EFFICIENCIES IN COORDINATION OF FLUID MILK SUPPLIES THROUGH COOPERATIVE MERGERS IN THE SOUTHWEST

By

MARILYN GRAVES KLETKE

Bachelor of Arts
Colorado College
Colorado Springs, Colorado
1966

Master of Science
Iowa State University
Ames, Iowa
1970

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fullfillment of the requirements
for the Degree of
DOCTOR OF PHILOSOPHY
December, 1981

EFFICIENCIES IN COORDINATION OF FLUID MILK
SUPPLIES THROUGH COOPERATIVE MERGERS
IN THE SOUTHWEST

Thesis Approved:

Leo V. Blakley
Thesis Adviser

James N. Plaxico

Daryll E. Ray

Paul D. Hummer

C. M. Bauer

Norman N. Durham
Dean of the Graduate College

PREFACE

This study is concerned with the estimation of potential efficiencies in coordination of fluid milk supplies through cooperative mergers in the Southwestern United States. Research objectives include estimating efficiencies gained through assembly and delivery transportation costs, processing costs, and seasonal and operating reserve levels. Costs and reserve levels are measured and compared under a centrally coordinated market structure and under one that is characterized by independently-operated local cooperatives.

My heartfelt thanks go to Dr. Leo Blakley, my committee chairman, for his time, patient direction and tremendous support during this research project. His kind and perceptive guidance has provided me with an education that will serve me throughout my professional career.

I would also like to thank the other members of my committee for their contributions; these are Dr. Charles Bacon, Dr. Paul Hummer, Dr. James Plaxico and Dr. Darryl Ray. Special thanks go to Dr. Plaxico, as it was he who first gave me the confidence and the opportunity to begin work on my Ph.D. in Agricultural Economics.

I am deeply appreciative of the financial and administrative support provided to me by Dr. James Osborn. I also appreciate the use of departmental facilities and computer funds.

Many thanks go to Elton Li for his computer work in the early stages of this project, and to the staff of the Department of Agricultural Economics for their help. The quality of the finished document is due to the efforts of Betty Hondronastas and her staff in the Word Processing Center. I appreciate their efforts in my behalf.

The sales and producer delivery data used in this research project were provided by Associated Milk Producers, Incorporated (AMPI). I would like to thank them for allowing us to use this data and to publish it in summary form. Market Administrators Dick Arnold and C. E. Dunham provided me with special data tabulations that were most important to the accuracy of the model. I appreciate their generosity.

To my family, Ben and Beckie Diven, and to my wonderful in-laws, Martin and Mildred Kletke, I express my heartfelt thanks for their constant support throughout my graduate work. Special thanks go to them for caring for our children for a period of time so that I could complete a rough draft.

I would also like to thank my sister, Betsy Graves, for her understanding and encouragement. Her support came when I needed it most.

To my many friends I express grateful thanks for their prayers and expressions of concern, as well as for their quiet strength. I deeply appreciate their patience as I neglected them and many of my responsibilities while I completed my research. Words cannot express how much their faithful support has meant to me.

Last, but certainly not least, my grateful appreciation and thanks go to my beloved family, Darrel, Bryan, Laura, Lyn, Deana, and Marc for their understanding, support, encouragement and many sacrifices. To them I dedicate this dissertation.

TABLE OF CONTENTS

Chapter		Page
I.	INTRODUCTION	1
	The Problem	1
	Background	3
	Research Objectives	9
	Research Framework and Methodology	9
	Organization	12
II.	THEORETICAL FRAMEWORK AND LITERATURE REVIEW	14
	Background	15
	Coordination	17
	Processing	17
	Reserve Levels	22
	Milk Movements	27
	General Support Theory	28
	Location Theory	28
	Linear Programming Theory	37
	Statistical Theory	39
III.	DATA, PROCEDURES, AND MODEL	40
	Design	40
	Data	42
	Procedure Implementation	45
	Demand Structure 1968	45
	Market Definitions	46
	Firm Structure of Fluid Processors	46
	Size Category Derivation	46
	Estimates of Distribution	52
	Firm Structure of Manufacturing Facilities	56
	Demand Structure 1978	56
	Demand Variability	56
	Sources	58
	Analyses	62
	Estimates of Variability	73
	Supply	87
	The Model	90
	Data Management	92
	The Optimizer	98
	The Matrix Generator	98

Chapter Page

The Local Cooperative Organization Matrix . 99
The Central Coordination Matrix 104
The Right Hand Side Generator 105
The Simulator 106
Milk Movements 108

IV. ANALYSIS AND RESULTS 114

Sources of Savings 114
Estimates of Savings 115
Transportation 115
Savings 115
Flow Patterns 119
Processing Costs 126
Imports and Exports 145
Reserves 151
Operating Reserves 151
Seasonal Reserves 159
Cross-Haul Savings 163
National Implications 165

V. SUMMARY AND CONCLUSIONS 168

Summary 168
Conclusions 169
Cost Savings 170
Reserve Levels 171
Limitations 171
Implications 172
Further Research 173

A SELECTED BIBLIOGRAPHY 176

APPENDIX 180

LIST OF TABLES

Table		Page
I.	Number of Fluid Milk Processors, U. S., 1950-1977 . . .	5
II.	Distribution of Fluid Milk Processing Plants in the U. S., 1971 and 1975	6
III.	Fluid Milk Processor Plant Size Categories from Selected Studies	50
IV.	Firm Numbers by Size, Selected Markets, 1969 and 1978	53
V.	Firm Numbers by Size Based on AMPI Southern Region Sales, Selected Markets, 1969 and 1978	54
VI.	Manufacturing Plant Locations and Capacities Under Local Cooperative Organization and Central Coordination 1968 and 1978	57
VII.	AMPI Southern Region Daily Deliveries to Plants Southern Region, October, 1977 and May, 1978	63
VIII.	Number of Processing Firms by Size and Market Classification Based on AMPI Southern Region Sales, October, 1977 and May, 1978	65
IX.	AMPI Southern Region Daily Deliveries to Plants by Market Classification, October, 1977	67
X.	AMPI Southern Region Daily Deliveries to Plants by Market Classification, May, 1978	68
XI.	Selected Statistics for Testing Distribution of Daily Sales by AMPI Southern Region, Mondays, October, 1977 and May, 1978	71
XII.	Summary Results of Normal Population Tests, AMPI Southern Region Sales, by Day of Week and Firm Size, October, 1977 and May, 1978	72
XIII.	Results of Bartlett's Test for Equal Variances Across Days of the Week by Firm Size Category, AMPI Southern Region Daily Sales, October, 1977 and May, 1978 . . .	74

Table		Page
XIV.	Market Mean, Two Market Standard Deviations, and Sum of Firm Standard Deviations for Dallas-Fort Worth Market, May, 1978	76
XV.	Selected Statistics for Regression of Sum of Firm Standard Deviations on Market Standard Deviations for Three Market Groupings, AMPI Southern Region, October, 1977 and May, 1978	80
XVI.	Ratios of Sum of Firm Standard Deviations to Market Standard Deviation for Selected Markets by Day of Week, AMPI Southern Region, October, 1977 and May, 1978	81
XVII.	Illustration of Procedure Used to Estimate Market Variation Each Day Based on Firm Sizes, 1968 and 1978	83
XVIII.	Analysis of Variance of Producer Deliveries, Three Time Periods and Two Markets, AMPI Southern Region, 1968-1978	89
XIX.	Producer Delivery Data by AMPI Southern Region Division, May and October, 1971-1975	91
XX.	Matrix Summary for Linear Programming Model, Local Cooperative Organization	100
XXI.	Estimated Sample Sizes Required, Two Confidence Levels, Organization Types, Months and Years	107
XXII.	Location of Assembly Centers Under Local Cooperative Organization, AMPI Southern Region, 1968 and 1978 . .	109
XXIII.	Average Monthly Assembly and Delivery Transporation Costs, Local Cooperative Organization and Central Coordination, May and October, 1968 and 1978	116
XXIV.	Manufacturing Plant Utilization Statistics, Local Cooperative Organization and Central Coordination, May and October 1968 and 1978	127
XXV.	Processing Costs by Plant, Local Cooperative Organization and Central Coordination, October 1978	131
XXVI.	Processing Costs by Plant, Local Cooperative Organization and Central Coordination, May, 1978	134

Table | Page

XXVII. Processing Costs by Plant, Local Cooperative Organization and Central Cordination, October 1968 137

XXVIII. Processing Cost by Plant, Local Cooperative Organization and Central Coordination, May, 1968 140

XXIX. Total, Per Unit Processing Costs, Local Cooperative Organization and Central Coordination, AMPI Southern Region, May and October, 1968 and 1978 . . . 144

XXX. Estimated Supplies, Utilizations, and Costs, Twenty Simulation Runs, Local Cooperative Organization and Central Coordination, AMPI Southern Region, May, 1968 146

XXXI. Estimated Supplies, Utilization, and Costs, Twenty Simulation Runs, Local Cooperative Organization and Central Coordination, AMPI Southern Region, May, 1978 147

XXXII. Estimated Supplies, Utilization, and Costs, Twenty Simulation Runs, Local Cooperative Organization and Central Coordination, AMPI Southern Region, October, 1968 148

XXXIII. Estimated Supplies, Utilization, and Costs, Twenty Simulation Runs, Local Cooperative Organization and Central Coordination, AMPI Southern Region, October, 1978 149

XXXIV. AMPI Southern Region Average Daily Sales Plus One Market Standard Deviation, Selected Markets, October, 1977 152

XXXV. AMPI Southern Region Average Daily Sales Plus One Market Standard Deviation, Selected Markets, May, 1978 154

XXXVI. Monthly Operating Reserves, Local Cooperative Organization and Central Coordination, AMPI Southern Region, October, 1977 and May, 1978 157

XXXVII. Average Daily Reserves, Local Cooperative Organization and Central Coordination, AMPI Southern Region October, 1977 and May, 1978 160

XXXVIII. Total Annual Savings, Central Coordination, AMPI Southern Region, 1978 166

Table		Page

XXXIX. Selected Statistics for Testing Distribution of Daily Sales by AMPI Southern Region, Tuesdays, October, 1977 and May, 1978 181

XL. Selected Statistics for Testing Distribution of Daily Sales by AMPI Southern Region, Wednesdays, October, 1977 and May, 1978 182

