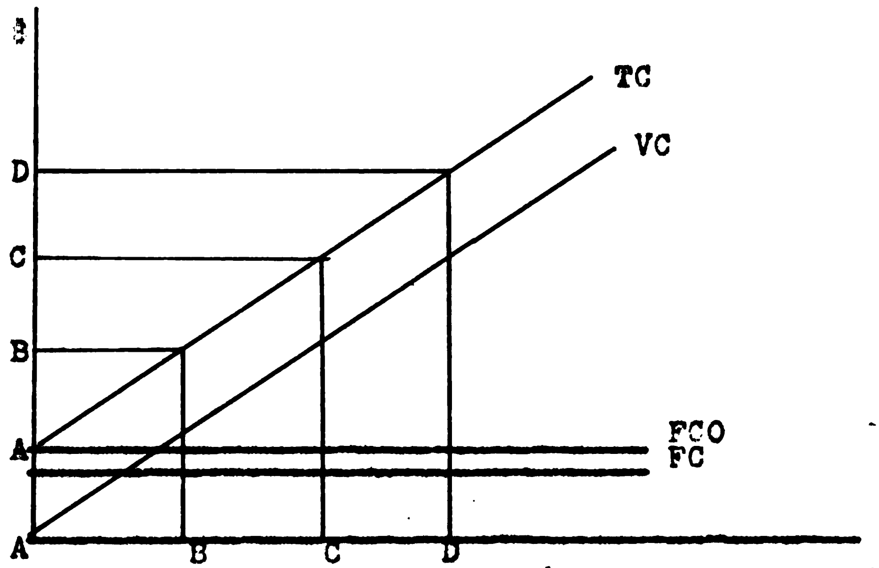
Fixed Costs of Operation - These are the costs which can be varied within a given time period but which are fixed and do not vary if the unit is utilized. The cost of loading and unloading compose this cost item. This cost does not vary with miles traveled and thus cannot be considered a variable cost.

Variable Costs - The variable costs of transportation are composed of costs incurred by drivers' wages, repairs, fuel, etc., which will vary within the given time period based on the number of miles the means of transport travels.

The variable costs associated with milk hauling are assumed to be linear in nature.[1] That is, fuel costs, labor costs, etc., increase at a constant rate with miles traveled.

The following figure shows a general graphical representation of these cost functions for a given size load carried any number of miles.

Costs of Transportation



As depicted in the figure price varies with miles traveled by the increase in variable cost. The variable cost being linear with distance, indicate a constant rate of increase in cost with miles traveled or a constant marginal cost indicating the addition to total cost of moving one more mile is constant.

On the basis of the above the concentric ring analysis

[1]This assumption appears justified and is based on data examined by the author and on discussion with Dr. E.W. Smykay, Associate Professor, Department of Marketing and Transportation Administration, Michigan State University.

used in constructing the model will consist of rings which move out from the market origin at a constant rate. The rings represent a constant increase in cost or miles. These increases are equal to the increase in cost incurred by moving a given number of miles or the number of miles that can be traveled at a given cost.

The above does not suggest that the fixed costs of transportation are unimportant or foregone. It does, however, indicate that they are not functionally distributed on the basis of miles traveled, but rather included on a cost per unit basis in the f.o.b. plant prices.

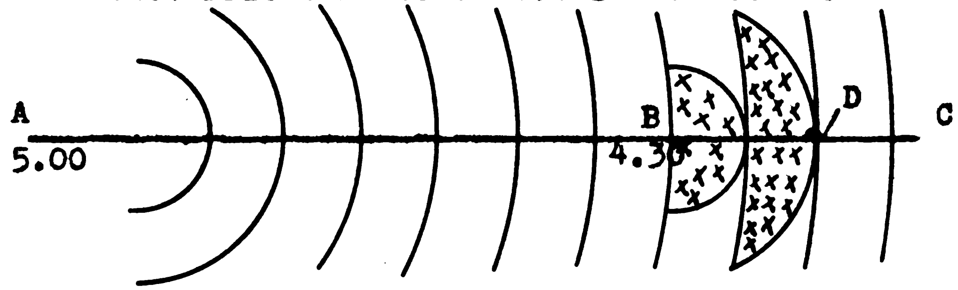
Theoretically all milk consumed in a market must be relocated from its point of production or collection. The fixed cost incurred to move this milk will then represent a portion of the value of that milk regardless of its source. For this reason it should be included in the quoted f.o.b. price.

The following example further exemplified the above.

In a concentric ring analysis with the rings varying in radius by a constant number of units the lines of indifference between the two markets or the lines defining the market boundaries will take on the form of a hyperbolic function. This function by definition will satisfy the condition of $A - B = K$ where A and B are the distances from the two markets to the point on the boundary line. The constant, K, is important as it relates the distance from B toward A (the basing point) at which the hyperbolic function

will cross the X axis. In case 1, K is considered the units from A to B either based on miles or the variable cost of transportation.

Market Prices Based on Total Variable Cost



The basing point, or Market A, price is equal to the surplus price ($3.00) plus the fixed cost of transportation ($0.50) plus the variable cost of transportation, $0.10 per 10 mile unit ($2.00). The f.o.b. price offered by A will be equal to this total cost of $5.50 minus an allowance per hundred weight to cover the fixed cost of transportation for the milk purchased ($0.50) or $5.00. The f.o.b. price at B is equal to the basing point f.o.b. price minus the variable cost of moving milk between A and B or $5.00-7 .$0.10 = $4.30.

At one unit from B towards A, A will offer its f.o.b. price minus the variable cost incurred by moving six units or $5.00 - $0.60 = $4.40. B will offer its f.o.b. price minus the variable cost associated with one unit of distance or $4.30 - $0.10 = $4.20. From this we can see that A will offer a higher price at all points between A and B and thus secure all the milk in that area. As we move toward C, A and B will offer the same price in the checked

area. For example at point D each will offer their market f.o.b. price minus the appropriate variable cost:

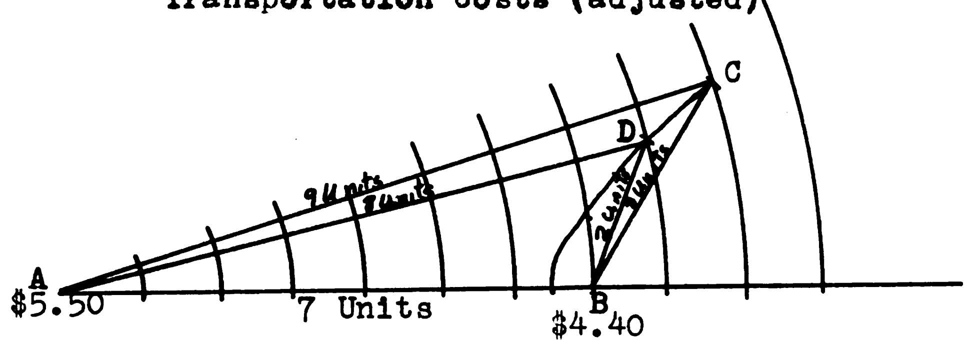
A = \$5.00 - \$0.90 = \$4.10; B = \$4.30 - \$0.20 = \$4.10.

As a result of the above we can see that when the f.o.b. prices vary only and exactly by the variable cost of transportation it is not economically profitable for a producer in an area such as indicated above to sell to one market in preference to the other, thus the market-supply area is indeterminate.

The above illustrates the importance of K. If K is equal to the total number of units by which the two markets differ the supply area becomes indeterminate. If K is less than the total number of units it reflects the amount by which the f.o.b. price in market B is above the base price minus the variable cost of transportation between the two points and thus the distance which the supply area for B will project toward A.

In case 2 we examine what will result if the f.o.b. prices vary by the total cost of transportation (fixed plus variable).

Market f.o.b. Prices Based on Total Transportation Costs (adjusted)



The costs are assumed to be the same as in case 1. In this analysis, however, the f.o.b. price at B is increased by \$0.10 so that the supply area boundary will not be indeterminate.

The basing point, or Market A, price will then equal the surplus price plus the total cost of transportation to A or \$5.50. The Price at B would be equal to the basing point price minus the total cost of transportation between the two points + \$0.10 or \$5.50 - \$0.50 - \$0.70 + \$0.10 = \$4.40. The following prices will be offered at point C & D based on the above f.o.b. prices and the total cost of moving milk between those points and the markets.

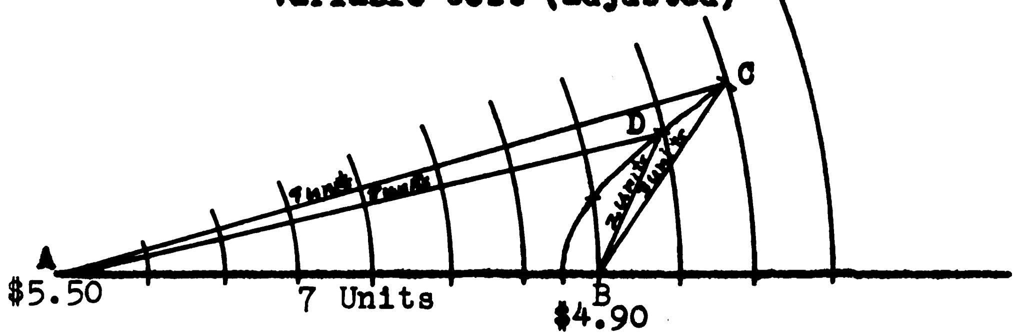
	F.o.b. prices	FC	VC	Price
Price at C for A =	\$5.50 -	.50 -	.90 =	\$4.10
Price at C for B =	\$4.40 -	.50 -	.30 =	\$3.60
Price at D for A =	\$5.50 -	.50 -	.80 =	\$4.20
Price at D for B =	\$4.40 -	.50 -	.20 =	\$3.70

Although mileage units indicate a market boundary is defined as A - B = K in neither case do the two markets pay an equal price at the common points. From this it is concluded that competitive market supply areas are not defined if prices differ by the total cost of transportation.

In case 3 the fixed costs of transportation are included in the f.o.b. prices and thus contribute nothing to the price variation among points in the market. In this case the f.o.b. price at B will again be increased by \$0.10

so that the supply area will be defined. The costsof transportation are assumed the same as in the previous cases.

Market f.o.b. Prices Based on Total
Variable Cost (adjusted)



As in case 1 where the f.o.b. price makes allowance to cover fixed costs the f.o.b. price at A is equal to $5.00. The f.o.b. price at B is then equal to the market A price minus the variable cost of transporting milk from A to B plus $0.10 or $5.00 - $0.70 + $0.10 or $4.40.

The following are the prices that will be offered at points C and D by markets A and B assuming just the variable cost is deducted from the f.e.b. price.

	F.o.b. Price	Variable Cost	Price
Price at C for A	$5.00	$0.90	$4.10
Price at C for B	$4.40	$0.30	$4.10
Price at D for A	$5.00	$0.80	$4.20
Price at D for B	$4.40	$0.20	$4.20

In both cases the conditions of A - B = K are satisfied using either cost or mileage units. At both C and D each market offers the same price. From this it is concluded that to competitively define market supply areas the f.o.b. prices must include the fixed cost of transportation and

must be somewhat less than the variable cost of transporting milk between the two points.

The above three cases are summarized as follows:

1) the fixed costs of transportation must be included in the f.o.b. prices if competitive supply areas are to be defined
2) the f.o.b. basing point price must be greater than that which would result from subtracting the total cost variation from one point to another.
3) the net prices offered to receiving stations (Producers) are less than the f.o.b. market prices in two competing markets by an amount equal to the variable cost of transportation and are equal on the market boundary.

In developing the theoretical model the concentric rings will vary in radius by a constant number of miles and cost as discussed earlier in the chapter. Based on previously published data and other data examined by the author a variable cost of approximately $0.001 per hundredweight per mile is applicable for tankers with a capacity of 50,000 to 55,000 pounds per trip.[1] The concentric rings in the model will be approximately ten miles apart and thus represent a cost change of approximately $0.01 per zone.

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[1]A mile in this study refers to trip mile or the cost incurred e.g., one mile round trip.

Market Supply Areas

The market supply areas are determined simultaneously for all the markets considered. This is done essentially by a series of approximations varying the amount by which the f.o.b. market price exceeds the base price minus the cost of transporting milk from the base point to the markets. When all the market demands are exactly satisfied and each decreasing price line represented by the concentric rings moving away from the basing point are continuous over the entire area the most efficient supply areas are defined. The supply areas for the markets are illustrated in Figure 4-1. It can be noted that each decrease in price is continuous over the whole area under consideration. In this case, 12.8 units is the maximum deviation from the basing point f.o.b. price. Where a price line is not continuous it represents an increase in prices for the market in which it is located. These increases come about in areas such as Grand Rapids where price actually increases with distance from the basing point over a given range. In the case of Grand Rapids this range is between A and B as indicated on the map. These increases in price are the result of less competition in the immediate area. Again using Grand Rapids as an example we can see on the map that it can radiate out using almost full rings as the requirements of the other markets are satisfied before reaching the Grand Rapids area.

In determining the correct price variation the f.o.b. prices will not necessarily be expressed in even dollars and

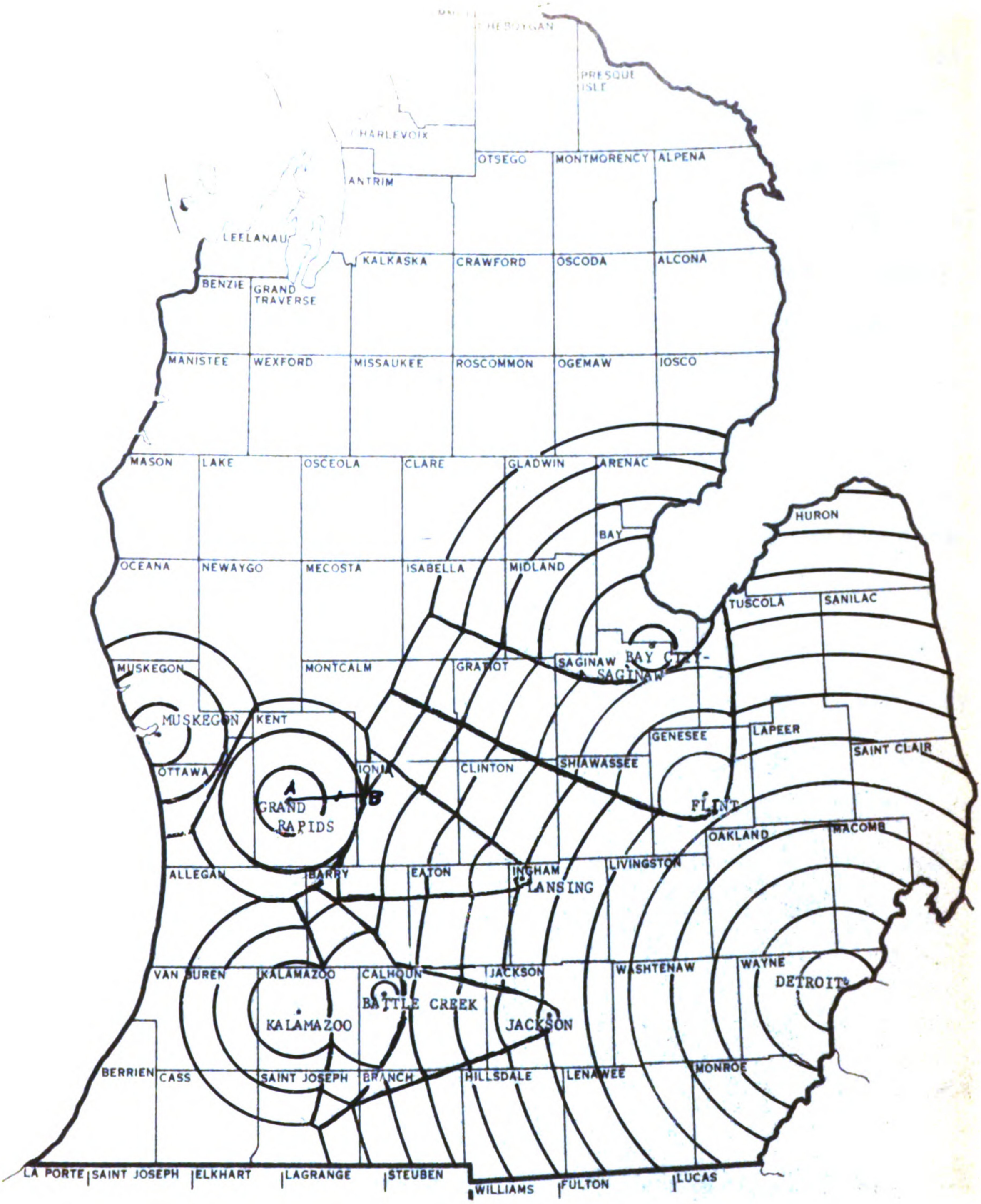


Figure 4-1

Theoretical Supply Areas for the Nine Marketing Areas in Michigan, November 1959 cents but in general will involve fractions of a cent. This results from the fact that the initial ring moving away from the city determines the size of the area included for that market. In most cases this ring is not a full ten miles and thus represents only a fraction of the cost of moving ten miles or a fraction of a cent. The radius of the initial ring is influenced by factors such as the density of production in the area in which the market is located and the effects of other competing markets. These factors will be discussed in more detail in Section II of this chapter which deals with the factors affecting price variation.