XLI. Selected Statistics for Testing Distribution of Daily Sales by AMPI Southern Region, Thursdays, October, 1977 and May, 1978 183

XLII. Selected Statistics for Testing Distribution of Daily Sales by AMPI Southern Region, Fridays, October, 1977 and May, 1978 184

XLIII. Selected Statistics for Testing Distribution of Daily Sales by AMPI Southern Region, Saturdays, October, 1977 and May, 1978 185

XLIV. Selected Statistics for Testing Distribution of Daily Sales by AMPI Southern Region, Sundays, October, 1977 and May, 1978 186

XLV. Selected Statistics for Testing Distribution of Daily Sales by AMPI Southern Region, Pooled by Firm Size or Month, Mondays, October, 1977 and May, 1978 187

XLVI. Selected Statistics for Testing Distribution of Daily Sales by AMPI Southern Region, Pooled by Firm Size or Month, Tuesdays, October, 1977 and May, 1978 188

XLVII. Selected Statistics for Testing Distribution of Daily Sales by AMPI Southern Region, Pooled by Firm Size or Month, Wednesdays, October, 1977 and May, 1978 189

XLVIII. Selected Statistics for Testing Distribution of Daily Sales by AMPI Southern Region, Pooled by Firm Size or Month, Thursdays, October, 1977 and May, 1978 190

XLIX. Selected Statistics for Testing Distribution of Daily Sales by AMPI Southern Region, Pooled by Firm Size or Month, Fridays, October, 1977 and May, 1978 191

Table | Page

L. Selected Statistics for Testing Distribution of Daily Sales by AMPI Southern Region, Pooled by Firm Size or Month, Saturdays, October, 1977 and May, 1978 192

LI. Selected Statistics for Testing Distribution of Daily Sales by AMPI Southern Region, Pooled by Firm Size or Month, Sundays, October, 1977 and May, 1978 193

LIST OF FIGURES

Figure		Page
1.	AMPI Southern Region Area, 1969	10
2.	Cost Curves Illustrating Economies of Size	18
3.	Cost Curves Illustrating Potential Economies of Specialization	20
4.	Delineation of Seasonality in the Theoretical Basic Supply, Deliveries to Plants, Reserve Levels, and Producer Deliveries	25
5.	Equilibrium in Two Markets With Trade and No Transfer Cost	30
6.	Equilibrium in Two Markets With Trade and Transfer Costs	32
7.	Theoretical Milkshed Configeration for Two Markets with Equal Prices and Transportation Costs	35
8.	Theoretical Milkshed Configuration Under Prices Which Differ With Transportation Costs From a Surplus Area . . .	36
9.	Selected Federal Order Milk Marketing Areas, January, 1969 .	47
10.	Fluid Milk Processing Plant Size Categories from Selected Studies-Number is Size Category for the Range in Volume . .	51
11.	Variability of AMPI Southern Region Daily Sales to Plants, Oklahoma City Market, May, 1978	60
12.	Variability of AMPI Southern Region Daily Sales to Plants, Dallas-Fort Worth Market, May, 1978	61
13.	Relationship of Two Market Standard Deviations to One Sum of Firm Standard Deviations for the Dallas-Fort Worth Market Area, May, 1978	77
14.	Relationship of Two Normal Curves	79
15.	Flow Diagram for Computer Modeling Process	93

Figure | Page

16. Grid Framework for Central Coordination, AMPI Southern Region 111

17. Minimum Cost Fluid Milk Movements, Assembly and Delivery to Processing Plants, Local Cooperative Organization, AMPI Southern Region, October, 1978 120

18. Minimum Cost Fluid Milk Movements, Assembly and Delivery to Processing Plants, Central Coordination Organization, AMPI Southern Region, October, 1978 121

19. Minimum Cost Fluid Milk Movements to Manufacturing Plants, Local Cooperative Organization, AMPI Southern Region, October, 1978 122

20. Minimum Cost Fluid Milk Movements to Manufacturing Plants, Central Coordination Organization, AMPI Southern Region, October, 1978 123

21. Seasonal and Operating Reserves, Local Cooperative Organization and Central Coordination, AMPI Southern Region, 1978 162

CHAPTER I

INTRODUCTION

The Problem

Milk is an agricultural commodity characterized geographically by atomistic production and centralized consumption. It is a highly perishable and easily contaminated product that is marketed in many forms: fluid milk and ice cream; soft products such as cottage cheese, sour cream and yogurt; cheese; butter and powdered milk; and canned products such as evaporated or condensed milk.

Demand and supply for fluid milk exhibit contraseasonal patterns creating the potential for large seasonal surpluses and/or deficits. In addition to these characteristics, the demand for milk is characterized by an unpredictable variability caused by consumption patterns, seasonal pressures, and geographically-related influences. Supply, too, is subject to a certain variability, although fluctuations in supply are much less dramatic than those in demand. The main factors influencing supply variability in the short run is weather, although feed type and quantity can affect it to some degree. Milk cannot be stored more than a few days, which means that differences between demand and available supply must be resolved through the maintenance of a continuous reserve that can be drawn upon to meet demand when milk production falls short. These factors combine to make milk marketing unique in terms of its technical aspects.

Coordination refers to the process of efficiently integrating individual facets of milk marketing so as to treat them as a marketing system. The ultimate goal is to market milk in the quantities, qualities, specific products, in the places and at the times dictated by demand. The individual facets include milk production, assembly, delivery, and processing of surplus milk. Coordination includes all of these, and the ways in which coordination is effected are dictated in part by institutional constraints in the form of federal order systems, price supports, and import restrictions.

At the producer level, price is the basic coordinating mechanism. It signals the producers to produce more milk or to cut back. In the past, the assembly function was carried out by handlers who were supplied by the producers. Coordination at this stage involved matching supplies with demands, and included hauling and transportation. Coordination at that stage was frequently aided by contracts between haulers and producers. Small local manufacturing facilities existed for processing surplus milk at the times when production outstripped demand in the localized market.

Through time, more and more of the coordinating burden has been taken on by dairy cooperatives. They were in a position of being able to receive and process information and signals more clearly than were single producers or handlers. They had personnel and were developing expertise that enabled them to implement coordinating activities effectively. They were potentially able to buffer surplus and deficit situations, and take action to minimize failures to meet demand. In addition they were able to provide additional services such as advertising and educational campaigns.

There has been lengthy public debate in recent years regarding the performance efficiencies of coordinated markets versus those of uncoordinated markets. A consensus regarding the precise benefits of coordination, if present, has remained elusive in the absence of extensive research in that area.

The purpose behind this research project was to produce some substantive results comparing the performance of an uncoordinated market structure with that of a potentially coordinated one. Performance measures included assembly and delivery transportation costs at the first-level handler stage, processing costs and manufacturing plant utilizations, import requirements, and reserve requirements. The results found here provide some information that may shed additional light on the potential value of coordination in the milk market.

Background

In the past, small local cooperatives were formed by farmers to help them market their milk. It was hoped that the cooperatives would help provide a more stable market than would otherwise be available to individual farmers. They provided some additional services and functioned to allocate milk in terms of time, place and form utility. Many small processors comprised the buyer structure for the milk, and the cooperatives functioned as middlemen between the producers and the processors.

After World War II the structure of milk marketing began to change. Technological advances and rising labor costs made economies of size attractive possibilities to milk processing firms, and the number of processors decreased as smaller ones exited from the industry and remaining ones grew in size. From 1950 to 1976 the number of fluid milk processors in the United States declined from 8185 to 1439 (11). While the numbers of smaller firms decreased, the numbers of larger firms increased as firms moved to take advantage of economies of size. Table I shows the overall changes between 1950 and 1977 (11) and Table II reflects the distributional changes between 1971 and 1975 (26) as an example of the changing structure. Improvements in transportation and storage methods enabled an expansion of market areas. Household deliveries decreased rapidly on their way to obsolescence and consumption patterns changed as consumers began to purchase larger quantities of milk on weekends. Processors began to change their processing patterns, and many cut back to fewer processing days in a week in response to changing consumer habits.

In response to the substantial changes taking place around them, dairy cooperatives began to pursue mergers in order to cope with the changing market structure. In the late 1960's there was increased merger activity of cooperatives, and several multi-market cooperatives began to appear. Among these was Milk Producers, Inc., which began operations in September of 1967 and was formed by the merger of five local cooperatives: Pure Milk Association in Tulsa, Oklahoma; North Texas Milk Producers Association in Arlington, Texas; Central Arkansas Milk Producers Association in Little Rock, Arkansas; Central Southwest Dairymen in Wichita, Kansas; and Central Oklahoma Milk Producers Association in Oklahoma City, Oklahoma. Early in 1969 MPI, Inc. merged with nine additional local cooperatives in Texas, New Mexico, Oklahoma, and Tennessee and with 11 Northern cooperatives (including Pure Milk

TABLE I

NUMBER OF FLUID MILK PROCESSORS,
U. S., 1950-1977

Year	Number of Processors
1950	8185
1955	6726
1960	5328
1965	3743
1970	2216
1971	2089
1972	1898
1973	1701
1974	1571
1975	1494
1976	1439
1977	1349

Source: Cook et al. (11, p. 27).

TABLE II

SIZE DISTRIBUTION OF FLUID MILK PROCESSING PLANTS IN THE U. S., 1971 AND 1975

Gallons Annually (000)	1971	1975	Percent Change
Less than 100	369	275	-25
100-299	569	354	-38
300-1,499	641	426	-34
1,500-4,999	405	400	- 1
5,000-14,999	228	286	+25
15,000 or more	96	114	+19
Total Plants with Known Production	2,308	1,855	-20

Source: Mueller (26, p. 31)

Cooperative of Chicago) to form Associated Milk Producers, Inc., a large multi-market dairy cooperative.

Producers were hopeful that through merger they would receive additional benefits unavailable to them at an individual level. They expected to have a steady, dependable market for their milk, and efficiencies that could be implemented by the cooperative would pass cost savings through to the farmers in the form of better prices for their milk. Cross-hauling could be virtually eliminated; larger percentages of milk produced in the Southern Region could be put to Class I usage rather than manufacturing "excess" milk that collected in locally concentrated pockets and importing milk from the North to satisfy fluid needs. Producers also were confident that the existence of the regional dairy cooperative would eliminate the bickering that had previously occurred over market area definition.