The price variation among the markets as computed on the basis of Figure 4-1 are shown in the Table 4-6. Each supply area covers an area which will supply exactly the amount of milk required by that market. The amount of milk included in the supply areas are determined geometrically. Each county's contribution in square miles is determined and then multiplied by the density of available production per square mile for that county. The total of all the county contributions are equal to the market requirements.

Section II

Price Variation

As shown in the preceding section when supply areas are determined for a set of markets the price variation among these markets are also determined. Table 4-6 shows the price variation among markets based on the theoretical

TABLE 4-6

PRICE VARIATION IN UNITS AMONG THE NINE MARKETING AREAS IN MICHIGAN
FOR NOVEMBER 1959 AS DETERMINED IN THE THEORETICAL MODEL 1/

	Detroit	Flint	Bay City-Saginaw	Lansing	Grand Rapids	Muskegon	Jackson	Battle Creek	Kalamazoo
Detroit	0								
Flint	5.05	0							
Bay City-Saginaw	7.50	2.45	0						
Lansing	7.85	2.80	.35	0					
Grand Rapids	10.33	5.28	2.83	2.48	0				
Muskegon	10.33	5.28	2.83	2.48	0	0			
Jackson	6.66	1.61	.84	1.19	3.67	3.67	0		
Battle Creek	9.55	4.50	2.05	1.70	.78	..78	2.89	0	
Kalamazoo	10.00	4.95	2.55	2.15	.33	.33	3.34	.45	0

1/ One unit equals $0.01 or cost of moving 10 miles model.

In this section a price variation formula is constructed. With this formula the price variation that must exist among the markets to insure minimum transfer costs for the whole area under consideration can be estimated.

For such a formula to be useful through time and have general applicability, the variables included must represent the relevant factors which effect the size, shape and thus the price in the markets and be capable of doing so as the market characteristics change.

The market characteristics or variables after being defined and quantified are put into the general formula described above and tested statistically for accuracy in computing price variation. The resulting formula, within its statistical limits, can then be used to determine the price variation which would insure a system of supply areas organized in accordance with the criteria set forth in this study.

Factors Affecting Price Variation

Location in Reference to the Basing Point

As previously stated this study is concerned only with the derivation of a most efficient set of supply areas based upon milk transport cost. In constructing the model in this manner we are assuming that labor costs, land costs, feed costs, etc., are constant throughout the area and consequently have no affect on price variation.

Based on the above we can see that price variation among the markets will be the same regardless of the basing point used. This is true since there is only one geometric combination of supply areas that will minimize total transportation costs for all markets. This does not say that the formula being developed will not change if the basing point is other than Detroit. The variables will remain the same but their quantitative values will change and since we are using a mathematical solution, so will their coefficients.

Detroit is used as the basing point because it has the largest market requirement and thus will have the largest supply area. Because of this it must have the greatest price at its origin relative to other markets to enable it to compete at distant locations. All price deviations will then result in f.o.b. prices which are less than Detroit's. If another market was used the variation would result in f.o.b. prices higher and lower than that of the basing point. The variations expressed in units would remain the same but they would be more difficult to handle mathematically.

In using Detroit as the basing point the concentric rings or iso-price lines moving out from its origin represent the maximum amount by which price can vary between the base point and a market located on a given radius if the supply area for that market is to be defined.

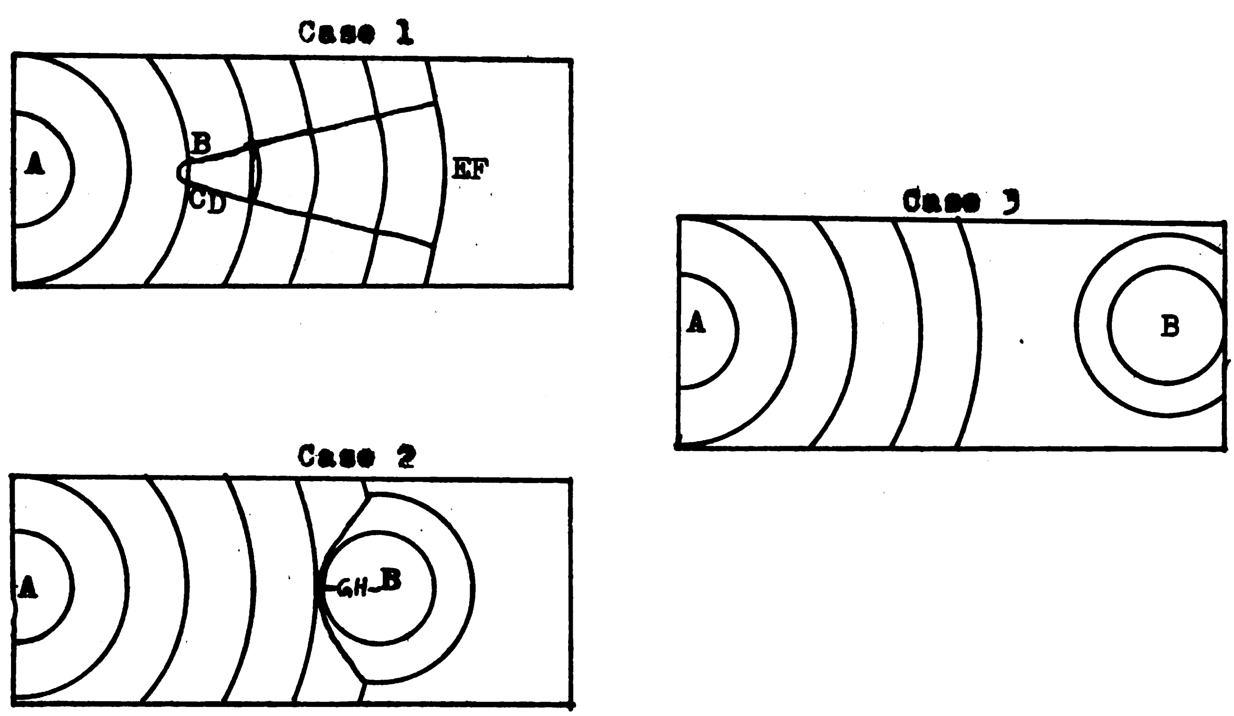
As discussed earlier if the variation is greater the supply area will not be defined in any manner and if it is exactly equal to that variation the supply area boundaries,

although indicated, will not be exactly defined. For this reason a variable expressing the relationship of the basing point to the individual markets must be included in the formula.

The importance of distance from the basing point is illustrated in the following example.

The density of available milk supply is assumed constant throughout the area in which the markets compete for milk. The requirements of A and B are also constant thus the geometric area in the respective supply area will be the same in all three cases.

Effects of Market Location in Reference
to the Basing Point



A = Basing Point

In case 1, market B is located relatively close to

the basing point. To satisfy the requirements of efficiency, B's market boundary is a line of indifference extending out as far as the two must move to satisfy their total requirements. As a result B's market takes the form of a long narrow hyperbola. In order to define such a hyperbola the price at B is just slightly above the base price minus transportation cost. The extent of this increase can be measured either by the distance CD or EF. If its deviation from the base price minus transportation cost were greater than this amount the market would secure its supply in a more circular manner and inefficiencies of cross haul would result.

In case 2, B is more distant from A. It can be noted in the example that most of A's market requirement is satisfied before A and B compete for the available supply. Because of this the relative price variation with distance from the basing point decreases from that found in the first case. As discussed in the previous section the concentric ring representing the lowest price or greatest differential from the base point must be the lowest for all markets. Because of this, market B's f.o.b. price is increasing with distance from the basing point between points GH. This increase represents the amount by which the f.o.b. price at B is greater than the f.o.b. base point price minus transportation costs. It can be seen even though B's requirements are the same this deviation is greater than in the earlier case. The amount of deviation is proportional to

the distance the market is located from the basing point.

Case 3 represents a situation wherein A and B secure their supply independent of direct competition. With A representing the basing point its outer concentric ring sets a price limit subject to transportation costs, which sets a maximum limit on the price variation at B or the minimum price that B can pay.

From the above it may be concluded that distance from the basing point does affect price variation among the markets.

In constructing a quantitative value for this variable the maximum amount of deviation due to distance is fixed by the distance between the two points. The relative market requirements will then determine the amount of the maximum variation that is relevant. If the markets were of equal size each would have an equal price and the area would be divided equally between them. As one market increases relative to the other, price variation appears. The variable expressing the relationship with the basing point is based on this principle of relative market size in determining the amount by which price variation will differ from the variation resulting from distance alone.

Each market as shown in the model has an f.o.b. price which is greater than the f.o.b. base point price minus transportation costs. The hyperbolic function defining the supply area boundaries determines this deviation. The distance from B that the hyperbola intersects the X axis going

from B to A indicates this deviation in price variation from the total transportation costs. From this we can see that if the population or market requirements of B increases or decreases relative to A the distance and thus the amount of deviation will increase or decrease as the hyperbola will change. This deviation then represents the push of B back on A and is termed the power effect, the ratio of B's population to A's being termed the power factor. As shown in Table 4-7, the power factor applied to the total distance A to B estimates the number of miles or units that B's market will move toward A. Column 4 of the Table shows the net effect on variation or the total distance minus the power effect due to the market relationship with the basing point. This is variable X_1 used in the formula.

As noted in column 2 of Table 4-7, the distance used for Grand Rapids and Muskegon is 13.8 units. Figure 4-2 shows that a 13.8 unit radius from Detroit encompasses enough fluid milk and cream to supply all the requirements of the included area and markets. This is then taken to be the maximum variation for markets located outside the 13.8 unit distance as discussed in case 3 of the above example.

In summary the variable is quantified by the following formula:

$$X_1 = \text{distance A to B} - \left(\frac{\text{Population B}}{\text{Population A}} \cdot \text{distance A to B}\right)$$

Relationship With Competing Markets

The number, location, and size of competing markets in relation to a given market also will affect price varia-

TABLE 4-7

BASING POINT VARIABLE FOR THE NINE MARKETING AREAS IN MICHIGAN, NOVEMBER 1959

Marketing Areas	Power Factor 1/	Distance from Detroit to the market (units) 2/	Power Effect 3/	Variable in Units 4/
Bay City	.0362	11.04	.399	10.641
Saginaw	.0771	9.15	.705	8.445
Flint	.0968	5.65	.547	5.103
Muskegon	.0389	13.80	.537	13.263
Grand Rapids	.0943	13.80	1.336	12.464
Lansing	.0553	8.00	.443	7.557
Jackson	.0342	6.87	.235	6.635
Kalamazoo	.0442	12.78	.565	12.215
Detroit	0	0	0	0

1/ The power factor reflects the push of the individual markets back on the basing point market. It is equal to the population of any marketing area divided by the population of the basing point marketing area.

2/ One unit equals 10 miles.

3/ The power effect is the power factor times the distance in units from Detroit to the market.

4/ The variable is equal to the total distance minus the power effect.

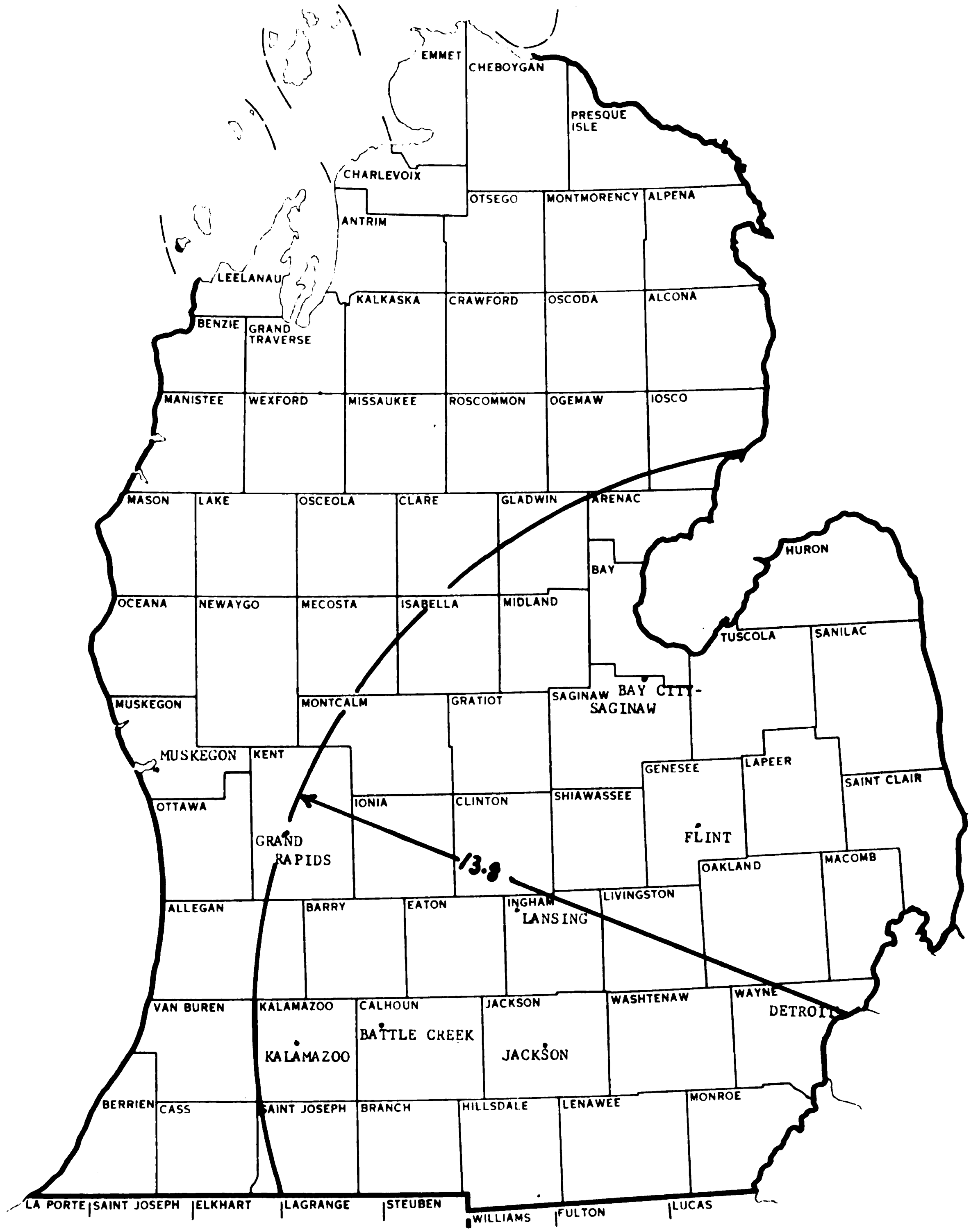


Figure 4-2

Maximum Distance Factor for Computing the Basing Point Variable for the Nine Marketing Areas in Michigan. (In Units of 10 Miles)

tion. If we refer to Figure 4-1, the model developed in the last section, it is easy to see that changes due to the above would cause price changes among the markets. If for example the requirements for Battle Creek were doubled, the size, shape and amount of price variation from the basing point would change for all the markets located near Battle Creek to enable it to satisfy its greater requirement.

The amount by which price variation will differ from that of transportation cost from the basing point can again be measured by the distortion of the concentric rings moving out from Detroit. To quantify an estimate of this distortion the following rationale is used.