Lastly, producers expected to benefit from savings in handling surplus milk. Under an atomistic marketing structure, milk production tended to accumulate around local processing plants as producers attempted to contract with individual processors in order to reduce their risk. "Surpluses" remained in the same area and were processed by many small high-cost manufacturing facilities frequently maintained by larger processors. Aggregating small pockets of surplus milk and moving it to a large lower-cost manufacturing plant was not a viable alternative because of a lack of incentive for an individual farmer or processing plant to bear the added cost of transporting the milk. Through coordination, both the costs and the benefits could be managed by the central agency thereby providing the economic incentive to streamline the manufacturing processes.

As the multi-market dairy cooperatives began to take hold and function in the new marketing environment, the scope of services they offered also grew. They operated receiving stations and manufacturing plants and coordinated supply with demand. They provided promotional services and conducted seminars and educational programs. They provided handlers with milk at the times and in the quantities they required, while simultaneously managing reserve levels and processing surpluses. The service most suited to their newly-developed capabilities was supply-demand coordination, and the flexibility they gained through their multi-market influence enabled them to implement substantial efficiencies in the movement of milk and in the levels of reserves required to meet a fluctuating demand.

As AMPI and other large dairy cooperatives grew in stature and influence, they became the focus of unfavorable attention by the Justice Department. Words such as "acquisition", "concentration", "dominance", and "monopoly" began to be used in connection with the cooperatives. Little information was available on realized or potential benefits of large cooperatives. Part of this was due to the lack of available data for research in this area, and part of it was attributable to the degree of difficulty in setting up a controlled situation whereby performance of a large cooperative could be evaluated and compared with that of several smaller cooperatives. Comprehensive studies in this area were involved and expensive, and the research efforts along these lines were limited. A great need developed for substantive results to provide information that could be used to answer some of the questions that were arising in increasingly great numbers.

Research Objectives

This research project considers the supply-demand structures of 1968 and 1978, and evaluates for both time periods the marketing performance of a centrally coordinated system compared with a group of independently organized local cooperatives. The specific objectives of the project are:

1. to measure the effects of central supply-demand coordination on marketing efficiency in the fluid milk industry in the Southwest in terms of
    a. assembly and first-level handler delivery transportation costs
    b. processing costs and capabilities
    c. the abilities to meet first-level demand requirements when faced with unanticipated shifts in supply-demand relationships
    d. import requirements
    e. size of reserves, operating and seasonal, necessary to handle fluctuations in fluid demand and supply
2. to make available some data on numbers and sizes of firms and related variabilities in demand levels by day of week, market, and season.

Research Framework and Methodology

The framework for carrying out the research to satisfy the objectives was built around the formation of AMPI. The Southern Region of AMPI, shown in Figure 1, forms the area included in this study. In

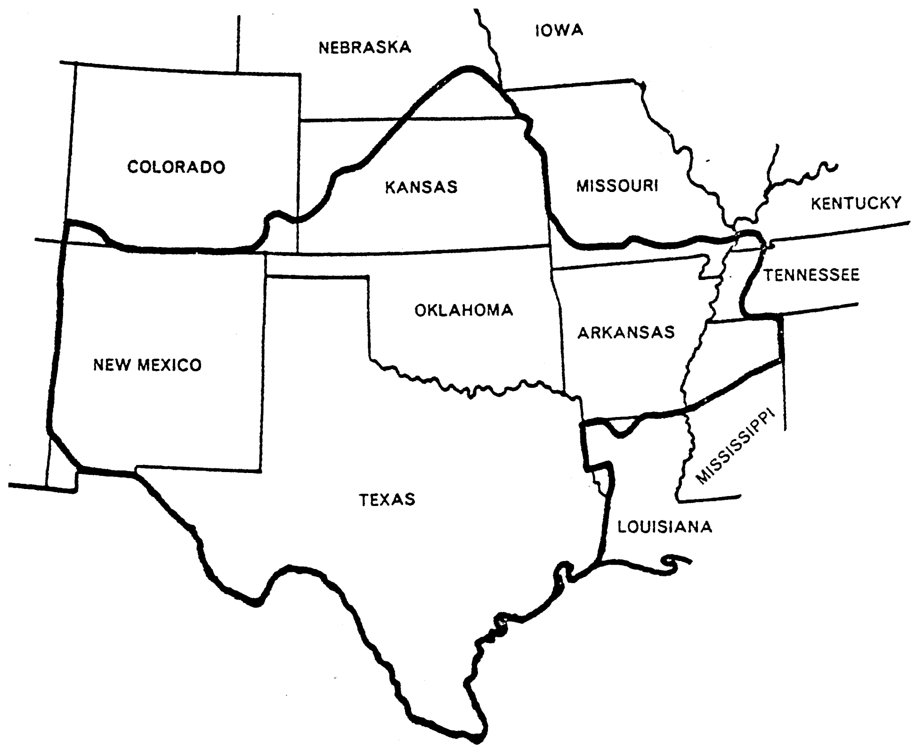


Figure 1. AMPI Southern Region Area, 1969

1968 prior to the merger, the marketing of milk was carried out in this area by approximately 17 local cooperatives. Each one was responsible for its own marketing area and satisfied fluid demand as best it could within that area. In deficit periods the local cooperatives reached out to neighboring cooperatives to procure additional Class I milk; in times of surplus they manufactured market surpluses into cheese or butter and powder. Cross-hauling of milk was common, and instances are recorded where groups of producers exported milk from their marketing area necessitating compensating imports from long-distance sources.

In 1978 the central coordination brought about by the formation of AMPI was organized and had been functioning for almost a decade. Transportation of fluid milk between producers and points of fluid demand was organized according to AMPI directives, and manufacturing facilities determined by AMPI as being inefficient had been shut down. An additional plant was opened at El Paso to handle large surpluses originating in the New Mexico-West Texas area. Reserve levels were coordinated across market areas, and changes initiated by central coordination of the regional market were in effect.

This research utilized some supply and demand data made available from AMPI records. Producer deliveries and sales to plants on a daily basis were provided for October, 1977, and May, 1978. These data provided a base from which could be built a model that could evaluate the performances of local cooperative organization and central coordination. The model simulated supply and demand levels and variabilities in 1968 and 1978; the simulation used the above data as a starting point. It was assumed that milk could be marketed in both years under local cooperative organization and under central coordination. Each year was set up to include October and May which represented extremes on the time continuum in the relationship of demand and supply. The market conditions were simulated for twenty time periods using random normal draws to set supply and demand levels. A set of twenty performance statistics was generated, permitting computation of averages that could be compared as measures of performance of the two marketing scenarios. Performance measures were chosen to meet the objectives of the study.

Organization

This dissertation begins with a brief introduction and background discussion leading to the objectives of the study. It provides the general environment into which this research project fits.

Chapter II sets the theoretical framework behind the study. It provides a short documentation of the interest and concern in the area of milk marketing through a discussion of some of the relevant publications. It then summarizes some of the research efforts being made to assess potential and realized benefits of coordination through processing of surplus milk, reserve levels, and movements of milk in the assembly and delivery phases. It finishes by grounding this research in some of the theory that gives depth to the results.

Chapter III discusses procedures that were developed, the parameters that were used, and the estimates that were computed to quantify certain behavioral characteristics. It also describes the data used in the study and how they were put together to support the study. It details the demand and supply structures that were developed, and the model that was built to simulate twenty periods of operation.

Chapter IV offers the results of the study and develops the analysis of the operating and seasonal reserve levels. It compares costs and manfacturing plant usage between the scenarios, and presents the research accomplishments as they relate to the objectives of the study.

Chapter V, the final chapter, summarizes the findings of the project and attempts to back away from the immense detail required in Chapter III to relate the findings to the economic structure of the milk marketing sector of the dairy industry. It also explores some implications of the research, details some limitations and some beneficial changes suggested by the awesome clarity of hindsight, and presents some directions for future research thrusts.

The Appendix provides the tables for some of the more detailed analysis which may be of interest, but which are better looked at outside of the main flow of the research.

CHAPTER II

THEORETICAL FRAMEWORK AND LITERATURE REVIEW

Milk marketing is a highly complex mechanism set into a structured, many-faceted framework. Performance within the industry is influenced by federal order regulations, the federal price support program, import restrictions, and the fluid milk pricing mechanisms for different use values and geographical areas. Within this structure dairy cooperatives function to market their producer-members' milk. In order to increase understanding of the ongoing analyses of the different aspects involving dairy cooperatives and coordination, it is helpful to obtain background information.

For purposes of grounding this study, there are several general publications that convey information about the dairy industry and the changes it has undergone since World War II. They explore the framework of milk marketing and help in gaining an understanding of the general structure within which dairy cooperatives function. Cook et al. (11), in _The Dairy Subsectors of American Agriculture: Organization and Vertical Coordination_, set the stage for the general situation in the dairy industry. Several concepts requisite to the understanding of the implications of cooperative mergers were presented there. _Public Policy Toward Mergers in the Dairy Processing Industry_ (26) is a second publication that conveys information in the area of firm mergers and their behavior. These two publications together provide an in-depth treatment of the environment within which this research project functions.

Background

In 1971 a report was prepared at the request of the U. S. Department of Justice entitled "An Economic Analysis of the Associated Milk Producers, Inc. Monopoly" (14). This analysis devoted no resources to the presentation of potential or realized economic and social benefits brought about by regional cooperatives, and because it was limited in scope, its findings do not describe the entire situation. This report was widely distributed and was taken by many as a comprehensive report on regional cooperatives in general, although the document was certainly never intended to be used in that way. Cook, Blakley and Berry (10) reviewed the document explaining its limitations and pointing out areas in which misleading conclusions regarding cooperative performance might have been drawn or encouraged. The two publications reflected the growing general interest in the changing dairy marketing structure, and also pointed up the need for research efforts designed to look at all aspects of regional cooperative performance.

In 1973 The Federal Trade Commission commissioned a study on structure and performance trends in the dairy industry. Parker (28), in *Economic Report On the Dairy Industry*, presented to the Commission the results of that study, which was conducted by the Bureau of Economics. The facts included therein were to be used by the Commission in determining future policy regarding mergers of dairy processing firms. It discussed the structure of the fluid processing sector and looked at concentration trends and developments in that area. It also served to document the increasing interest of the federal government in the changes taking place within the dairy industry.

In November of 1975 the Justice Department commissioned a staff report on the effects of government regulation of the dairy industry. This report was published in an edited form by MacAvoy (23) and provided an interesting contribution to the literature. Its stated objective was to report on the effects of government regulation on the milk marketing industry. It described dairy marketing under controls and presented the background behind the controls. The publication discussed how the behavior of dairy marketing might differ under the absence of controls, and concentrated on potential disadvantages of the regulatory system. It stated, however, that these disadvantages are only half of the needed analysis; that benefits derived from government intervention in the milk market must be measured and weighed before any final conclusions may be drawn. It also mentioned that as of 1975 there had been no studies which have attempted to quantify the benefits attributed to the federal market order system. The benefits referred to included, among others, maintaining "orderly market conditions to avoid unreasonable fluctuation in supply and price" and assuring "an adequate and dependable supply of fluid grade milk" (23, p. 113). The publication went on to discuss how regional cooperatives, in the opinion of authors, are self-serving and have taken unfair advantage of the federal order system. Research on benefits of the federal order system and those of regional cooperatives would be helpful in completing the missing part of the analysis referred to by MacAvoy.

Coordination

After the developments through 1975, there began to appear results of research efforts directed towards measurement of benefits. Dairy cooperatives function within the environment set up by the federal order system, and as such benefits brought about by their operation to the marketing system are also benefits of the federal order system. One of the major areas in which dairy cooperatives can make positive contributions is in the area of coordination, or balancing supply with demand. This function helps bring about the benefits mentioned earlier that were specifically intended by Congress and stated by MacAvoy (23, p. 113). Coordination results can be seen most directly through processing, reserve levels, and milk movements.

Processing

Consider first the processing of surplus milk into cheese, butter, and nonfat dry milk solids. Regional dairy cooperatives are able to reduce the number of small localized processing plants to fewer, larger plants. Figure 2 shows how economies of size can be attained through the operation of one large plant over that of two smaller ones.

The long-run average cost curve for a hypothetical processing plant is represented by LAC. If the plant size were optimal, in other words if it were the most efficient of all possible sizes, it would be processing Q_3 lbs. of surplus milk at an average cost of P_3. Suppose Q_3 lbs. of milk were processed by two plants with short run average cost curves of SAC_1 and SAC_2, respectively. For example Q_1 lbs. of milk might be processed at an average cost of P_1, and Q_2 lbs. of milk

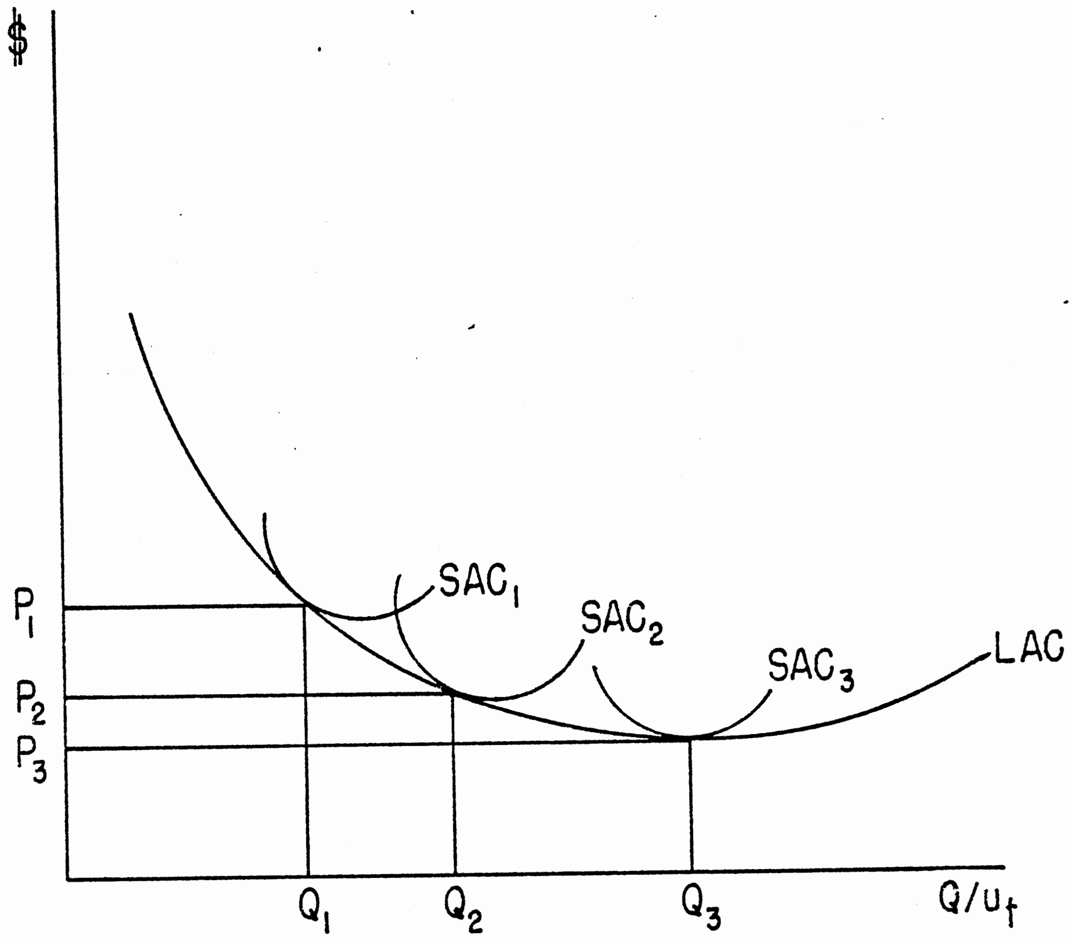


Figure 2. Cost Curves Illustrating Economies of Size

might be processed at an average cost of P_2. The total cost of Q_3 lbs. of milk processed by two firms would be $Q_1P_1 + Q_2P_2$, which is greater than the total cost Q_3P_3 would be if processed by one optimal size firm.

This, then, is one area of potential savings that can be realized through coordination. Another source is in the area of specialization. By allowing plants to process cheese or butter, but not both, economies due to specialization can be brought about. These can come from several sources. First, as far as labor is concerned, proficiency is gained by concentration of effort (15). If a worker performs several jobs and works with different pieces of equipment, he loses time and efficiency in moving around as well as in relearning tasks each time he changes. These translate to increased per unit costs in production. Through specialization of labor, average costs are decreased through gains in proficiency and elimination of time-consuming charges of task, location and equipment.

A second source of efficiency through specialization is through technological factors. Larger machines do not cost proportionately higher than smaller machines, so placing more volume on one larger machine can be less costly than splitting that volume and processing it in two places on two smaller machines. There is also more flexibility in effectively meshing complementary machinery both in terms of time and quantity if only one product is made in a given plant. The theoretical representation of potential savings due to specialization can be seen in Figure 3.

The curve LAC_1 represents the long run average cost function of a plant which can make both butter, say, and cheese. LAC_2 reflects the

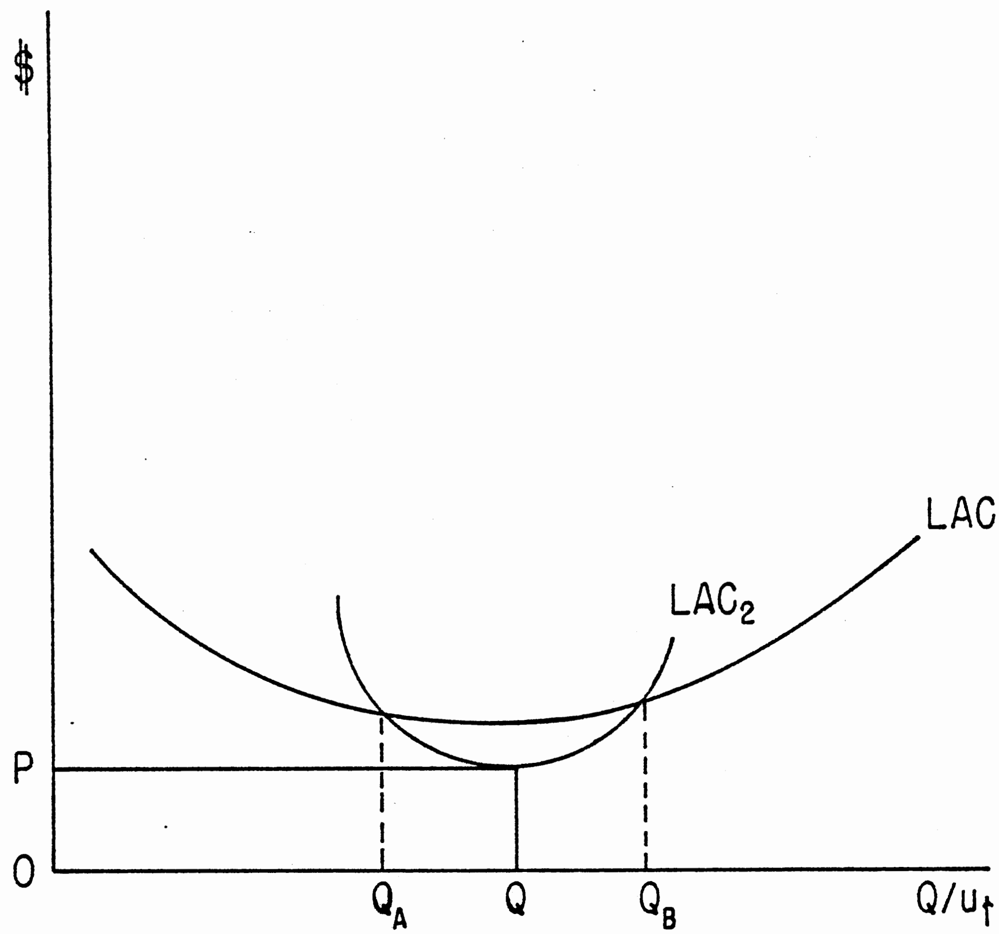


Figure 3. Cost Curves Illustrating Potential Economies of Specialization

long run average cost curve for a specialized firm. The differing shapes of the two curves are explained and defined by the economies of size realized in each case. At volumes between Q_a and Q_b a specialized plant can produce at lower per unit costs, but if volume decreases below Q_a, the increase in variable costs more than offsets the gains due to specialization.