As discussed earlier a line from Detroit through a given market center represents the X axis used in forming the hyperbolic function representing the market boundaries. Since a hyperbola is symmetric to this line the location in which the supply area will be formed is determined by the angle or direction of the X axis. As noted in Figure 4-3, if X axes are constructed for all the markets we have three groups of axes with similar angles from the basing point. This indicates that supply areas formed on these axes will come into contact over a large portion of their boundary. For purposes of computing variable X_2 the markets in each of these groups are considered as the primary source of distortion. This does not say that other markets will not influence price variation but rather that for estimating purposes the affects from other markets are not measured. The

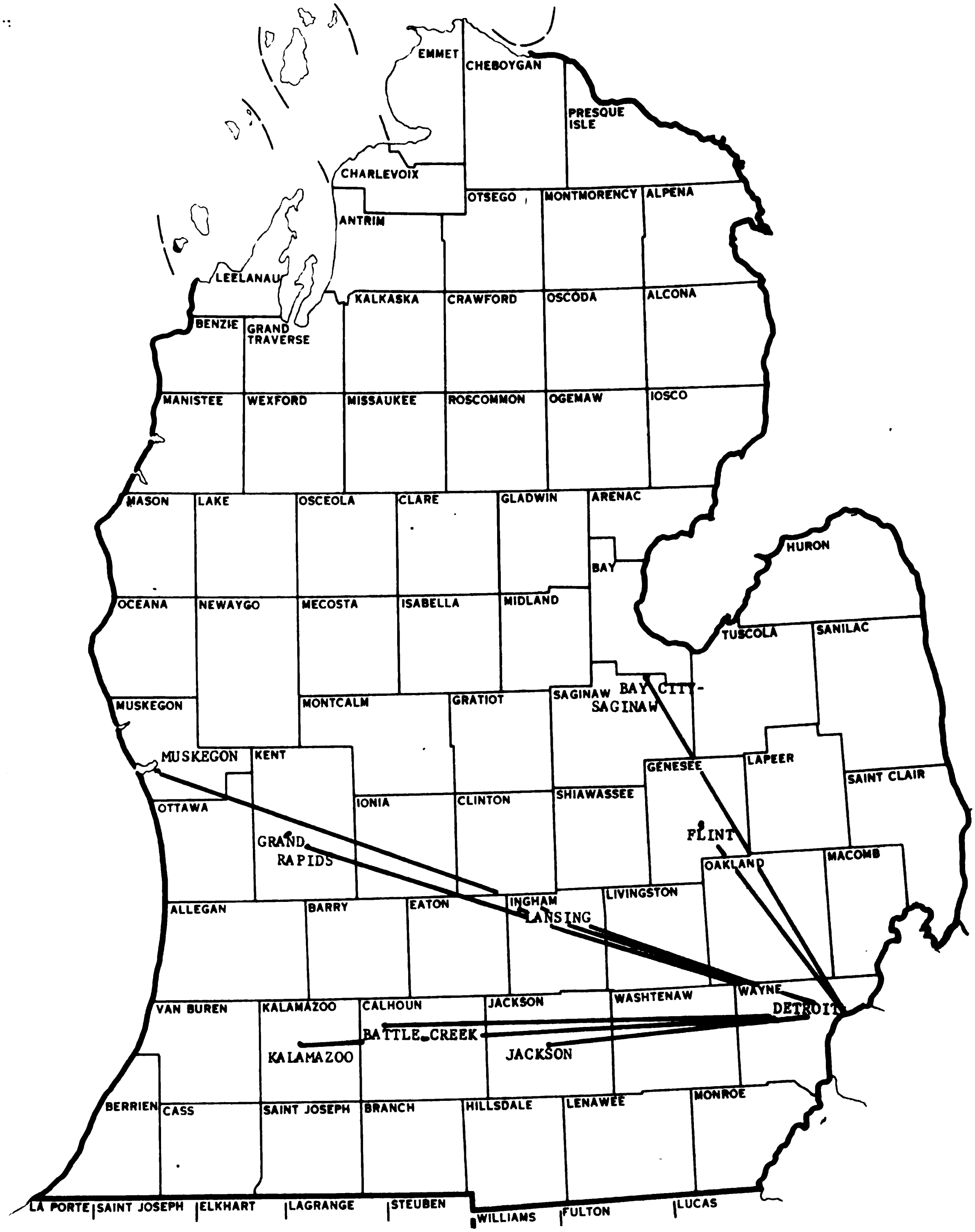


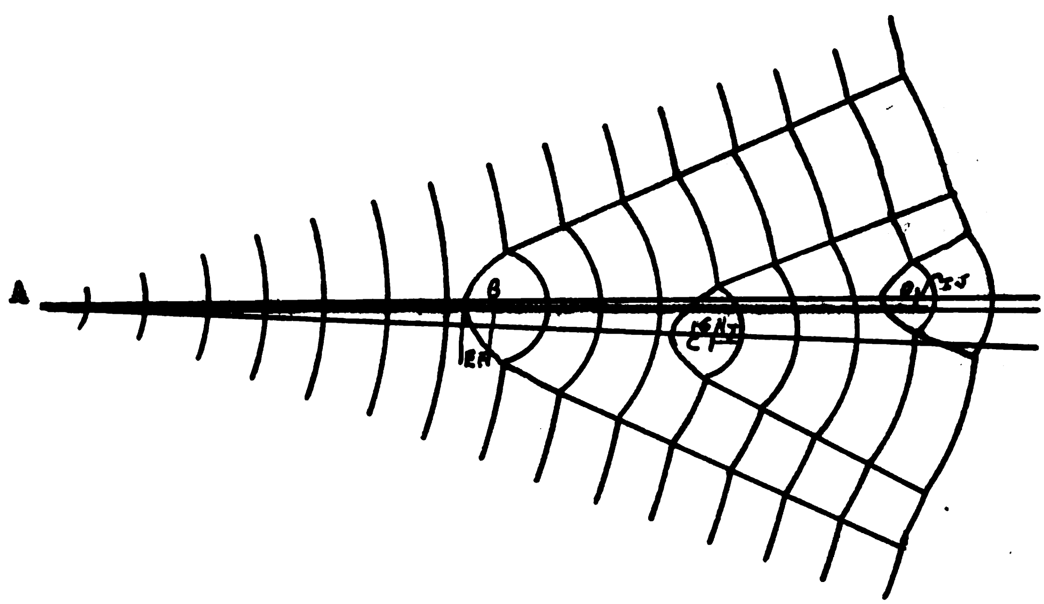
Figure 4-3

"X" Axes Used to Estimate the Relationship of Competing Markets for the Nine Marketing Areas in Michigan, 1959

reason for this is that those markets not competing over wide areas of their boundary will have little effect on the market price and that without constructing a model as used in the last section the number and importance of affecting markets other than those with like X axes cannot be estimated accurately.

The following example illustrates the accumulative nature of the distortion among markets with similar X axes.

Affects of Interrelated Markets
on Price Variation



A is the basing point. As discussed in reference to the X_1 variable, B's deviation from the maximum variation can be measured by EF. The axes represented by AB, AC, and AD used in determining the hyperbolic functions have approximately the same angle in reference to A. As shown in the example this causes C's market to be constructed on concentric rings moving out from B and D's from rings moving out from C. Thus the X axes for C and D are actually lines originating from B and C respectively. The amount of deviation from transportation costs from B to C for market C is thus measured by GH, with the total deviation from the basing point being GH + EF. The same is true for market D with its total variation equal to IJ + GH + EF. From the above we can see that the price variation is influenced by the accumulated effects moving away from the basing point.

As mentioned in discussing the X_1 variable the distance between any two markets influences the concentric ring distortion. Based on this the accumulative distances are used in quantifying the X_2 variable. The quantified variables as shown in Table 4-8 represent the total distance in units such as from the basing point to market B plus the distance from market B to C, etc., for all markets affected. The variables are negative because they will have a price increasing, or price variation decreasing affect in relationship to the base price.

As will be shown later, the resulting variable is highly correlated with the variation found in the theoretical model.

The general equation for this variable would be as follows:

X_2 = distance to market being considered from the basing point plus the distance from that market to all other markets located between the two points which compete directly

TABLE 4-8

LOCATION AND COMPETING MARKET VARIABLE FOR THE NINE MARKETING AREAS IN MICHIGAN IN UNITS 1/

	Bay City-Saginaw	Battle Creek	Flint	Muskegon	Grand Rapids	Lansing	Jackson	Kalamazoo	Detroit
Variable 2/	12.900	15.140	5.650	23.050	19.650	8.000	6.870	20.350	0

1/ One unit equals 10 miles

2/ The variable is equal to the distance from the basing point to the market being considered plus the distance to other markets with which it competes directly located between the two points.

with the market being considered.

Effects of Density of Production

Figure 4-4 shows the density of available fluid milk per square mile for November, 1959, in the area under study. As can be noticed the density varies widely over the area being considered. Because of this variation two markets with identical requirements may have supply areas which differ in total area included.

To the extent that price or price variation is a function of the size of the supply area an allowance must be made for this variation in density in reference to the average density of the basing point supply area. Variable X_3 is included for this purpose.

Even though we know that the boundaries separating supply areas will take a form based on hyperbolic functions it is difficult to visualize these boundaries without actually constructing a model. This is due to the accumulative effects of distortion discussed in reference to the X_2 variable. It thus becomes impossible to determine the exact average density that a supply area will have without going through the type analysis discussed in section 1.

To get a quantitative value for this variable it is necessary to form an estimate for the density which will exist in the supply areas.

When looking at the supply areas devised in the model we can see that two straight lines intersecting at a point

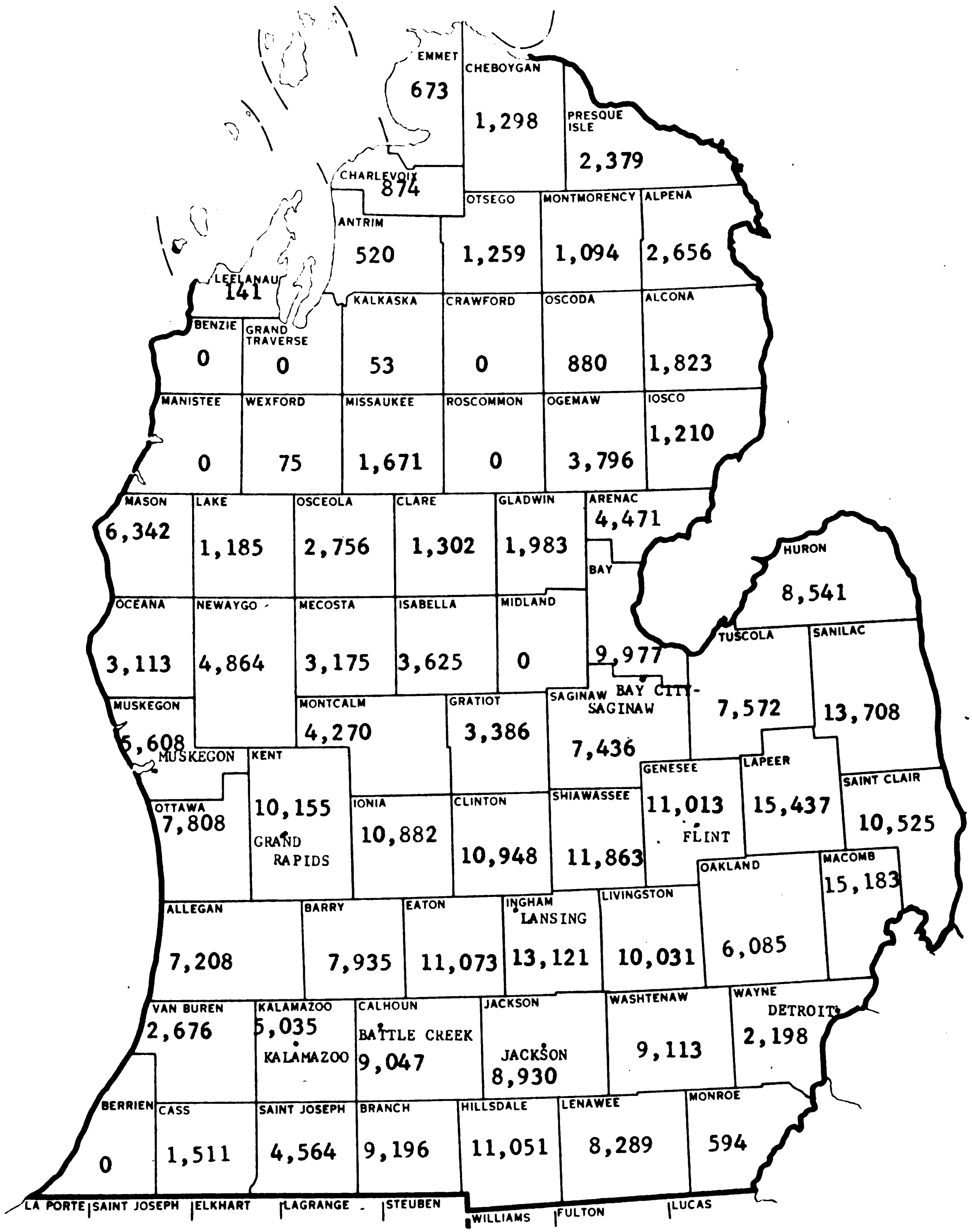


Figure 4-4

Pounds of Fluid Milk Per Square Mile Available to the Marketing Areas, November 1959

between the market being considered and the basing point gives a fairly good representation of the general shape of the supply area boundary. If we construct a set of these as done in Figure 4-5, taking into account the market requirement and the available supply located in the area between the lines, we can get an indication of the counties that will be included in the supply area. By using these counties, an approximation of the density in the supply area can be derived. Appendix E shows the computation of the estimated average densities as shown in column 2 of Table 4-9. It is emphasized that in constructing these estimated boundaries that the location of other markets, density of available production and market requirements must be kept in mind because the angle formed by the intersection of the two lines is important in quantifying the variable.

As the price variation is put in terms of deviation from the base point f.o.b. price the estimated density of the Detroit market is used as a basis of comparison for the other markets. If the estimated density for a given market is the same as Detroit's the X_3 variable has a value of zero as both markets secure the same amount of milk from a given unit of area. If a market's estimated density is higher than Detroit's the variable is positive as the Detroit market procures less on the average from a given area than the market being considered. As a result Detroit would have to have a higher price to enable it to move farther away from its origin to get an equal amount of milk. It is the same as a

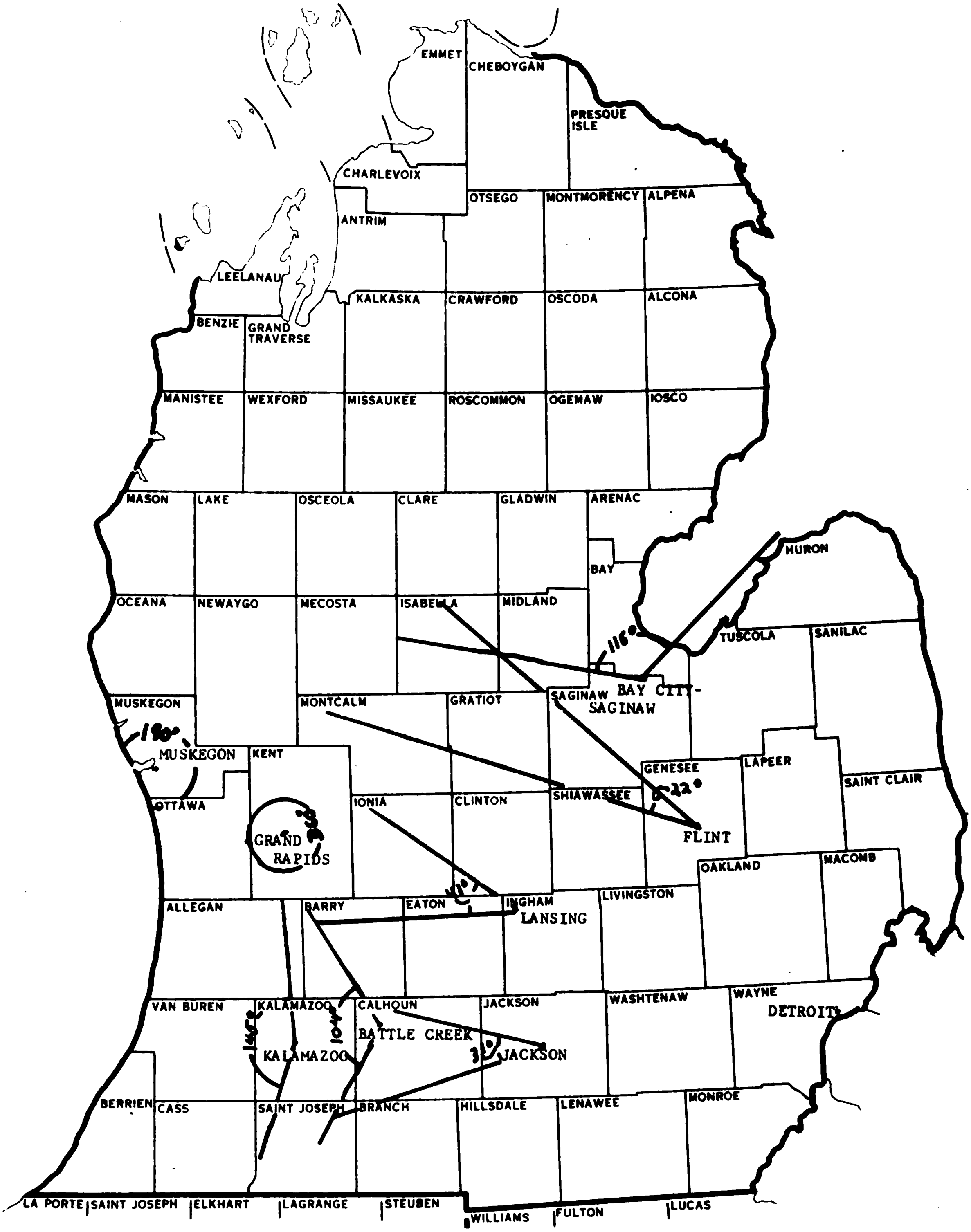


Figure 4-5

Estimated Angles Between the Supply Area Boundaries for the Nine Marketing Areas for Michigan, November 1959

TABLE 4-9

AREA IN SQUARE MILES NEEDED TO FULFILL THE MARKET REQUIREMENTS OF THE NINE MARKETING AREAS IN MICHIGAN, NOVEMBER 1959

Marketing Areas	Market Requirements	Estimated Density of Supply Areas		Number of Square Miles Needed To Fulfill Market Requirements	
		Marketing area square miles 2/	Detroit square miles 2/	Based on Estimated Supply Area Density 3/	Based on Estimated Detroit Supply Area Density 4/
	Column 1	Column 2	Column 3	Column 4	Column 5
Saginaw	9,698,009	4,241	8,939	2,287	1,085
Flint	12,180,544	6,431	"	1,894	1,363
Muskegon	4,899,480	5,071	"	966	548
Grand Rapids	11,860,522	7,545	"	1,572	1,327
Lansing	6,961,372	10,804	"	644	779
Kalamazoo	5,563,960	5,086	"	1,094	622
Battle Creek	4,551,730	6,834	"	666	509
Jackson	4,307,332	8,106	"	531	482
Detroit	125,832,412	8,939	"	14,076	14,076

1/ Market requirements equal per capita consumption of fluid milk and cream in milk equivalents for November 1959 (28.603) times the population in the marketing area

2/ Density estimated to prevail in the supply areas. Computation of estimates shown in Appendix E

3/ Column 1 divided by column 2

4/ Column 1 divided by column 3

decrease in the other market price, or an increase in variation between the two. If the supply area's density is less than Detroit's the reverse is true.