Regional dairy cooperatives have the potential for allowing volumes to be processed at a particular plant that are between Q_a and Q_b, thereby taking advantage of specialization. Q would be the quantity that would minimize average costs. By looking at the different values associated with cheese and butter manufacturing, coordinated efforts can direct proper volumes of surplus milk to a set of manufacturing plants, thereby gaining efficiencies through both size and specialization. Such economies would not necessarily arise without central coordination because individuals would try to maximize local firm returns - not returns to the entire marketing system.

In actuality, a manufacturing plant cannot take complete advantage of economies of specialization. Prices of cheese and butter fluctuate, and demand response shifts quantities processed to emphasize cheese one time and butter another. Due to this, manufacturing plants are set up to allow some flexibility in processing between cheese and butter. This limited flexibility allows them to cope with unpredictable changes in quantities demanded of cheese and butter, but it prevents them from taking full advantage of economies of specialization. The economies shown in theory in Figure 3 are still achieved, although to a lesser degree in actuality.

Stellmacher (34) and Stellmacher and Blakley (36) developed processing costs under coordination and also provided information on manufacturing plant sizes and how they have changed under coordination in the Southern Region. These studies produced some tangible results suggesting that benefits are being realized from coordination.

Buccola and Conner (8) looked at potential efficiencies through coordination in the Northeastern U. S. They determined the manufacturing plant configuration that would have prevailed in 1976 and 1977 had regional coordination been in effect. They discussed benefits that would have been possible under complete coordination. They corroborated that significant potential economies can be associated with coordination, and provided more information in the area.

Reserve Levels

Another potential advantage of coordination is in the reduced reserve levels made possible through coordinated planning. Milk reserves are a necessary and costly part of the milk marketing system. The demand for fluid milk fluctuates on a daily basis and also on a seasonal basis. Production of milk is subject to extensive seasonal variation due to biological factors and because the number of cows producing milk is fixed in the short run. Milk production displays minor day-to-day variation, as it is subject to influence by the weather.

The demand for fluid milk on any given day must be matched with the milk supply available at that time. Since fluid milk is highly perishable, long term storage is infeasible. This implies that production of fluid milk for a given period of time must occur at a sufficiently high level to insure that the demand is satisfied on peak days during that period. This necessarily leads to a fluid milk surplus on low-demand days in that time period since milk production displays less day-to-day variability than demand. These day-to-day surpluses are known as operating reserves and are necessary in order for demand to be met.

Seasonal patterns of demands and supply run opposite to one another; that is, in the spring when milk production peaks due to biological factors, consumption drops to its minimum. In the fall when milk production reaches its minimum, demand approaches its maximum as families return to normal winter routines and school lunch programs get underway. The contraseasonal pattern implies the existence of substantial seasonal reserves. Coordination has the potential of decreasing those seasonal reserves in individual markets through better management of fluid milk movements for a larger geographic area.

The problem of efficiency in reserve levels has been considered recently by several researchers. Christensen et al. (9) conducted a detailed study in which much of the theory of reserves was presented. In that study basic supply was defined to be the maximum amount of milk required by and supplied to handlers on a regular basis. Its level was determined on the day when demand was seasonally lowest relative to production. This amount, then, represented the production of a constant number of producers, and varied only with daily and seasonal variations in milk production. This quantity of milk could in theory be collected on a daily basis from the same set of producers and could be delivered to the same set of plants without having to reroute any of it in the process of coordinating supply with demand. The plants, however, would require other sources of milk for meeting Class I sales during almost all months of the year.

The basic supply curve was formed by passing the producer delivery curve for that constant number of producers through the point on the delivery-to-plants curve where demand was lowest relative to supply. Figure 4 shows this relationship for theoretical sales and producer deliveries. The supplemental supplies required by the plants are shown as the differences between average Class I sales and the basic supply for each month and are the additional fluid milk that must be delivered to plants in response to seasonal variability in demand.

Operating reserves for each week represent the quantity of milk that must be produced and kept on hand by the cooperative during that week's time in order that the market demand always be met on the days and in the quantities required. What is not used during the remainder of the week must be transported to manufacturing facilities to be made into cheese and butter. Operating reserves required by the plant are shown in Figure 4 as the difference between the peak Class I sales and average Class I sales curves.

Christensen et al. defines the total necessary supply by superimposing the producer-delivery curve at the point where peak demand is seasonally highest relative to production onto the corresponding point on the peak Class I sales curve. The difference between total necessary supply and peak deliveries to plants is called the seasonal reserve supply. Seasonal reserve supply is determined to be the extra milk that must be produced above and beyond basic supply, supplemental supply, and operating reserves due to seasonal variations in production and demand. On the day when demand is seasonally highest relative to supply there is no seasonal reserve. In Figure 4 seasonal reserve is

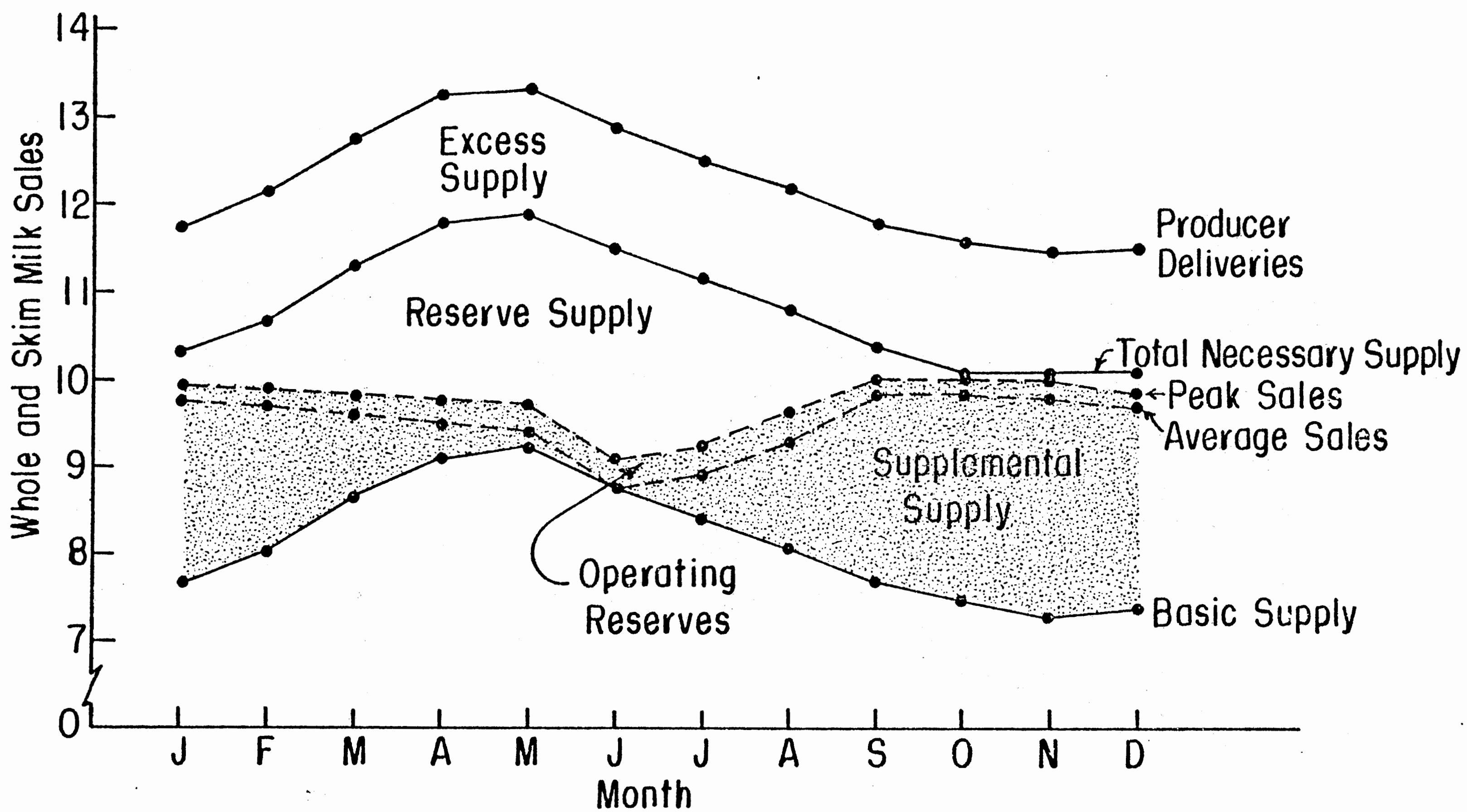


Figure 4. Delineation of Seasonality in the Theoretical Basic Supply, Deliveries to Plants, Reserve Levels, and Producer Deliveries

the difference between total necessary supply and basic supplemental deliveries plus operating reserves. There will be only one level of demand when there are no seasonal reserves on hand. That level occurs on the day or days where demand is seasonally highest relative to production. It is where the total necessary supply curve was defined, and total necessary supply and peak demand are equal there. At all other quantity levels on the demand curve there will be seasonal reserves in existence.

Christensen et al. discussed the coordination performed by seven cooperatives during a twelve-month period in 1975-76 in the Intermountain States. They pointed out that

> With considerable variation in both supply and demand from day to day, the larger the volume under the control of a single agency such as a cooperative, the more individual plant variations tend to offset one another, and the more efficient handling reserve milk becomes compared with when each handler attempts to take care of his own (p. 2).

They stated that in their study coordination reduced operating reserve levels from 13.1% to 11.3%, and reduced seasonal reserves from 13.2% to 10.9% for the period September, 1975 through August, 1976. These percentages were taken as a percent of total necessary supply.

Lasley (20) also analyzed the need for reserve levels under coordination. In the Oklahoma market for 1962 he determined that three plants required 21% more reserve milk to meet weekly fluctuations when operating independently than they did when they were combined. As for operating reserves, weekly producer receipts were shown to be 105-149% of fluid sales 90% of the time for the three plants combined, but only 70% of the time were they that low as individual plants. Thus as individual plants they maintained greater operating reserve levels than would be required if they were combined. In the Pittsburgh market Lasley (21) showed that over a 16-week period a coordinated market would have required only half the reserves of the individual markets operating separately. There is more supporting evidence in both of these publications suggesting that there are measurable and realized benefits which come from coordination of reserve supplies.

Additional data on reserve levels were made available by Smith, Metzger, and Lasley (30) as they examined production-consumption balances in the Northeast. Their focus was primarily to quantify those reserves on a state-by-state basis for a specific period of time, and to determine what they would be if the area were managed in a coordinated framework. They determined that the total necessary reserves for the Northeast region in 1974-76 were 22% of the Class I sales. These reserves were comprised of 6% operating reserves and 16% seasonal reserves.

Milk Movements

Coordination has much to contribute to efficiency in milk movements, both at the assembly stage and in processing plant location and geographical distribution of surplus milk. Several studies address these aspects of potential and realized efficiencies.

Boehm and Connor (5) conducted a study in the Southeastern part of the United States which looked at the minimization of transportation costs of fluid milk and of processing the surplus. They considered seasonal patterns and worked with optimal manufacturing plant locations. They concluded that "substantial technical economies" remain to be realized by more fully coordinating the milk marketing industry.

Lamb (19) looked at potential savings in milk assembly at the producer level. He discussed benefits to be gained under coordination from restructuring milk procurement areas for an entire region. He pointed out that a particular weakness of studies that attempt to evaluate efficiency improvements through coordinated milk assembly is that they fail to quantify savings correctly, due to the inability to model the existing movement of milk.

General Support Theory

Studies such as those mentioned above and also the present study are based on certain bodies of formalized theory. These include location theory, transportation and linear programming theory, and statistical theory. The following discussion presents some of the concepts intrinsic to this research, but in no way does it attempt to recreate the work of the textbooks in the various subjects. The purpose is to demonstrate the particular segment of theory and its relevance to this research project.

Location Theory

The main body of location theory deals with how market areas develop, and what factors cause a product to move from its point of production to one particular market as opposed to another. It establishes the reasons behind the flow patterns of the model and shows how this model can be run without the explicit inclusion of product prices. Much of the material presented in this section is covered in greater detail in Bressler and King (7).

The nature of milk production precludes its production location from moving to consumption centers. It requires the use of a basic resource, land. This requirement automatically guarantees that:

1. dairy production will occur at many spatially dispersed locations
2. these locations will not be located in the major consumption centers, as land there is too costly to be used as an agriculturally-related resource.

Milk, therefore, must be transported to some regional assembly center in order to fill demand. The resultant movement of milk will behave according to economic principles of location theory. The following discussion presents a simplified discussion of these principles.

Assume initially that there are two regions, X and Y, and one product; that production aggregated within region X forms a regional supply curve S_x; that production aggregated within region Y forms a regional supply curve S_y; and that demand aggregated similarly by region yields regional demand curves D_x and D_y. Also assume for the moment that there are no transfer costs for the product. Figure 5 shows that in the presence of regional isolation the equilibrium quantities moved are determined independently by each region's supply and demand curves. The price in region X is oa, while the price in region Y is lower than that at ob. If this situation occurred in actuality, barring artificial constraints, producers in region Y would begin shipping product to region X because they would realize a higher price there than in region Y. Supply would continue to move from region Y to region X until an equilibrium between the two regions was reached. This equilibrium would occur at the interesection of the sum of the

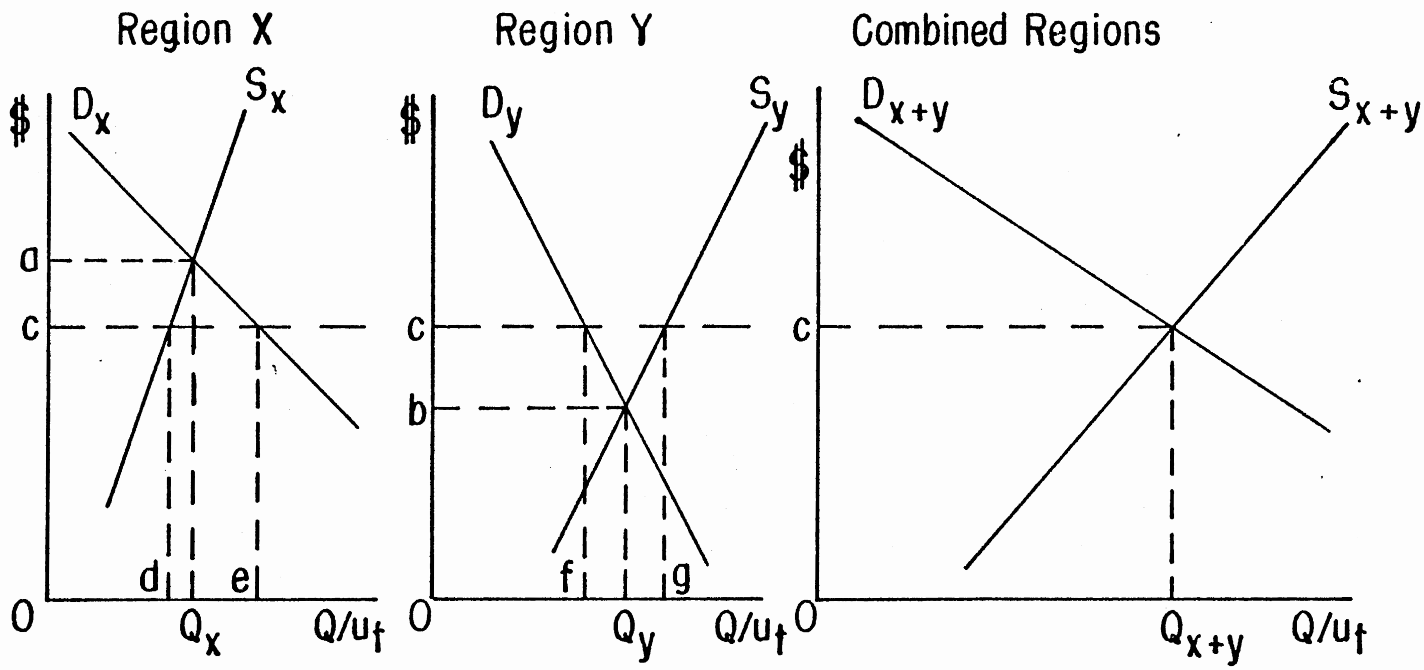


Figure 5. Equilibrium in Two Markets with Trade and No Transfer Cost

demand curves and the sum of the supply curves. The total quantity of product would be the same as before, but it would be allocated differently across the regions. Eventually quantity fg would leave region Y and move to region X; this is equal to quantity de, the amount gained in region X. There would be one equilibrium price, oc, which would hold in both regions.

Transfer costs can now be introduced into the described structure. For the sake of simplicity it is assumed that transfer costs are composed only of transportation costs, and that there are no loading or unloading charges. In order for producers in Y to take advantage of the higher product prices in X, they must move their product to region X at a transfer cost of t. If they can obtain a price for their product more than t cents above the price they receive in their own market, they will ship product to region X. Product movement, then, will occur until the price differential between the two markets is equal to the transfer cost of moving product from Y to X.

Equilibrium with positive transfer costs is shown in Figure 6. The aggregate supply and demand curves and the horizontal axis for region Y have been moved upward uniformly by the amount of the transfer cost. This allows a horizontal line to represent not equal prices in the two regions, but prices differing by the amount of the transfer cost. The equilibrium price in market X is oc', that of market Y is o'c', and o'c' plus the transfer cost oo' is equal to oc', the product price in region X. The quantity of product moved from Y into X is smaller than when there were no transfer costs, and is represented by f'g' as it leaves market Y and e'd' as enters market X. ES_x and ES_y represent the excess supply curves in markets X and Y, respectively.

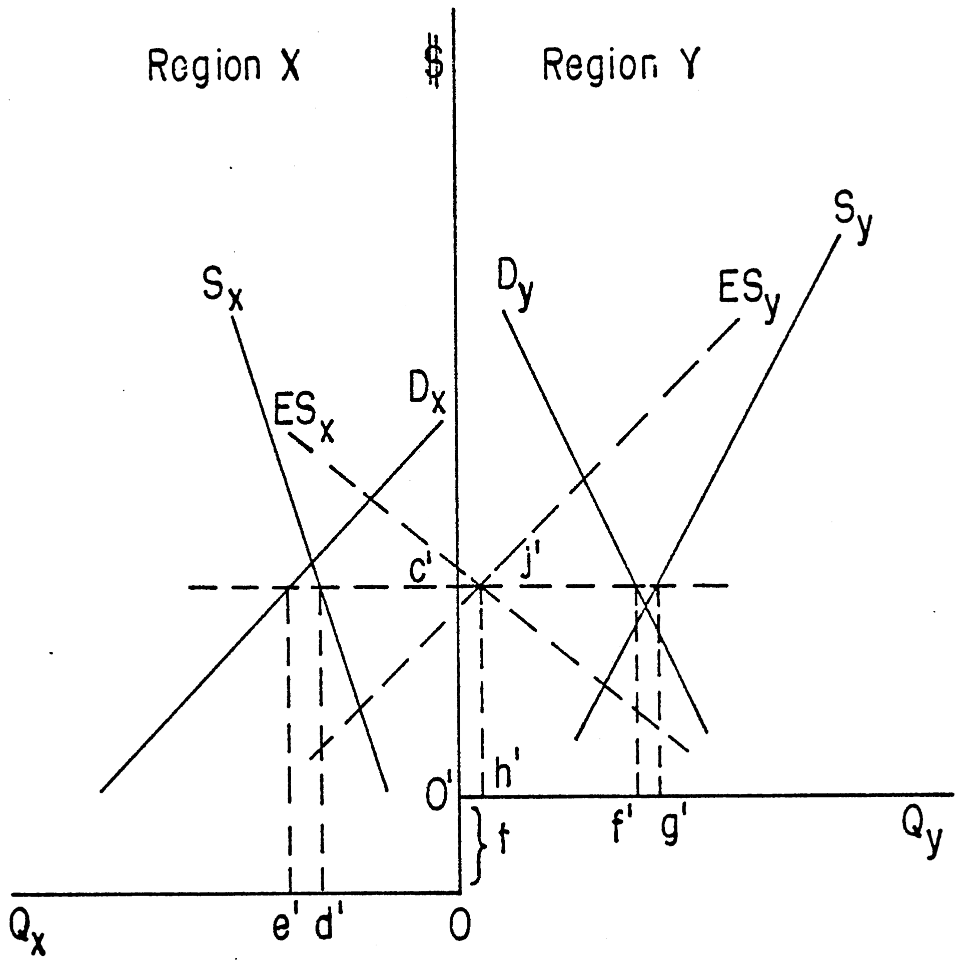


Figure 6. Equilibrium in Two Markets with Trade and Transfer Costs

Their intersection at j' is at the point where the surplus in region Y is exactly equal to the deficit in region X, given the supply and demand curves as graphed, and the transfer costs. This is the quantity of fluid milk that moves from region Y to region X in order to achieve equilibrium between the two markets.