Column 1 of Table 4-10 shows the angles formed by the estimated market boundary. The density variable is based on the distance a given market will have to go to secure its supply, based on its estimated density in comparison with the distance it would have to go if the Detroit supply area density prevailed. We are interested in a comparison of radii of the most distant concentric rings under the two circumstances. To derive this, the angles in column 1 of Table 4-10 are put in terms of a full circle as shown in column 2. Columns 3 and 4 designate the number of square miles needed to fulfill the requirements of the markets, as calculated in Table 4-9, based on the two market densities. It is these areas that would have to be included within the angles given in column 1. To put these in terms of a complete circle as shown in columns 5 and 6, they are multiplied by column 2. Columns 5 and 6 then represent the areas of two circles, one determined on the basis of the estimated Detroit supply area density and the other on the basis of the given market's estimated density. To determine the difference in radii of these circles the areas are put into the formula $r^2 = \frac{A}{\pi}$. The radii for the two circles are shown in columns 9 and 10 and their differences in column 11. The X_3 variables, as shown in column 12, are in terms of unit differences in radii, or column 11 divided by 10.

TABLE 4-10

COMPUTATION OF THE DENSITY VARIABLE FOR THE NINE MICHIGAN MARKETING AREAS
NOVEMBER 1959

Marketing areas	Angles 1/	360° / Angles 2/	Number of square miles needed to fulfill the market requirements: Based on Detroit density 3/	Based on estimated market supply area density 3/	Area need in terms of a full circle (A): Column 3 times column 2 4/ (square miles)	Column 4 times column 2 4/ (square miles)	The square of the radii of the circles: Column 5 / 3.1416 5/ miles	Column 6 / 3.1416 5/ miles	Estimated radius of circumference enclosing market requirement (miles): √Column 7 6/	√Column 8	9-10 7/ miles	Variable in units 8/
	Col. 1	Col. 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10	Column 11	Column 12
Saginaw	115	3.13	1,085	2,287	3,396	7,158	1,081	2,278	32.88	47.73	-14.85	-1.485
Flint	22	16.36	1,363	1,894	22,298	30,985	7,098	9,863	84.25	99.31	-15.06	-1.506
Muskegon	190	1.89	548	966	1,036	1,826	329	581	18.14	24.10	- 5.96	- .596
Grand Rapids	360	1.00	1,327	1,572	1,327	1,572	422	500	20.54	22.36	- 1.82	- .182
Lansing	41	8.78	779	644	6,840	5,654	2,177	1,800	46.66	42.43	4.23	+ .423
Kalamazoo	145	2.48	622	1,094	1,543	2,713	491	864	22.16	29.39	- 7.32	- .732
Battle Creek	104	3.46	509	666	1,761	2,304	561	733	23.69	27.15	- 3.46	- .346
Jackson	31	11.61	482	531	5,596	6,165	1,781	1,962	42.21	44.30	- 2.09	- .209

1/ Angles of estimated supply area boundaries. See figure 4-6
2/ 360° divided by angles in column 1
3/ As determined in table 4-9
4/ Columns 3 and 4 times column 2. This puts the area needed in terms of a full circle.
5/ Using the formula $A = \pi R^2$ or $R^2 = \frac{A}{\pi}$ to determine R_2

6/ To determine the radius of the circumference enclosing the areas in columns 5 and 6, the square roots of columns 7 and 8 are determined in miles.
7/ Column 10 minus column 9 gives us the difference in radii in miles based on the Detroit and market supply area density estimates.
8/ The difference in radii (column 9 minus column 10) divided by 10.

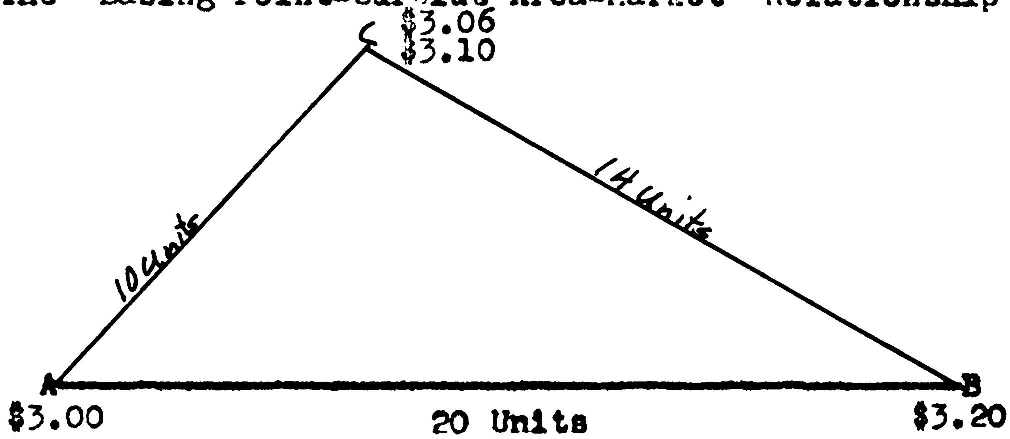
The variable computed above gives us a relative measure among the markets of the effects of variation in density on price variation with reference to the basing point. In other words, it is an estimate of the amount and direction of price change needed to discount the variations in density from the non-basing point markets in reference to the basing point.

Relationship With the Surplus Area

In theory, prices in all markets are influenced by that market's distance from the surplus area. The surplus price plus the cost of transportation determine the minimum and maximum prices in the market. The maximum f.o.b. basing point price and thus the maximum price that the basing point market will offer at any point is based on the surplus price plus cost of transportation to the basing point. In turn, the minimum price that is acceptable at any point is based on the surplus price plus the cost of transportation. In our case the Detroit (basing point) market is the major buying market, points located distant from Detroit can be thought of primarily as selling markets. The maximum price offered by the basing point is then determined by the surplus price plus transportation cost to Detroit minus the transportation cost to the point being considered. In terms of the selling markets the surplus area, in effect, sets the maximum value that their product is worth. The deviation between the two is the basis of the X_4 variable. The

following example illustrates the above:

The "Basing Point-Surplus Area-Market" Relationship



The basing point price equals $3.20, or the surplus price plus the cost of transportation. The price B will offer at C equals $3.20 - .14 = $3.06, or the basing point f.o.b. price minus the cost of transportation to C. In turn, the value C places on its produce = $3.00 + .10, or the surplus price + cost of transportation. Thus at point C, C values product at four units or $0.04 above that which B is willing to pay.

In quantifying the X_4 variable the price discrepancies described above for the markets are shown in column 3 of Table 4-11. They are equal to the distance AC + CB - AB, or column 1 minus column 2. Figure 4-6 shows these distances for the individual markets. The distance from the surplus area is taken from point A on the map. Although this is not in the surplus area of Wisconsin, it is the point of entry into Michigan and thus can be used. The price assigned to that point represents the surplus price

TABLE 4-11

THE VARIABLE EXPRESSING THE RELATIONSHIP BETWEEN THE MARKETS, THE SURPLUS AREAS AND THE BASING POINT FOR NINE MICHIGAN MARKETING AREAS, NOVEMBER 1959

Marketing areas	Distance from the market to Detroit plus the distance from the market to the surplus area in units 1/	Distance from the surplus area to Detroit in units 1/	Amount of discrepancy between Detroit price and surplus price in units 2/	Power factor 3/	Net effect on price variation in units 4/	Sign 5/	Variable in units 6/
	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7
Flint	23.74	19.65	4.09	.097	.397	-1	-.397
Bay city-Saginaw	28.11	19.65	8.46	.077	.651	-1	-.650
Lansing	21.39	19.65	1.74	.055	.096	-1	-.096
Jackson	19.64	19.65	0	.034	0	-1	0
Battle Creek	20.26	19.65	.61	.036	.022	+1	+.022
Kalamazoo	20.08	19.65	.43	.044	.018	+1	+.018
Grand Rapids	24.08	19.65	4.43	.094	.416	+1	+.416
Muskegon	27.56	19.65	7.91	.038	.300	+1	+.300

1/ One unit equals 10 miles.

2/ Column 1 minus column 2. For detailed discussion refer to text.

3/ Power factor equals the population of the marketing area divided by the population of the Detroit marketing area.

4/ Column 4 times column 3 - for detailed discussion refer to text.

5/ Where the distance from Detroit to the market is greater than the distance from the surplus area to the market the net effect on price variation is positive. Where the reverse is true, it is negative. See Fig.4-7

6/ Column 6 times column 7

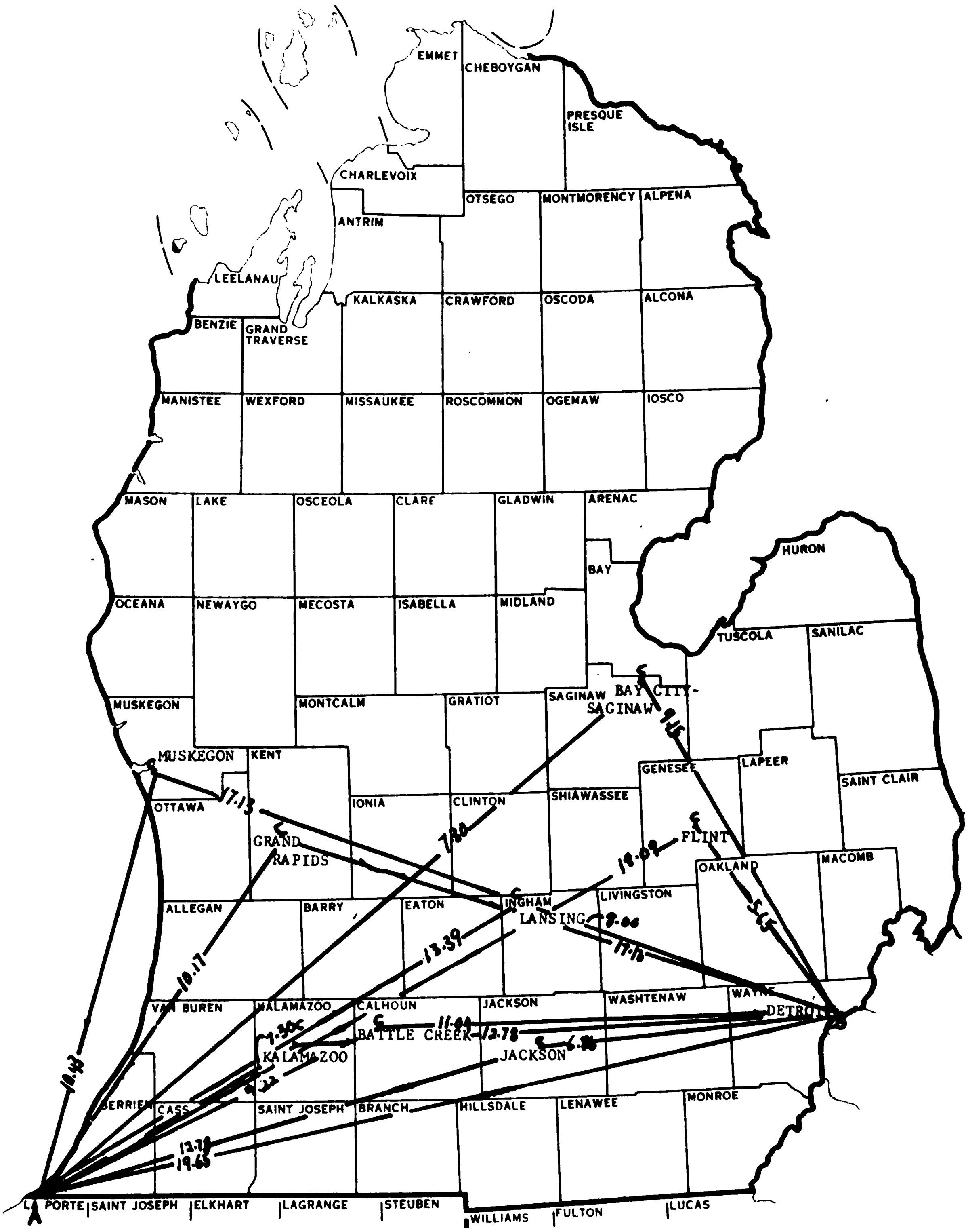


Figure 4-6

Distance to Detroit and the Surplus Area from the Nine Marketing Areas in Michigan
(In ten mile units)

plus transportation costs to that point. For price variation purposes we are thus subtracting a constant from all markets which will not affect variation in price among the markets. The deviation from the price variation as determined by distance alone is taken to equal the price discrepancy, or column 3 times the relative power factor derived earlier as shown in column 4. In effect, this states that the price variation is influenced by the competitive power of the market. The net effects are shown in column 5 of the table. The X_4 variable will be either positive or negative depending upon whether AC or CB is greater. Where AC is the larger, the variable is negative representing an increase in price variation or a decrease in price. This results because the basing point is closer to the market than the surplus area and thus represents the primary influence. Where CB is greater the variable is positive representing a decrease in price variation or an increase in price. This is due to the dominant influence of the surplus area. The above reflects the decreasing possibility of using the surplus area rather than the basing point outlet as distance from the surplus area increases.

Price Variation Formula

The variables to be used in predicting the price variation between the nine f.o.b. market prices and the basing point price were discussed and quantified above.

The general formula that is used to predict the price

variations is $\hat{Y} = b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4$, where Y is the estimated price variation between the market being considered and the base market. X_1, X_2, X_3, and X_4 are the independent variables; distance to the basing point, location and number of competing markets, density of production and relationship with the surplus area, and the b's represent the partial regression coefficients.

It is of interest to see which of these variables can be directly related to the actual price variation found in the theoretical model. To determine this relationship the predictor variables are correlated with the observed Y values. Table 4-12 lists these variables as determined earlier in the section. The results of the analysis show that both the X_1 and X_2 variables are directly related to price variation as they have correlation coefficients of .97 and -.92 respectively.[1] Variables X_3 and X_4 with correlation coefficients of +.39 and +.81 cannot be directly related as indicated by their low coefficients. These results suggest that the price variation may be closely associated with distance to the basing point and competing markets but not with density of production and location in reference to the surplus area. They do not, however, tell us anything about the combined effects of using these variables to predict the price variation.

To determine the weight (b_1) that should be given to

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[1]All statistical computations for this section are shown in Appendix F.

TABLE 4.12

PRICE VARIATION AND VARIABLES FOR THE NINE MARKETING AREAS IN MICHIGAN, NOVEMBER 1959

Marketing areas	Y Variation from basing point	X_1 Distance to basing point	X_2 Number and location of competing markets	X_3 Density of production	X_4 Relationship with the surplus area
Bay City-Saginaw	7.50	8.445	- 12.900	- 1.485	- .650
Battle Creek	9.55	10.641	- 15.140	- .346	+ .022
Flint	5.05	5.103	- 5.650	- .506	- .397
Muskegon	10.33	13.263	- 23.050	- .592	+ .300
Grand Rapids	10.33	12.464	- 19.650	- .182	+ .416
Lansing	7.85	7.557	- 8.000	+ .423	- .096
Jackson	6.66	6.635	- 6.870	- .209	0
Kalamazoo	10.00	12.215	- 20.350	- .723	+ .018
Detroit	0	0	0	0	0
Total	67.27	76.323	-111.610	- 4.620	- .387
Average	8.409	9.540	- 13.951	- .478	- .0484

each of the variables to obtain a "best estimate" of the price variation a multiple regression analysis is used. The "best estimate" is then tested for its accuracy in predicting $\hat{Y}$ by a correlation analysis between $\hat{Y}$ and Y.

The regression coefficients, or the b_1 values and their standard errors are:

b_1,	+ 1.3677 (.0885)	b_2,	+ .3139 (.0396)
b_3,	+ .2353 (.0828)	b_4,	- .8180 (.1038)

These coefficients indicate the relative weights of their respective variables in determining the price variation. The standard errors show that all the coefficients are significantly different from zero.

To test these variables for significance in determining the estimated price variation a T test is used. The standard errors are divided into the regression coefficients and compared with the T distribution at the 95% and 99% levels. The resulting T values are:

b_1, $\frac{1.3677}{.0885} = +15.446$ b_2, $\frac{.3139}{} = +7.920$

b_3, $\frac{.2353}{.0828} = +2.840$ b_4, $\frac{-.8180}{.1038} = -7.884$

These results show that b_1, b_2, and b_4 are significant at the 99% level and that b_3 is significant at the 95% level. It is thus concluded that all the variables are significant in determining price variation.

The general formula then becomes $\hat{Y} = 1.3677X_1 + .3139X_2$

$+ .2353X_3 + (-.8130X_4)$. Using this equation the estimated price variations are computed. The resulting estimates are shown in column 5 of Table 4-13. The standard error of estimate is .0479.

To determine the reliability of these estimates in determining the appropriate price variations they are tested for correlation with the observed Y values. As indicated in Appendix F they are found to be highly correlated, with a coefficient of .99967, indicating that the estimated Y's are very close to the actual Y's found in the theoretical model.

The equation giving the exact value of the estimated variation is:

$$\hat{Y} = \bar{Y} + b_1(X_1 - \bar{X}_1) + b_2(X_2 - \bar{X}_2) + b_3(X_3 - \bar{X}_3) + b_4(X_4 - \bar{X}_4) + E,$$

$\bar{Y}$ being the mean of the observed Y values.

The formula for the standard deviation of Y is:

$$Sy = \left(\sqrt{1 + \frac{1}{N} + (X_{1ij} - \bar{X}_1)^2 Sb_1^2 + (X_{2ij} - \bar{X}_2)^2 Sb_2^2 + (X_{3ij} - \bar{X}_3)^2 Sb_3^2 + (X_{4ij} - \bar{X}_4)^2 Sb_4^2}\right) S_{yx}.$$

S_{yx} = the standard error of estimate.

Using the Lansing Market as an example we find that $\hat{Y} = 7.888 + .53$, or $7.835 < \hat{Y} < 7.941$. Referring back to Table 4-13 we find that the predicted value for Lansing was 7.99. The estimated value is .05 greater than the upper limit. This amount can be attributed to rounding in the computation.

In summary, it was found that all the variables signif-

TABLE 4-13

ESTIMATED PRICE VARIATION FOR THE NINE MARKETING AREAS IN MICHIGAN, NOVEMBER 1959

Marketing Areas	X_1 $b_1 = 1.3677$ 1/	X_2 $b_2 = .3139$ 2/	X_3 $b_3 = .2333$ 3/	X_4 $b_4 = .8180$ 4/	$\hat{Y}$ 5/	Y 6/
Battle Creek	8.445	-12.900	-1.485	-.650	7.68	7.50
Bay City-Saginaw	10.641	-15.140	- .346	-.022	9.70	9.55
Flint	5.103	- 5.650	-1.506	-.397	5.18	5.05
Muskegon	13.263	-23.050	- .590	+.300	10.51	10.33
Grand Rapids	12.464	-19.650	- .182	+.416	10.49	10.33
Lansing	7.557	- 8.000	+ .423	-.096	7.99	7.85
Jackson	6.635	- 6.870	- .209	0	6.87	6.66
Kalamazoo	12.215	-20.350	- .723	+.018	10.13	10.00
Detroit	0	0	0	0	0	0

1/ Values for the variable reflecting the distance to the basing point.

2/ Values for the variable reflecting the number and location of competing market.

3/ Values for the variable reflecting the density of production.

4/ Values for the variable reflecting the relationship with the surplus area.

5/ Estimated price variation from the basing point.

6/ Price variation found in the theoretical model to be consistent with maximum efficiency.

icantly influenced the price variation. It was also shown that the price variation estimated by the formula was close to the observed price variation. Based on the above it is concluded that the price variation formula can be used to predict the correct price variation which must exist if the market supply areas are to be organized in accordance with the criteria set forth in this study.

CHAPTER V

COMPARISON OF THE PRESENT SUPPLY AREAS WITH THE THEORETICAL

In the preceding chapter supply areas for the nine markets being examined were constructed on the basis of November, 1959, production and consumption data. The perfectly competitive model developed, even though it is based on current data, cannot be considered consistent with reality as the conditions of a perfect market are seldom encountered in today's world. Using this framework, however, has enabled the development of a system which serves not only as an ideal for comparative purposes but also as the desired end insofar as minimum costs of transfer are concerned.

In section one of this chapter a set of supply areas are derived on the basis of current production, consumption, and transportation cost figures. The price structure among the markets, however, is determined by the present governmental regulations in the area being considered.[1]

In section two the resulting set of supply areas from section one are compared with the supply areas as determined in Chapter 4, Section 1.

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[1]In this thesis the present governmental regulation refers to the Southern Michigan Markets Order which became effective February 1, 1960.

Section 1

The Present Supply Areas

Under the present Southern Michigan Marketing Order the Detroit price is subject to location adjustments.[1] These adjustments determine the amount by which the minimum price received in any area can be less than the Detroit price. Figure 5-1 shows the area under consideration and the appropriate adjustments, by county, as prescribed in the Southern Michigan Order.

The set of supply areas derived in this section are based on the price variation determined by the location adjustments. The price variation and the f.o.b. city plant prices are shown in Table 5-1. The prices are based on a $5.50 base price in Detroit minus the applicable adjustment for the county in which the market is located.

With the f.o.b. prices fixed the markets will again secure their supplies by moving away from their origin in a concentric manner. The units between each ring are equal due to the linearity of transportation costs as discussed in Chapter 4.

Figure 5-2 illustrates the resulting supply areas. It will be noted that the areas take on a variety of shapes. These variations form a general pattern as was found to re-

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[1] United States Department of Agriculture, Agricultural Marketing Service, Order No. 24 as Amended Effective February 1, 1960, T. 7, Ch. IX, Code of Federal Register Marketing Order - Part 924, Section 924.54, p. 6.

TABLE 5-1

PRICE VARIATIONS AND CORRESPONDING F.O.B. PLANT PRICES BASED ON THE SOUTHERN MICHIGAN MARKETING ORDER LOCATION ADJUSTMENTS FOR THE NINE MARKETING AREAS IN MICHIGAN

Market	Location adjustment for county in which market is located (cents)	Assumed f.o.b. plant price 1/
Detroit	0	$5.50
Flint	0	5.50
Bay City-Saginaw	0	5.50
Lansing	7	5.43
Grand Rapids	15	5.35
Muskegon	20	5.30
Jackson	7	5.43
Battle Creek	12	5.38
Kalamazoo	15	5.35

1/ The base price in Detroit is the same as that used in the examples in Chapter IV. It is equal to a price in the surplus area of $3.00 plus the fixed and variable costs of transportation or $3.00 + .50 + .01 X 200 = $5.50.

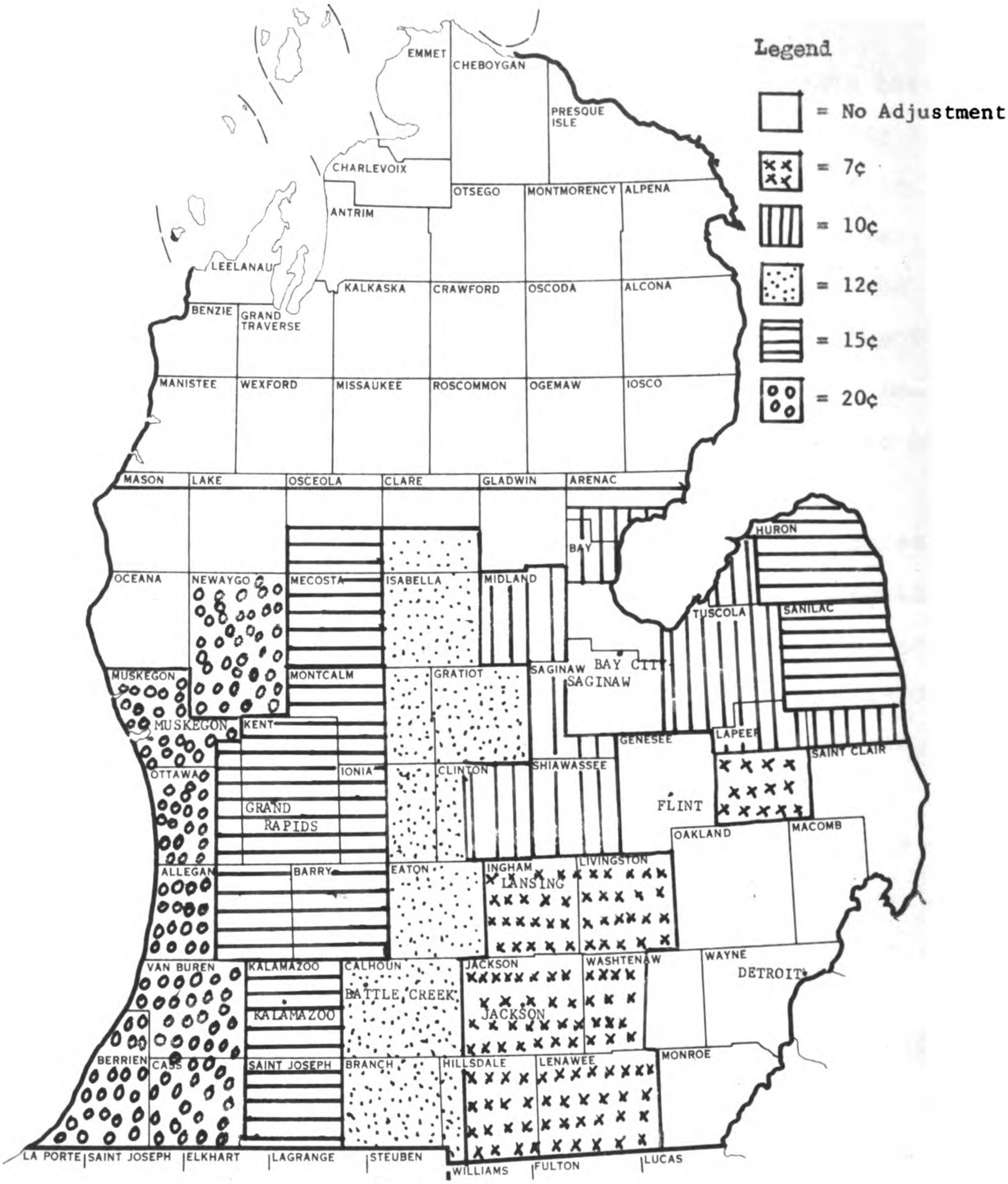


Figure 5-1

Location Adjustments Under the Southern Michigan Marketing Order

Source: USDA-AMS, <u>Order No. 24, as amended</u> effective February 1, 1960, T. 7, Ch. IX, Code of Fed. Regs. Marketing Order Part 924, pg.6.

sult in the theoretical model which are due primarily to the price relationships among the markets.

The Detroit, Flint, and Bay City-Saginaw markets have equal f.o.b. prices. As a result of this price equality the area between the markets should be equally divided as discussed in Chapter 1. Due to different market requirements and densities of production, however, the Flint and Bay City-Saginaw market requirements are satisfied without competing with each other or with Detroit price-wise. Because of this the market boundaries do not define points of indifference between the markets.

The above situation results because as Detroit moves toward the other two markets it is forced to offer a continually decreasing price due to the increasing total cost of transportation. Bay City-Saginaw and Flint having a fixed f.o.b. price equal to that of Detroit will offer a higher price over the area which is needed to fulfill their requirements, 23, and 18 miles respectively. For a similar reason the Bay City-Saginaw and Flint markets do not compete price-wise.

The Lansing Market takes on a resemblance to the theoretical market developed in the previous chapter. This is due to the fact that the f.o.b. price in Lansing is just slightly above the Detroit price minus the transportation cost between the two points. As will be noted in Figure 5-2 the supply area takes on a hyperbolic form signifying price competition for the twenty miles it extends to satisfy its

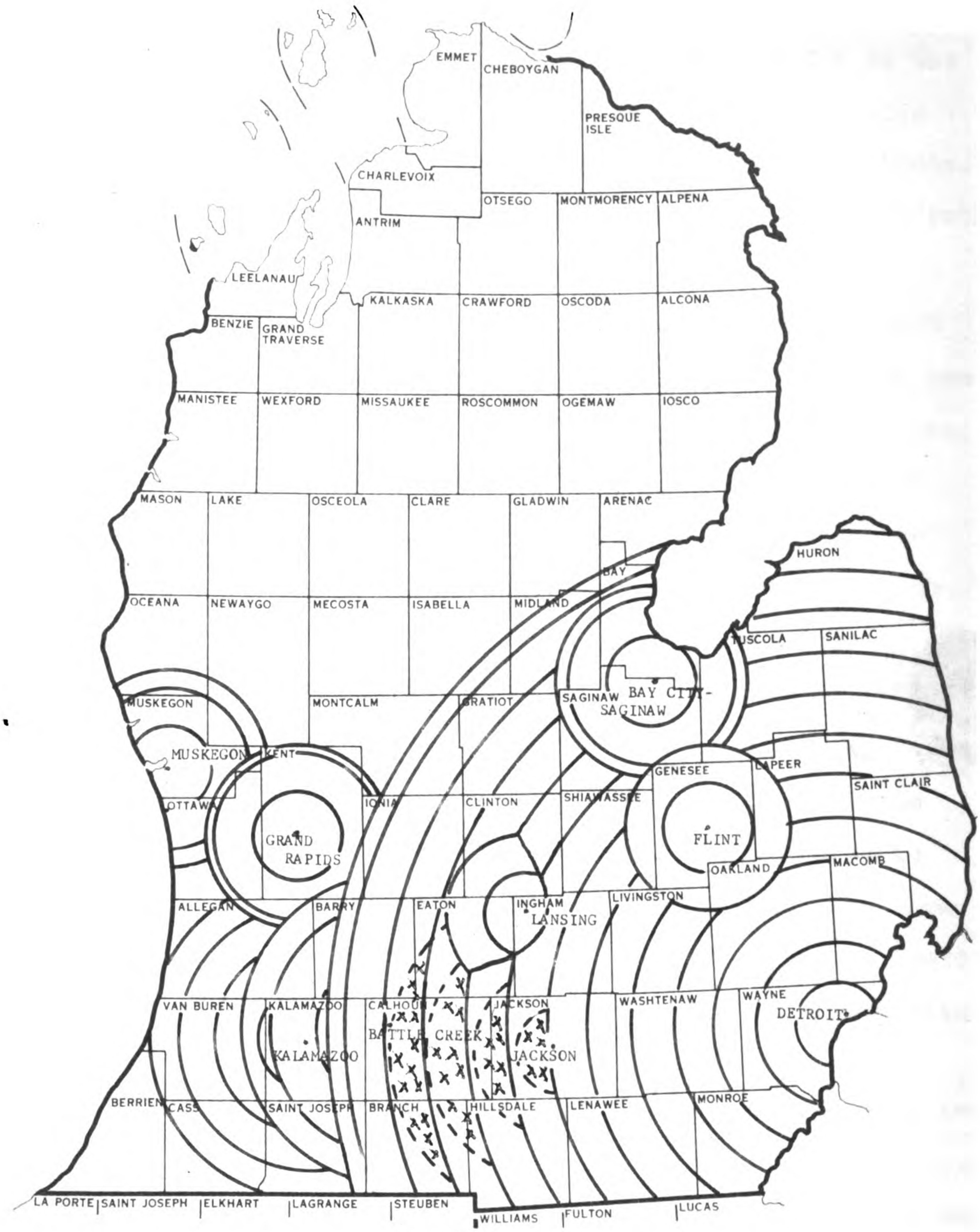


Figure 5-2

The Supply Areas for Nine Michigan Marketing Areas, November 1959, Using Location Differentials Provided-The South Michigan Order, Effective February 1, 1960.

requirements.