In summary, producers will market their product at the nearest market center as long as prices between markets do not differ by more than the cost of transfer between markets. When the location differential, as it is called, is exceeded by price differences between markets, producers will export their product to other markets until a new equilibrium is established. That equilibrium means that prices between markets differ only by the location differentials.

In the milk marketing industry the base price of Class I milk the price at Eau Claire, Wisconsin, and a location differential is added to that to determine the Class I price at other locations. Producers receive a "blend" price computed on the basis of Class I utilization for the market. In the Southern Region the benefits of coordination are shared among all the producers in the region and not allocated to specific producers on the basis of location. It is noticeable that as transfer costs increase, they reach a point where they exceed the price difference that would exist in the isolated region situation. There exists a distance beyond which produce will not flow into a given market. Technological advances that reduce transfer costs will increase the geographical extent of market areas. This explains why the advent of the interstate highway system, for example, changed the locational structure for many products that could be shipped by truck. Transportation costs were decreased, which reallocated the amounts of products that were being exported to deficit markets.

There are many determinants of transfer cost, and frequently distance determinants are non-uniform. A transfer cost function for a model is the relationship between length of haul and cost of transfer services. For this study it was set up to be a linear function of distance, and the hauling cost was a constant of $0.30 per cwt. per hundred miles. There were no components included except transportation costs. In theory, this cost function can be pictorially represented as in Figure 7. There are two markets with equal transportation costs and cost functions. The market centers are located at points X and Y, and a linear transportation cost is represented by two sets of concentric circles equidistant apart. These circles represent isocost contours, or the locus of points where equal transfer costs occur when shipping product to X or Y. The line AB represents the locus of points where a producer would be indifferent between marketing his milk in X or in Y; his product price would be the same in either case.

The pricing structure for fluid milk alters the shapes of the milksheds shown in Figure 7. Fluid milk production is not geographically uniform in the U. S., and the Wisconsin-Minnesota region produces a substantial surplus. The price paid to producers increases with distance to the South, which has traditionally been a deficit area. The increase is a function of transportation costs, and this locational differential has the effect of pulling milk from the surplus area into the deficit area. The shape of the milksheds become irregular under these circumstances, and assumes oblong shapes similar to those in Figure 8. Each market obtains more of the supply from the direction of the surplus production area than from the opposite direction (4).

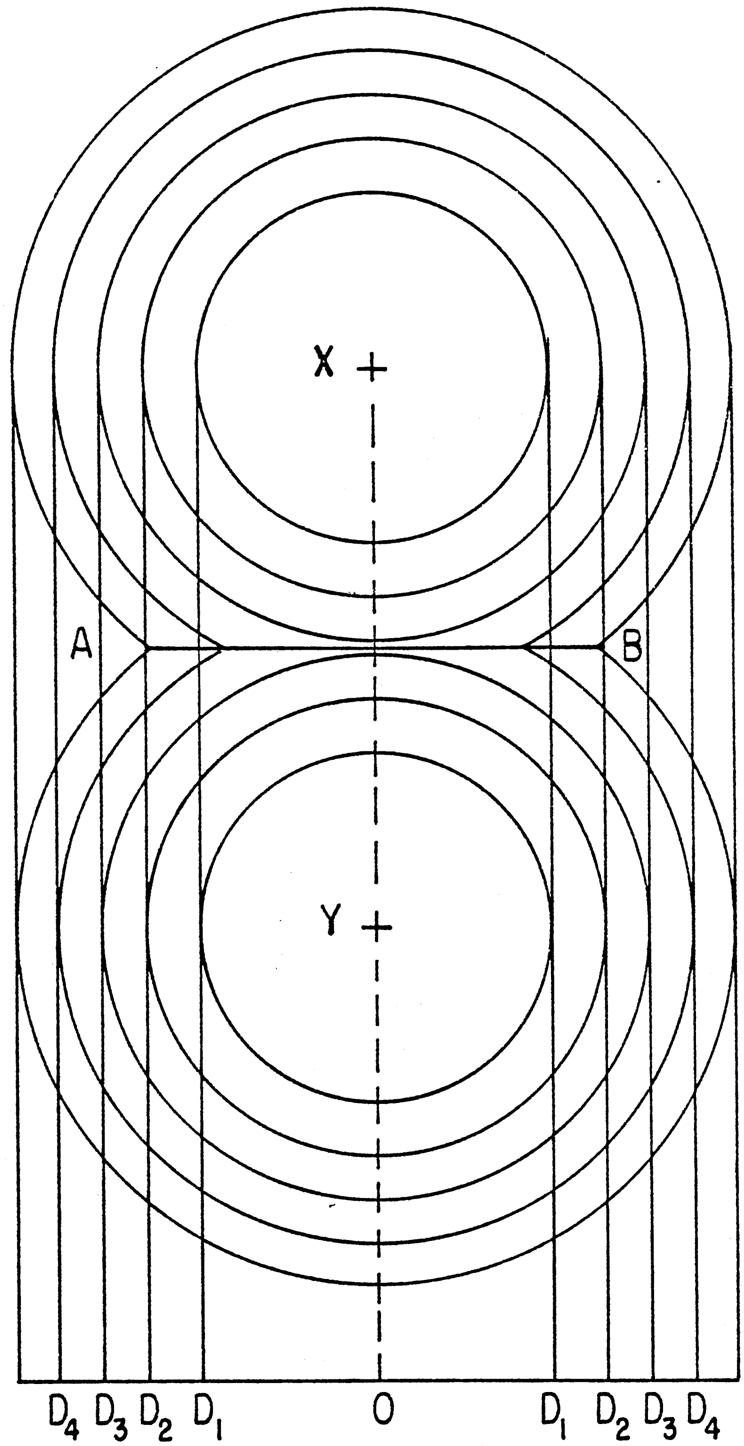


Figure 7. Theoretical Milkshed Configuration for Two Markets with Equal Prices and Transportation Costs

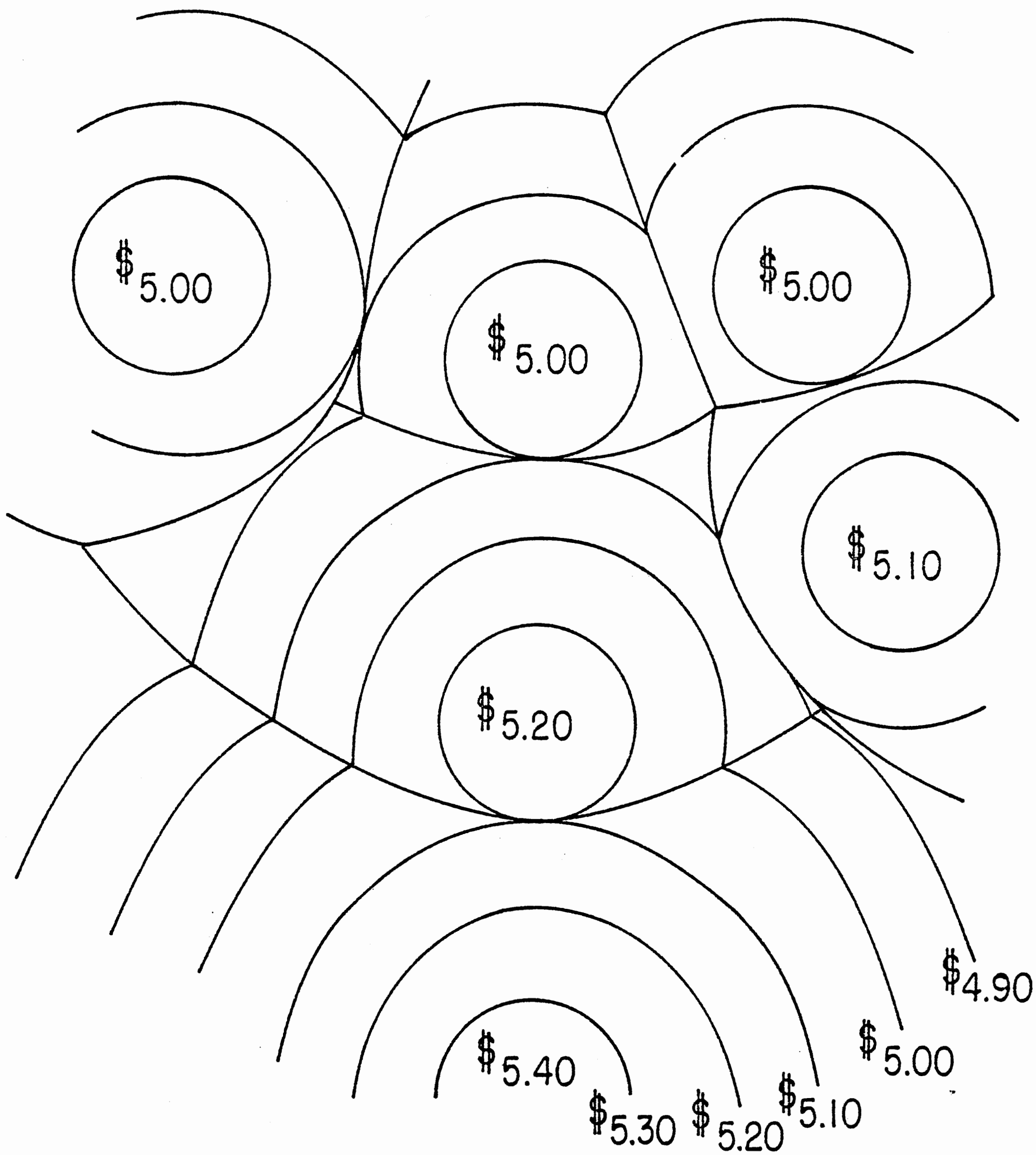


Figure 8. Theoretical Milkshed Configuration Under Prices Which Differ With Transportation Costs From A Surplus Area

The transportation cost-minimization approach to product allocation among markets ensures that there is an equilibrium reached between supply and demand among markets, as well as ensuring that it is attained through minimizing the transportation costs. This is detailed in Bressler and King (7) and shows that product movements can be optimized without reference to product prices.