The Jackson supply area is indeterminate due to the fixed f.o.b. price which differs from the Detroit price only by the cost of transportation between the two points. The checked areas in Figure 5-2 are the areas in which both markets offer the same price.

The Battle Creek and Kalamazoo supply areas do not encompass the centers of population for which they are constructed because of their price relationship with Detroit. In both cases the adjustment is larger than the cost of transportation between the two points. This results in relatively low f.o.b. prices in the two markets. As the f.o.b. prices are fixed the receiving stations located near the two markets find it more profitable to ship to Detroit than to the nearby markets. Because of this the Kalamazoo and Battle Creek supply areas are not defined until the Detroit requirements are satisfied. As can be noted in Figure 5-2 Battle Creek secures its supply first and then Kalamazoo for the same reason. The exception in the above case is the small area in which Kalamazoo can compete with Battle Creek in Battle Creek's most distant zone.

The Kalamazoo supply area is again pushed further away from its origin because of its relatively low price in comparison to that of Grand Rapids with whom it comes into contact on its northern boundary.

The Grand Rapids and Muskegon supply areas are somewhat similar to those of Bay City-Saginaw and Flint primarily because of their distance from Detroit. The Detroit market and those which it encompasses have satisfied their requirements before reaching the Grand Rapids area and thus are discontinued. As a result, Grand Rapids can radiate out and encompass those areas not included in the previously discussed markets. As shown in Figure 5-2, because of its price relationships Grand Rapids does not have a competitive boundary with the markets south or east of it. Likewise, Muskegon does not have a competitive boundary with Grand Rapids.

In summary we can say that when a set of markets have fixed f.o.b. prices the size, shape, and location of their supply areas will be determined by the relationship of the fixed price to the base price, the density of production, and the location of competing markets.

Section II

Comparison

For comparative purposes the two sets of supply areas are superimposed as shown in Figure 5-3.

The total area included in the theoretical model is slightly larger than that of the existing supply area model as can be seen in Figure 5-3. We may conclude however that this does not signify a greater total transportation cost and thus a less efficient system. This is because of the fact that the areas in which the theoretical model extends beyond the existing are areas of low average density per

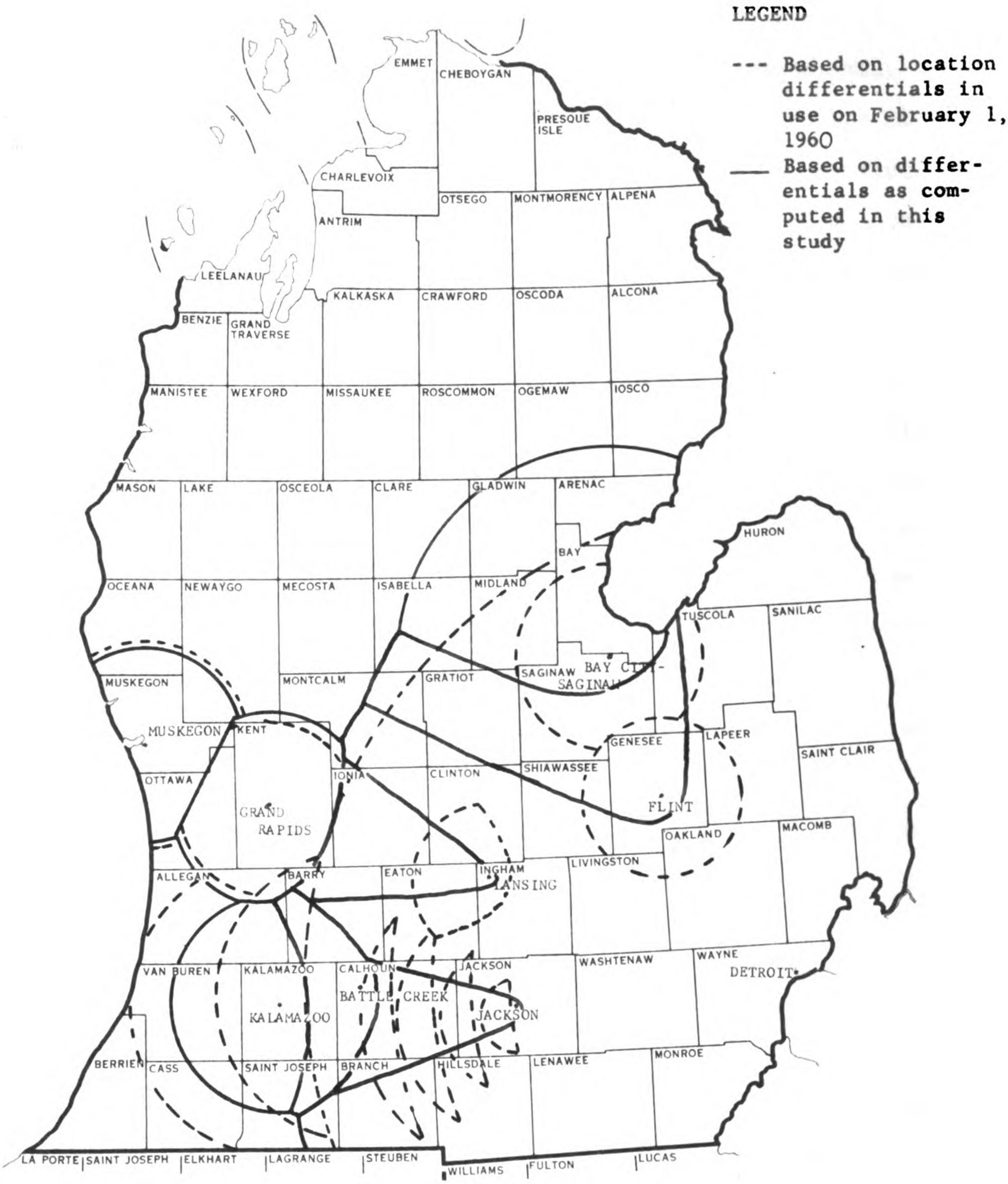


Figure 5-3

Theoretical and Existing Areas for the Nine Michigan Marketing Areas, November 1959, Superimposed

square mile while the reverse is true in those areas in which the existing model extends beyond the theoretical. Since total transportation costs are a function of the number of loads carried as well as distance it cannot be concluded that the theoretical model represents a greater total cost.

Table 5-2 shows the longest distance each market must travel and the length of the perimeter it must cover at that distance to satisfy its requirement.

The Bay City-Saginaw, Flint, Lansing, Grand Rapids, and Detroit markets all extend further in the theoretical model than in the existing model. This would tend to indicate a greater total transportation cost. When we consider the length of the perimeter covered at this distance the above indication becomes less evident. In all cases the perimeter in the existing model is greater at the most distant points than in the theoretical model. Detroit, being the extreme, has to cover 104 miles at a distance of 125 miles in the existing model as compared with having to cover 11 miles at a distance of 128 miles in the theoretical model. From this we can see that the length of the average trip and the total cost will be greater in the existing model even though the most distant point is greater in the theoretical model. In the case of Flint we do find a lower total cost of transportation in the existing model than in the theoretical because of the extreme variation in density of production. The area included in the existing supply area, as can be noted on the density map (Figure 4-5), is

TABLE 5-2

LONGEST DISTANCE TRAVELED AND PERIMETER AT THAT RADIUS FOR THE SUPPLY AREAS DEVISED ON THE BASIS OF THE EXISTING PRICE VARIATION FOR THE NINE MICHIGAN MARKETING AREAS NOVEMBER 1959

Marketing area	Length of longest radius in theoretical model units 1/	Perimeter at that radius units 1/	Length of longest radius in existing model units 2/	Perimeter at that radius units 2/
Detroit	12.80	1.100	12.50	10.467
Flint	7.70	2.000	1.80	5.652
Bay City-Saginaw	5.30	3.054	2.30	6.078
Lansing	5.00	.100	2.00	2.215
Grand Rapids	2.55	2.557	2.20	4.202
Muskegon	2.40	2.407	2.4	2.721
Jackson	5.40	.100	3/	3/
Battle Creek	3.40	3.853	3.8	4.540
Kalamazoo	2.85	.400	3.8	3.314

1/ Derived from Figure 5-2, One Unit equals 10 miles.

2/ Derived from Figure 4-2.

3/ Indeterminate.

high in available fluid milk whereas the area covered in the theoretical model is low and in some cases zero. Because of the variation in density the area included in the existing model is enough smaller than that in the theoretical to make the average length of trip smaller and thus the total cost less. It must be remembered that we are interested in total cost of all the markets and not in minimizing them for any one market in particular.

In the Muskegon market the greatest length of trip is equal in both models. The perimeter covered at that distance is slightly larger in the existing model which would seem to indicate a greater total cost.

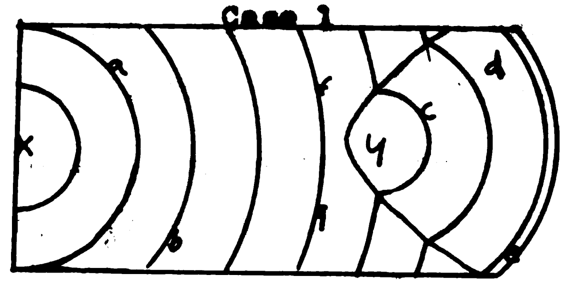
The remaining defined markets of Battle Creek and Kalamazoo quite obviously involve a greater total cost in the existing model than in the theoretical model. In both cases the most distant point is farther and the perimeter covered is greater.

The above comparisons, although primarily visual in nature, indicate that the total cost of transportation on the individual market basis is not always less in the theoretically more efficient model. When we consider all markets as a unit, however, the indication is that the total cost is less in the theoretical model.

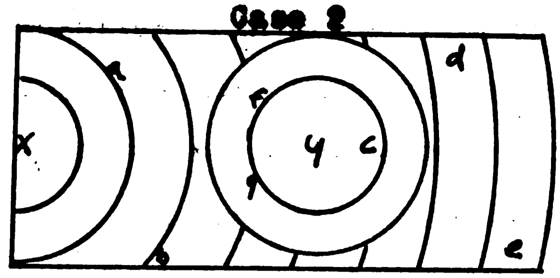
The following geometrical example is evidence of the above. The total area under consideration is taken to be equal to that included in the rectangular figures. The

Cost of Transportation With Different Market Structures

Case 1



Case 2



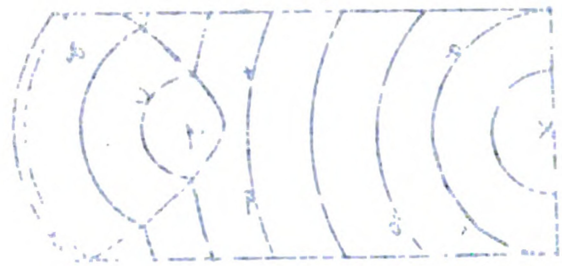
Transportation Costs (Units)

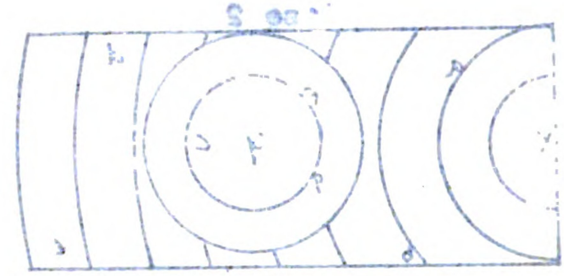
	Case 1		Case 2	
	x	y	x	y
a	2		2	
b	3		3	
c		1		1.8
d		2	7.6	
e		3	8.4	
f	5			1
g	5			1
Total	15	6	21	3.8
Total x + y	21		24.8	

production within them is just equal to the requirements of the two markets x and y. X requires four units and is the basing point. Y requires three units. The units are represented by a - g. In case 1, y's supply area takes on the form of a hyperbolic function as a result of satisfying the conditions discussed in Chapter IV.

In case 2, the f.o.b. prices are fixed and equal. This is similar to the case of Flint and Bay City-Saginaw in the second model developed.

The costs of transportation are summarized next to the example. In both cases the transportation cost of x exceeds that of y. In case 1, the cost is less for x than





in case 2. The reverse is true for y.

To evaluate the efficiency of the total system we must compare total costs. In our example we find that case 1 has the least total cost indicating a more efficient system. Case 1, from the above illustration, can be directly related to our theoretical model in that the market boundaries take their form because of being hyperbolic functions. When examining the theoretical supply areas we find that where two or more markets come together they are divided by a hyperbolic function. In price terms it is shown by a line that divides the area such that all markets will be offering the same price at a common point.

In the case of Jackson, Lansing, and Flint the outside boundaries are determined by an interrelationship with the Detroit price. In the remaining markets more than one market influences the shapes of the boundaries, the extreme being Grand Rapids which is influenced by all eight other markets. Because of this complete system of competitively defined market boundaries each enclosing exactly the required amount of fluid milk and cream to satisfy its requirement we have a system which minimizes total transportation costs.

On the contrary in the model developed based on existing f.o.b. prices the supply area boundaries are not a function of competitive bidding. As a result of this supply areas are defined that involve cross-hauling which increases the total costs of transportation when all markets are considered.

It is therefore concluded that, given the assumptions set forth in the theoretical model, the supply areas developed illustrate the most efficient manner in which the nine marketing areas under study can secure their given requirements of fluid milk and cream.

The increase in efficiency can best be measured in terms of dollars saved when the supply is secured as indicated in the theoretical model.

In making a comparison between the two models total fixed costs are assumed to be the same. The fixed costs of operation will obviously be the same in both cases. There may however be a decrease in the fixed costs associated with truck ownership, repair parts, etc., in the theoretical model due to a decrease in the total number of miles traveled. Since this study does not go into a detailed analysis of truck capacities or maximum distances each unit can be driven within a given time period the possibility of a decrease in fixed cost is recognized but not estimated. It should be noted, however, that a decrease in fixed costs would indicate additional savings resulting from supply areas organized as in the theoretical model.

Assuming the total fixed costs equal in both models we can then determine the savings which would result from using one of the models by comparing the variable cost incurred to secure the supply.

It will be remembered from the earlier discussion that the variable cost is a function of the number of miles

traveled. The model with the lowest total variable cost for all markets thus has the lowest total cost and is, on this basis, the more efficient of the two. Table 5-3 shows the computation of total variable costs for the two models. Column 1 of the table shows the fluid milk and cream requirements for each market. These requirements divided by the average size tanker load determine the total trips necessary to secure the market requirements. These figures are shown in column 3 of the table. The average distance of haul is then taken to be equal to the radius from the market center which encloses one-half of the market requirement. With the pounds of milk hauled per tanker per load being equal the number of loads hauled less than this distance is equal to the number hauled greater than this distance. Figures 5-4 and 5-5 indicate the areas that are closest to the market center which includes one-half of the market requirements. The cases where the geometric areas are not equally divided indicates variations in the density of available milk in the supply area. Columns 5 and 6 of Table 5-3 show the average length of trip determined in the above manner. The total miles traveled as shown in column 7 and 8 are determined by multiplying the average length of trip by the total trips made.

Having found the total number of miles traveled for each market we can then determine the total variable cost by multiplying the total units (ten miles) traveled by $5.25. This is the cost of moving 52,500 pounds of milk one unit

TABLE 5-3

TOTAL VARIABLE COSTS OF TRANSPORTATION FOR THE NINE MARKETING AREAS IN MICHIGAN
NOVEMBER 1959

Market	Market requirement (pounds)	Average size tanker load 1/ (pounds)	Number of tanker loads to fulfill requirements	One-half of market requirements (pounds)	Average length of trip Radii enclosing one-half of the market requirements in units 2/ model	existing	Total units traveled to secure supply 3x5 theoretical model	3x6 existing model	Total variable cost of securing supply 7x$5.25 model	8x$5.25 existing 3/
	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10
Battle Creek	4,551,730	52,500	36.7	2,275,865	1.11	3.10	96.2	268.8	505.05	1,411.00
Bay City-Saginaw	9,698,009	"	184.7	4,849,005	2.70	1.70	498.7	314.0	2,618.18	1,648.50
Flint	12,180,544	"	232.0	6,090,272	2.20	1.25	510.0	290.0	2,677.50	1,522.50
Muskegon	4,899,480	"	93.3	2,449,740	1.47	1.50	137.2	140.0	720.30	735.00
Grand Rapids	11,860,522	"	225.9	5,930,261	1.55	1.45	350.1	327.6	1,838.03	1,719.90
Lansing	6,961,372	"	132.6	3,480,686	2.35	1.40	311.6	185.6	1,635.90	974.40
Jackson	4,307,332	"	82.0	2,153,666	2.25	2.75	184.5	225.5	968.63	1,183.88
Kalamazoo	5,563,960	"	106.0	2,781,980	1.65	3.00	174.9	318.0	918.22	1,669.50
Detroit	125,832,412	"	2,396.8	62,916,206	7.80	8.75	13,695.0	20,972.0	98,148.75	110,103.00
Total	185,855,360						20,958.2	23,041.5	110,030.56	120,967.88

1/ Based on data relevant to Michigan in 1959 and examined by the Author
2/ One unit equals 10 miles
3/ $5.25 =0.01 per hundred weight per units x 525 or 5.25 to move 1 truck 1 unit.

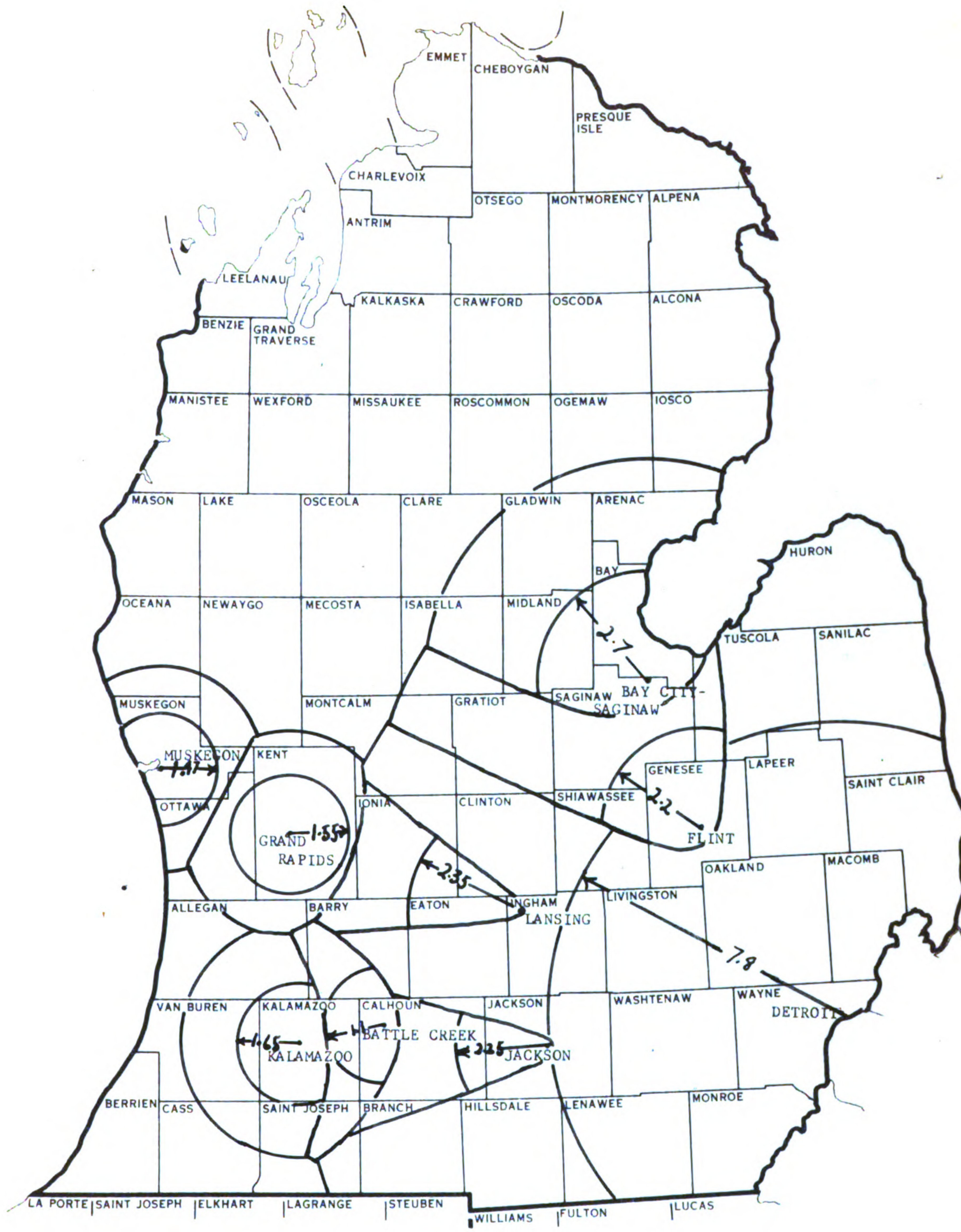


Figure 5-4

Average Length of Haul per Tanker Load in the Theoretical Model for the Nine Marketing Areas in Michigan, November 1959. (In Units of 10 Miles)

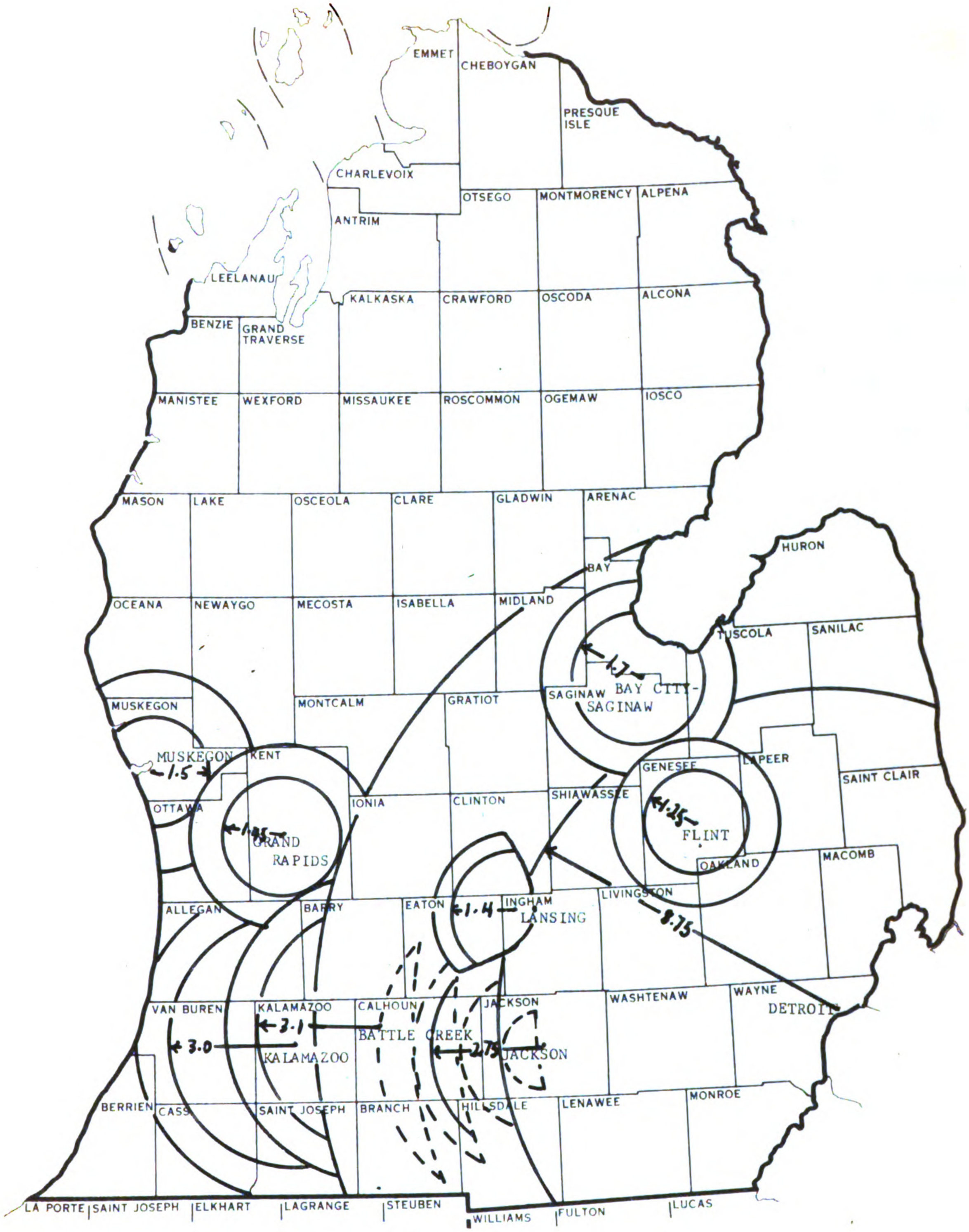


Figure 5-5

Average Length of Haul per Tanker Load in the Existing Model for the Nine Marketing Areas in Michigan, November 1959. (In Units of 10 Miles)

or ten miles. It should be noted that the transportation cost is in terms of a round trip and not one way.

When comparing the total variable costs incurred in the individual markets we can see, as earlier noted, that minimizing total cost for all the markets is not necessarily consistent with minimizing costs in the individual markets.

In summarizing the comparison we can see that the total variable cost in the theoretical model is $10,937.32 less than that in the model based on the existing conditions for the month of November 1959. This represents a decrease in cost per hundred-weight hauled of $0.00588.

In examining these savings in a somewhat different manner we can see that the savings in the month of November would more than cover the cost of securing the market requirements of milk in the Battle Creek, Bay City-Saginaw, Flint, Muskegon, Grand Rapids, Lansing, and Kalamazoo markets combined for the same month.

In summary we have seen that the supply areas defined by competitive boundaries derived from hyperbolic functions minimize total transportation costs. In turn the model developed on the above basis was found to be more efficient than the model representing the existing conditions by $10,937.32 in November 1959.

CHAPTER VI

Summary and Conclusions

This study was concerned with the delineation of milk supply areas for the Detroit, Jackson, Battle Creek, Kalamazoo, Lansing, Grand Rapids, Muskegon, Bay City-Saginaw, and Flint, Michigan consuming areas in such a way that total transport costs would be at a minimum. The nine areas include all counties having one or more cities with a population of 40,000 or more and contain 75.6 percent of the population in Lower Michigan.

Most of the basic data used in the study were from secondary sources. In most cases the data used were those relating to November 1959, the time period upon which the analysis is based.

The fluid milk and cream requirements, in milk equivalents, for the nine marketing areas was found to be 185,855,360 pounds. This was based on the per capita consumption of 28.603 pounds, the number of consumers in the marketing areas and a 15 percent allowance for variations in production and consumption.

It was found, based on the average number of milk cows in each county and the average production per cow, that 363,831,640 pounds of milk were produced in Lower Michigan in November 1959. Of this, 216,498,324 pounds were available to the marketing areas for fluid use. The remainder was milk not of fluid quality, milk fed on the farm where produced and milk consumed outside the marketing areas. Adjustments were made for net exports or imports of milk and for that milk shipped into deficit milk producing counties outside the marketing areas.

In satisfying the criteria of efficiency established for the study, it was found that all supply area boundaries common to more than one market were defined by points of price indifference to the receiving stations in reference to the competing markets. The resulting boundary lines were hyperbolic functions with the points of indifference defined by the intersection of corresponding iso-price lines radiating from the competing markets.

The increase in the cost of moving milk as distance traveled increased was found to be equal to the increase in the variable cost incurred. The variable cost was found to be $0.001 per mile per hundred weight and linear with distance. The iso-price lines used to define the supply area boundaries were separated by ten mile intervals representing an increase in transportation cost of $0.01 per hundred weight.

A model of the most efficient supply areas for the nine markets based on the market requirements and the available supply of fluid milk was developed in Chapter IV. In essence it was the result of a series of approximations of the f.o.b. city plant prices for all markets.

The price variations that were found to exist between the markets and the basing point were found to be less than the cost of transportation between the two points. The distortion of the appropriate iso-price line moving out from the basing point determined the amount of variation from that of transportation costs. This variation was found to be influenced by the location of the market in relation to the surplus area, distance to the basing point, density of production and the number and location of competing markets.

The above factors were quantified and used as independent variables in the formula $Y = b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4$ to determine the degree of accuracy with which the price variation (Y) could be predicted. The regression coefficients which resulted from a regression analysis were found to be significantly different from zero indicating that all the independent variables were significant in determining the price variation. A correlation coefficient of .99967 was obtained when the predicted price variations were tested against those observed in the theoretical model.

In Chapter V an approximation of the size, shape and location of the present supply areas was made. This approximation was based on the price variations suggested by the location differentials in the present Southern Michigan Marketing Order. The variation for the individual markets was taken to be equal to the location adjustment applicable to the county or counties in which the marketing area was located.

When comparing the two models it was found that the variable cost incurred to move the total market requirements of November, 135,855,360 pounds, was $120,967.83 in the model representing the existing conditions and $110,030.56 in the theoretical model. The $10,937.32 decrease was the result of a $0.00538 decrease in the average total variable cost associated with transporting a hundred weight of milk. The average length of trip decreased from 63.1 miles in the model representing the existing conditions to 59.5 miles in the theoretical model making these savings possible.

The following general conclusions can be drawn from this study.

1. It is possible within the perfect market concept to develop a most efficient system of supply areas.
2. The correct price variation among the market will insure a minimization of total cost of transfer.
3. Price variation is a function of the characteristics of the market in relation to the basing point.
4. The f.o.b. city plant prices must be greater than the basing point price minus the variable cost of transportation between the basing point and the market if the supply area

boundaries are to be defined.

5. The fixed costs of transportation must be included in the f.o.b. city plant prices, leaving only the variable cost to determine a competitive boundary if supply areas are to be efficient.

6. The present system of supply areas does not insure minimization of the transfer costs in meeting the milk requirements of the designated markets.

7. Total costs can be decreased if the present system of supply areas are reorganized through price variation adjustment in accordance with the model developed.

APPENDIX A

Appendix A, page 1 - AVERAGE MILK PRODUCTION PER COW FOR HIGH AND LOW MONTH AND THAT MONTH'S PERCENTAGE OF THE TOTAL ANNUAL PRODUCTION, MICHIGAN, 1950 - 1959

Year	June production per cow 1/ (pounds)	November production per cow 1/ (pounds)	Yearly production per cow 1/ (pounds)	June as a percent of total annual production	November as a percent of total annual production
1950	651	432	6,280	10.37	6.88
1951	654	435	6,340	10.32	6.86
1952	667	452	6,470	10.31	6.97
1953	660	450	6,500	10.15	6.92
1954	666	455	6,510	10.23	6.99
1955	675	480	6,670	10.12	7.20
1956	670	485	6,820	9.82	7.11
1957	691	539	7,090	9.75	7.60
1958	692	560	7,200	9.61	7.78
1959	696	556	7,270	9.57	7.65
Average				10.03	7.20

1/ Michigan Department of Agriculture, Michigan Agricultural Statistics, 1956, p. 45, 1957, p. 43, 1959, p. 44.

Appendix A, page 2 - ANALYSIS OF VARIANCE BETWEEN NOVEMBER AND JUNE PRODUCTION, MICHIGAN, 1950 - 1959

Month		Years										
		1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	Total
June	x	651	654	667	660	666	675	670	691	692	696	6,722
November	y	432	435	452	450	455	480	485	539	560	556	4,844
Total		1,083	1,089	1,119	1,110	1,121	1,155	1,155	1,220	1,252	1,252	11,566

	df	ss	E MS	F. Ratio
Tss	19	200,791		
Css	9	2,356	261.8	.12
Rss	1	176,345	176,345	79.8 x
Er	10	2,209	2,209	

$F_{95(10,1)} = 10.04$

Reject hypothesis of no significant difference between November and June production

Correlation coefficient

$$r_{yx} = \frac{\Sigma xy - \frac{(\Sigma x)(\Sigma y)}{10}}{\sqrt{\Sigma x^2 - \frac{(\Sigma x)^2}{10} \quad \Sigma y^2 - \frac{(\Sigma y)^2}{10}}} = r_{yx} = .9758$$

Conclude there is a direct relationship between x and y

T test

Year	d (x-y)
1950	219
1951	219
1952	215
1953	210
1954	211
1955	195
1956	165
1957	152
1958	132
1959	140
Total	1,878
Average	187.8

$$Sd^2 = \sqrt{\frac{\Sigma d^2}{9} - \frac{(\Sigma d)^2}{10}} = 51.45$$

$$T = \frac{187.8 - 0}{51.45} = 3.650$$

$T_{95} = 2.228$

Conclude significant difference among years.

APPENDIX B

Appendix B - ESTIMATION OF THE AVERAGE PRODUCTION PER COW BY DISTRICT, MICHIGAN, 1959

District	Production per cow 1951 1/ pounds	District average production as a percent of the State average production 1951	Average production per cow 1959 2/ pounds	Average production per cow by district 1959 3/ pounds
1	5,790	83.9	7270	6,463
2	5,664	87.0	"	6,325
3	5,723	88.0	"	6,398
4	6,124	94.1	"	6,841
5	6,119	94.0	"	6,834
6	6,644	102.1	"	7,422
7	6,342	102.2	"	7,430
8	6,843	105.1	"	7,641
9	6,973	107.1	"	7,786

1/ Michigan Department of Agriculture, Dairy Trends in Michigan, June 1955, p. 16.

2/ Michigan Department of Agriculture, Michigan Agricultural Statistics, July 1960, p. 37.

3/ Column 2 applied to column 3.

APPENDIX C

Appendix C - PRODUCTION OF MANUFACTURING MILK BY DISTRICT, MICHIGAN, 1957 AND ESTIMATE FOR 1959

District	Estimated yearly production by district 1957 1/ (million pounds) Column 1	Average rate of decrease of production 2/ (percent) Column 2	Projected 1958 production by district 3/ (million pounds) Column 3	Projected 1959 production by district 4/ (million pounds) Column 4	Estimated November production 5/ 6/ (million pounds) Column 5
2	158.4	13.8 %	136.5	117.7	8.5
3	28.2	"	24.3	20.9	1.5
4	25.8	"	22.2	19.1	1.3
5	370.8	"	319.6	275.5	19.8
6	231.0	"	199.1	171.6	12.4
7	181.8	"	156.7	135.1	9.7
8	273.6	"	235.8	203.3	14.6
9	52.8	"	45.5	39.2	2.8

1/ The estimated 1957 receipts by district = the total 1957 production (footnote 2, page 32) times the percent of cows 2 years and over in each district.

2/ G. McBride, W. Blanchard. Changes in Michigan's Manufacturing Milk Industry, Michigan State University, Department of Agricultural Economics, Special Bulletin 427, 1959, pp. 13-19.

3/ Column 2 applied to column 1

4/ Column 2 applied to column 3

5/ November production taken to equal 7.2 percent (appendix B) of the total.

6/ The percentage of cows two years and over in each county is applied to these district figures for November to arrive at the county figures in column 3 of Table 4-4.

APPENDIX D

Appendix D, page 1 - ADJUSTMENT FOR EXPORTS IN EXCESS OF IMPORTS FROM MICHIGAN AND FOR DEFICIT PRODUCING COUNTIES, NOVEMBER 1959

County	Source and Amount of net export to Toledo market November 1959 1/ (pounds)	Source and Amount of net export to Cleveland November 1959 2/ (pounds)	Total Amount of net export November 1959 (pounds)
Calhoun		253,355	253,355
Hillsdale	10,886	253,355	264,241
St. Joseph		253,355	253,355
Kalamazoo		253,355	253,355
Branch	4,406	1,013,420	1,017,826
Lenawee	36,029		36,026
Monroe	8,100		8,100
Jackson	1,620		1,620
Wastenaw	3,758		3,758

1/ Based on percentages given in Analysis of Producers Receipts, Toledo, Ohio marketing area, January, June, and December, 1959. Branch County 6.8%, Hillsdale County 16.8%, Jackson County 2.5%, Lenawee County 55.6%, Monroe County 12.5%, Washtenaw County 5.8%.

2/ One-half allocated to Branch county where plant is located and 1/8th to each of the remaining counties as indicated.

Appendix D, page 2 - SOURCE OF FLUID MILK AND CREAM FOR DEFICIT PRODUCING COUNTIES, MICHIGAN, 1959

Deficit County	Amount of deficit November 1959 (pounds)	Contributing counties and percentage of contribution 1/ of each		Amount of allocation to deficit county
			percent	pounds
Crawford	61,977	Kalkaska	33	20,452
		Otsego	33	20,452
		Oscoda	34	21,073
Total	61,977		100	61,977
Roscommon	58,669	Missaukee	33	19,360
		Ogemaw	33	19,360
		Clare	17	9,974
		Gladwin	17	9,974
Total	58,669		100	58,669
Midland	486,363	Gladwin	30	145,909
		Isabella	40	194,545
		Gratiot	10	48,636
		Saginaw	5	24,318
		Bay	15	72,955
Total	486,363		100	486,363
Benzie	70,839	Leelanau	75	53,129
		Wexford	25	17,710
Total	70,839		100	70,839

Deficit County	Amount of deficit November 1959 (pounds)	Contributing counties and percentage or total contribution 1/ of each		Amount of allocation to deficit county
			percent	pounds
Grand Traverse	391,636	Leelanau	20	78,327
		Antrim	20	78,327
		Kalkaska	40	156,655
		Wexford	20	78,327
Total	391,636		100	391,636
Manistee	48,398	Wexford	34	16,456
		Mason	33	15,971
		Lake	33	15,971
Total	48,398		100	48,398
Berrien	1,362,269	Cass	50	681,135
		Vanburen	50	681,135
Total	1,362,269		100	1,362,276

1/ The percent of contribution is based on the available supply in that county and the length of its common border with the deficit county.

Appendix D, page 3 - SUMMARY OF DEDUCTIONS FOR NET EXPORTS AND CONTRIBUTION TO DEFICIT PRODUCING COUNTIES BY COUNTIES

Counties	Amount deducted due to contribution to deficit (pounds)	Amount deducted due to net exports (pounds)	Total amount of deduction (pounds)
Antrim	78,327		78,327
Bay	72,955		72,955
Branch		1,017,826	1,017,826
Calhoun		253,355	253,355
Cass	681,135		681,135
Clare	9,974		9,974
Gladwin	155,883		155,883
Gratiot	48,636		48,636
Hillsdale		264,241	264,241
Isabella	194,545		194,545
Jackson		1,620	1,620
Kalamazoo		253,355	253,355
Kalkaska	177,107		177,107
Lake	15,971		15,971
Leelanau	131,456		131,456
Lenawee		36,026	36,026
Mason	15,971		15,971
Missaukee	19,360		19,360
Monroe		8,100	8,100
Ogemaw	19,360		19,360
Oscoda	20,452		20,452
Otsego	21,073		21,073
Saginaw	24,318		24,318
St. Joseph		253,355	253,355
Van Buren	681,134		681,134
Washtenaw		3,758	3,758
Wexford	112,493		112,493

APPENDIX E

Appendix E, page 1 - ESTIMATED DENSITY OF MILK PRODUCTION, PER SQUARE MILE, MICHIGAN, NOVEMBER 1959

Market and Contributing Counties	Production Available by County (pounds)	Square Miles in County
Kalamazoo		
Kalamazoo	2,855,012	567
St. Joseph	2,318,428	508
Van Buren	1,624,471	607
Allegan	5,968,460	828
	12,766,371	2,510

Average production per square mile = 5,086 pounds.

Battle Creek		
Barry	4,356,470	549
Calhoun	6,414,445	709
Kalamazoo	2,855,012	567
St. Joseph	2,318,428	508
	15,944,355	2,333

Average production per square mile = 6,834 pounds.

Jackson		
Jackson	6,295,953	705
Calhoun	6,414,445	709
Branch	4,653,360	506
St. Joseph	2,318,428	508
	19,682,186	2,428

Average production per square mile = 8,106 pounds.

Lansing		
Ionia	6,257,326	575
Clinton	6,251,580	571
Ingham	7,334,633	559
Eaton	6,278,473	567
Barry	4,356,470	549
	30,478,482	2,821

Average production per square mile = 10,804 pounds.

Muskegon		
Muskegon	2,826,414	504
Ottawa	4,403,461	564
Newaygo	4,168,725	857
Oceana	2,602,603	836
	14,001,203	2,761

Average production per square mile = 5,071 pounds.

Appendix E, page 2 - ESTIMATED DENSITY OF MILK PRODUCTION, PER SQUARE MILE, MICHIGAN, NOVEMBER 1959

Market and Contributing Counties	Production Available by County (pounds)	Square Miles in County
Grand Rapids		
Kent	8,753,721	862
Montcalm	3,040,111	712
Barry	4,356,470	549
Allegan	5,968,460	828
Ottawa	4,403,461	564
	26,522,223	3,515

Average production per square mile = 7,545 pounds.

Market and Contributing Counties	Production Available by County (pounds)	Square Miles in County
Flint		
Genesee	7,092,322	644
Saginaw	6,038,262	812
Shiawassee	6,405,806	540
Gratiot	1,916,197	566
Montcalm	3,040,111	712
Mecosta	1,787,483	563
Isabella	2,073,343	572
	28,353,524	4,409

Average production per square mile = 6,431 pounds.

Market and Contributing Counties	Production Available by County (pounds)	Square Miles in County
Bay City-Saginaw		
Saginaw	6,038,262	812
Bay	4,449,889	446
Arenac	1,645,337	368
Iosco	661,697	547
Ogemaw	2,178,654	574
Gladwin	841,747	503
Midland	—	
Isabella	2,073,343	572
Clare	744,852	572
	18,633,781	4,394

Average production per square mile = 4,241 pounds.

Appendix E, page 3 - ESTIMATED DENSITY OF MILK PRODUCTION, PER SQUARE MILE, MICHIGAN, NOVEMBER 1959

Market and Contributing Counties	Production Available by County (pounds)	Square Miles in County
Detroit		
Monroe	333,891	562
Lenawee	6,249,766	754
Hillsdale	6,377,192	601
Branch	4,653,360	506
St. Joseph	2,318,428	508
Wayne	1,334,205	607
Washtenaw	6,524,595	716
Jackson	6,295,953	703
Calhoun	6,414,445	709
Macomb	7,303,243	481
Oakland	5,336,819	877
Livingston	5,727,611	571
Ingham	7,334,633	559
Eaton	6,278,473	567
Barry	4,356,470	549
St. Clair	7,788,693	746
Lapeer	10,173,234	659
Genesee	7,092,322	644
Shiawassee	6,405,806	540
Clinton	6,251,580	571
Ionia	6,257,326	575
Montcalm	3,040,111	712
Gratiot	1,916,197	566
Saginaw	6,038,262	812
Tuscola	6,178,986	816
Sanilac	13,173,134	961
Huron	7,020,557	822
	158,175,292	17,697

Average production per square mile = 8,939.

APPENDIX F

Appendix F - CORRELATION BETWEEN PRICE VARIATION AND DISTANCE TO BASING POINT

x	7.500	9.550	5.050	10.330	10.330	7.850	6.660	10.000	67.27
y	8.445	10.641	5.103	13.263	12.464	7.557	6.635	12.215	76.33
	15.945	20.191	10.153	23.593	22.794	15.407	13.295	22.215	

$$ry = \frac{\Sigma xy - \frac{(\Sigma x)(\Sigma y)}{N}}{\sqrt{\Sigma x^2 - \frac{(\Sigma x)^2}{N} \quad \Sigma y^2 - \frac{(\Sigma y)^2}{N}}} = \frac{40.36}{41.36} = .9758 = ryx$$

$$\Sigma xy = 682.15$$

$$\frac{(\Sigma x)(\Sigma y)}{8} = \frac{5134.72}{8} = 641.8 \qquad \begin{array}{r} 682.15 \\ -\ 641.72 \\ \hline 40.36 \end{array}$$

$$\Sigma x^2 - \frac{(\Sigma x)^2}{8} = 592.35 - \frac{4,525.25}{8} = 592.35 - 565.65 = 26.70 \qquad 5.17$$

$$\Sigma y^2 - \frac{(\Sigma y)^2}{8} = 792.27 - \frac{5,826.27}{8} = 792.27 - 728.28 = 63.99 = 8 \qquad \begin{array}{r} 5.17 \\ 8 \\ \hline 41.36 \end{array}$$

Appendix F (continued) CORRELATION BETWEEN PRICE VARIATION AND LOCATION AND NUMBER OF COMPETING MARKETS

x	7.500	9.550	5.050	10.330	10.330	7.850	6.660	10.000	67.27
y	-12.900	-15.140	-5.650	-23.050	-19.650	-8.000	-6.870	-20.350	-111.61
	20.400	24.690	10.700	33.380	29.980	15.850	13.530	30.350	

$\Sigma xy = -1{,}023.01$

$$\frac{(\Sigma x)(\Sigma y)}{8} = \frac{-75080.0}{8} - 938.5 \qquad = \begin{array}{r} 1{,}023.01 \\ -\ 938.50 \\ \hline -\ 84.51 \end{array}$$

$$ryx = \frac{-84.51}{91.56} = -.923$$

$$\Sigma x^2 - \frac{(\Sigma x)^2}{8} = 5.17$$

$$\Sigma y^2 - \frac{(\Sigma y)^2}{8} = 1870.30 - \frac{12456.79}{8} \quad 1557.00 = \quad 313.3 = 17.71$$

$$\begin{array}{r} 17.71 \\ 5.17 \\ \hline 91.56 \end{array}$$

Appendix F (continued) - CORRELATION BETWEEN PRICE VARIATION AND DENSITY OF PRODUCTION

7.500	9.550	5.050	10.330	10.330	7.850	6.660	10.000	67.27
-1.485	- .346	-1.506	- .592	- .132	+ .423	- .209	- .723	- 4.620
8.985	9.896	6.556	10.922	10.922	8.273	6.869	10.723	

$\Sigma xy = 35.34$

$$\frac{(\Sigma x)(\Sigma y)}{8} = \frac{-310.8}{8} = 38.90 \qquad \begin{array}{r} 38.90 \\ -35.34 \\ \hline + \quad 3.56 \end{array} \qquad ryx = \frac{3.56}{9.10} \quad .39$$

$$\Sigma x^2 - \frac{(\Sigma x)^2}{8} = 5.17$$

$$\Sigma y^2 - \frac{(\Sigma y)^2}{8} = 5.27 - \frac{21.34}{8} = 5.27 - 2.67 = 3.05 = 1.76 \qquad \begin{array}{r} 5.17 \\ 1.76 \\ \hline 9.10 \end{array}$$

Appendix F (continued) CORRELATION BETWEEN PRICE VARIATION AND RELATIONSHIP WITH SURPLUS AREA

x	7.500	9.550	5.050	10.330	10.330	7.850	6.660	10.000	67.27
y	- .650	+ .022	- .397	+ .300	+ .416	- .096	0	+ .018	- .387
	8.150	9.572	5.447	10.630	10.746	7.946	6.660	10.018	

$\Sigma xy = .153$

$\frac{(\Sigma x)(\Sigma y)}{8} = \frac{-26.033}{8} = -3.254$

$.153 + 3.254 = 3.407$

$ryx = \frac{3.407}{4.203}$

$\Sigma x^2 - \frac{(\Sigma x)^2}{8} = 5.17$

$ryx = .810$

$\Sigma y^2 - \frac{(\Sigma y)^2}{8} = .85 - \frac{.1498}{8}$ $.850 - .019 = .66 = .813$

$5.17 + .813 = 4.203$

Appendix F (continued) CORRELATION BETWEEN y and y

y	7.50	9.55	5.05	10.33	10.33	7.85	6.66	10.00	67.27
y	7.68	9.70	5.18	10.51	10.49	7.99	6.87	10.13	68.55
	15.18	19.32	10.23	20.84	20.82	15.84	13.53	20.13	

$\Sigma xy = 603.10$

$$\frac{(\Sigma x)(\Sigma y)}{8} = \frac{4611.36}{8} = 576.42 \qquad \begin{array}{r} 603.10 \\ \underline{576.42} \\ 26.68 \end{array} \qquad ryx = \frac{26.68}{26.68}\ 1.00 \ 1/$$

$$\Sigma x^2 - \frac{(\Sigma x)^2}{8} \qquad 5.17$$

$$\Sigma y^2 - \frac{(\Sigma y)^2}{8} = 614.06 - \frac{4699.10}{8} = 26.68 = 5.16 \times 5.17 = \begin{array}{r} 614.06 \\ \underline{587.38} \\ 26.68 \end{array}$$

1/ When solved by the computer it was found to be .99967

Appendix F (continued) - LIMITS WITHIN WHICH y WILL FALL USING LANSING AS AN EXAMPLE

$$\hat{y} = \bar{y} + b_1 (x_1 - \bar{x}_1) + b_2 (x_2 - \bar{x}_2) + b_3 (x_3 - \bar{x}_3) + b_4 (x_4 - \bar{x}_4) + Sy\,x \pm S\hat{y}$$

$$S\hat{y} = \left[\sqrt{1 + \frac{1}{N} + (x_{1j} - \bar{x}_1)^2 Sb_1^2 + (x_{20} - \bar{x}_2)^2 Sb_2^2 + (x_3 - \bar{x}_3)^2 Sb_3^2 = (x_4 - \bar{x}_4)^2 Sb_4^2}\right] \quad Syx$$

$$S\hat{y} = \left[\sqrt{1 + .125 + (3.932)\ .008 + (35.414)\ \ .002 + (1.002)\ \ .00006 + (.002)\ \ .011}\right] \quad .048$$

$$S\hat{y} = \left[\sqrt{1.125 + .031 + .071}\right] \quad .048$$

$$S\hat{y} = \left[\sqrt{1.227}\right] \quad .048$$

$$S\hat{y} = [\ 1.11\ ]\ \ .048 = .053$$

$$\hat{y} = 8.409 + 1.3677(-1.983) + .3139(5.951) + .2353\ (1.001) + .8180(.048) + .048 \pm .053$$

$$\hat{y} = 8.409 - 2.712 + 1.868 + .236 + .039 + .048 \pm .053$$

$$\hat{y} = 7.888 \pm .053 \quad \text{or} \quad 7.835 < \hat{y} < 7.941$$

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