Linear Programming Theory

Linear programming is a planning tool that deals with the problem of allocating limited resources among competing activities in an optimal way. It is ideally suited for solution by computer algorithms, and as such has contributed substantially to operations research efforts in recent years. Generally speaking, the goal is to maximize or minimize an objective function subject to a set of linear constraints. The objective function for this research project is the total of transportation costs, so minimization will be used. Expressing the concept in mathematical terms, the objective is to minimize the objective function

$$Z = C_j x_j$$

subject to the set of linear restrictions

$$a_{ij} x_j \leq b_i$$

and

$$x_i \geq 0, \ i = 1,2,\ldots, m \text{ and } j = 1,2,\ldots,n$$

Z in the above formulation represents total cost; C_j are the unit costs of each of the decision variables; x_j are the decision variables; a_{ij} are the amounts of resource i used by activity x_j; and b_i is the total amount of resource i that is available (1,18).

This means that the levels of the decision variables, x_i, are to be found such that the cost of producing them is minimized, while at the same time the sum of the total resources used to produce at these levels cannot exceed the available amounts. The levels of the decision variables must be non-negative.

Four assumptions must hold for a linear programming model to be effective. The first of these is proportionality. Each decision variable x_i has a unit cost associated with it that is the same for all levels taken on by x_i. There are no start-up costs, for example, or cost increases or decreases as levels of x_i change. Resource use, too, is proportional as levels of x_i change. In short, this simply says that the relationships between activities and resources are linear. Additivity is a second assumption. There are no interaction terms among decision variables. In other words, total use of resources and total costs are equal to the sum of the individual uses and costs. Divisibility is the third assumption that must hold. Resources and activity levels must have the capability of being divided into any fractional levels. The fourth assumption is certainty: costs, resource use, and constraint values are known with certainty.

The problem in this research project was put into a generalized linear programming framework and a corresponding computer algorithm was used for its solution. With some modifications it could have been set into a transportation framework as long as transshipment was added to augment the routing decisions. Had that been done, however, the methods used to aggregate groups of activity levels into rows in order that situation statistics would be available through non-constraint row levels could not have been used. It was also desirable to maintain the flexibility associated with the linear programming framework in order to make later modifications possible if they did not fit within the transportation framework.

Statistical Theory

Basic statistical theory was used in several different contexts throughout the analysis. The study employed standard tests of hypothesis, tests for normality of various distributions, Bartlett's test for homogeneity of variance, and sampling theory. The specific techniques used are discussed as they occur, except for standard tests of hypothesis. The theory behind testing means and variances of two populations is standard, and can be found in many elementary statistics textbooks.

CHAPTER III

DATA, PROCEDURES, AND MODEL

Design

The framework for the research was designed to compare the marketing of milk as it was carried out in 1978 through coordination with how it would have been accomplished by local cooperatives. Additionally, the marketing of milk in 1968, the last year before the formation of AMPI, was studied as it was essentially under local cooperative organization and compared with how it would have been under central coordination. Local markets and milk sheds as they existed in 1968 were defined, and assembly centers and processing plants were located as they were then. Changes in the markets between 1968 and 1978 were determined and built into the model. These changes occurred in numbers and distribution of first-level handlers as well as in location and size of manufacturing facilities. Market changes due to the type of organization, local cooperative organization and central coordination, were also assessed and included. Supply and demand relationships were built, and variability was estimated by market for 1968 and 1978 and put into the model. It was also decided to include seasonal detail in the analysis, so October and May were chosen and maintained as separate situations. These two months represented the yearly extremes in seasonality as October saw demand at its highest relative to supply, and in May it was at its lowest relative to supply.

All of these effects were combined and used with a simulator that subjected the model to random supply and demand shifts in order to obtain a distribution over time for each of the quantitative performance measures that were taken. Under each of the types of organizations for each of the two years, fluid milk was moved from the producers to the first-level handlers, and surplus milk was transported to the processing plants according to movement rules particular to the type or organization. Performance measures were studied and conclusions were drawn about the relative efficiencies of a coordinated marketing system and an uncoordinated system.

In summary, the general plan was to perform the following functions for the October and May situations for both 1968 and 1978:

1. generate a simulated level of demand by region according to developed procedures,
2. generate a simulated level of supply by region according to developed procedures,
3. adjust supplies and demands at the county levels to reflect the simulated regional values,
4. set up the permissable milk movements for local cooperative organization and for central coordination,
5. employ a linear programming algorithm to determine the least cost solution for satisfying demand and processing surplus milk under both scenarios,
6. store and analyze key quantities and costs.

These steps comprised one run of the simulator, and 20 simulation runs were made for each of the eight situations. This yielded 20 sets of key costs and quantities that would permit estimation of an average and standard deviation for each of the particular values involved under the particular situation. Comparison of these averages and standard deviations provided information as to the relative effectiveness of the two scenarios in the different time periods and months.

The Data

Several sources of data provided the information necessary to build the framework of the research project. There were three sets of data basic to the model which were used to establish a demand level, a supply level and a set of distances used in the transportation portion of the model. In addition there were auxiliary data coming from federal order statistics, from records maintained by AMPI, and from the Market Administrators of several federal orders (2,13). The generosity of the Market Administrators in providing data for this project is greatly appreciated. These auxiliary data made possible the valid representation of local cooperative organization and also a reconstruction that approximated the processing plants as they existed in 1968. Through the auxiliary data it was possible to simulate average supply conditions, and to link all information by state and county, by federal order, and by geographic area. All data were aggregated by county in order to preserve the integrity of the individual handler and producer data, and all milk movements within the model were set up to occur from county seat to county seat.

The first basic data set was daily sales to plants by AMPI for the Southern Region for October of 1977 and May of 1978. The data were detailed by firm which made it possible to analyze sales variability by weekday, by season, by market and by other categorizations of firms. These data were combined with state and county codes to pinpoint location, and were used to build the demand framework in the linear programming matrices and in the simulator.

The second set of basic data was daily producer deliveries to AMPI for the same two periods as the sales data. For the model it was aggregated by county and used to construct the supply structure for the model. The resulting county supply levels were used in the linear programming matrix and in the simulator.

The third set of data was a distance matrix. Data here were Great Arc distances (based on longitude and latitude locations) from county seat to county seat for all counties and states in the Southern Region. These data underwent two transformations before they were used in the model. First the distances were translated into road mileages by multiplying the Great Arc distances by the factor 1.138. Charles Deason (12) of AMPI, Inc. provided this constant on the basis of a study he performed which compared for a sample set of data the Great Arc distances with road distances. Second, a subset of the matrix was created which held only the distances which were thought to be needed in the model. This was done to decrease the cost of accessing the distance matrix. The distances were used only in the matrix generator part of the model and were converted into costs of shipping milk by assuming a unit cost of $0.30 per hundredweight per one hundred miles. This cost figure is based upon average shipping costs incurred by AMPI for moving milk in the Southern Region during the latter part of the 1970's.

Some important auxiliary data used in the model came from a USDA publication, <u>Sources of Milk For Federal Order Markets in 1967</u> (40).

This publication showed for each county where and in what quantities its milk was marketed under a Federal Order in 1967. The data reflected the milksheds as they occurred in 1967 under the local cooperative organization. It detailed by county and federal order the numbers of producers that marketed their milk to that federal order. Since the South Texas federal order area was not in existence until 1968, it did not appear explicitly in the data. Flows to the South Texas federal order area were developed by considering flows in the 1968 period and splicing them in with the 1967 data to approximate flows to South Texas in 1967.

Two sets of data were input to the simulator in the model. The first of these specified an approximation of the numbers and sizes of processing firms comprising AMPI sales as they existed in 1968 prior to the merger. These data were built using Market Administrator information on numbers and sizes of firms by federal order areas in 1968 and 1978 in combination with numbers and sizes of firms comprising the 1978 AMPI sales to plants (2,13). These were used to build variability into the demand.

The second set of data used directly by the simulator was average AMPI producer deliveries by area for the years 1971 through 1975. These quantities provided average supply levels as well as standard deviations, and specified the parameters within which supply could vary. Miscellaneous groups of auxiliary data helped connect operations in the simulator and enabled classification by various characteristics. State and county codes used throughout the model were those set up by the National Bureau of Standards in 1973 and are referred to as "FIPS" codes (41). Official federal order codes were used to identify individual marketing areas, and these came from federal order statistics (38). All demand and supply locations were categorized not only by state and county code, but also by federal order number. Shipping constraints associated with local cooperative organization were entered in terms of state and county codes and federal order numbers.

One last group of data needed for the simulation portion of the model included uniform random numbers and normally distributed random numbers with various means and standard deviations. Computer routines from the Statistical Analysis System (17) were used to generate uniform numbers and normal deviates with a mean of zero and a standard deviation of one. The random normal draws were converted to the particular distribution by multiplying them by the standard deviation and adding them to the mean.

The preceding section specifies the external information used in obtaining the results of the research project. It presents a detailed description of the data, and states the sources from which the data come. The discussion below details the procedures set up to answer the questons and meet the objectives of the project.

Procedure Implementation

Demand Structure 1968

The most complicated design in the system involved the 1968 market structure, and methodology for creating this environment was developed first. The two dimensions to the structure were geographical market definitions and structure, size and definition of the fluid handlers.

Market Definitions

In 1968 and prior to the merger, independent market areas were operating primarily on the basis of the federal order definitions. Each federal order area had a local cooperative that assumed marketing responsibilities in that area. These areas were the core of the local cooperative organization marketing structure and as such come to be an integral part of the model. They were also logical areas to consider for ascertaining demand variability, and it was possible to obtain needed statistics on federal order areas. The demand variability in each area would have been handled by the local cooperative for that area, so it was decided to let these market areas serve as the localized demand areas in the model. Figure 9 outlines the geographical markets as defined in the model; they are the federal order areas existing in 1968 (38).

Four local market areas were also defined in order to simulate more accurately the actual milk flows under local cooperative organization. These were: Linn, Kansas; Mangum, Oklahoma; Tulsa, Oklahoma; and Enid, Oklahoma. For each of these small local markets there was a manufacturing demand level set up to reflect use of these facilities, and it was to be filled from neighboring counties. Under central coordination they would be used only as the least cost solution might dictate.

Firm Structure of Fluid Processors

Size Category Derivation. Once these geographical areas were delineated, a way was needed to estimate the number of firms that existed

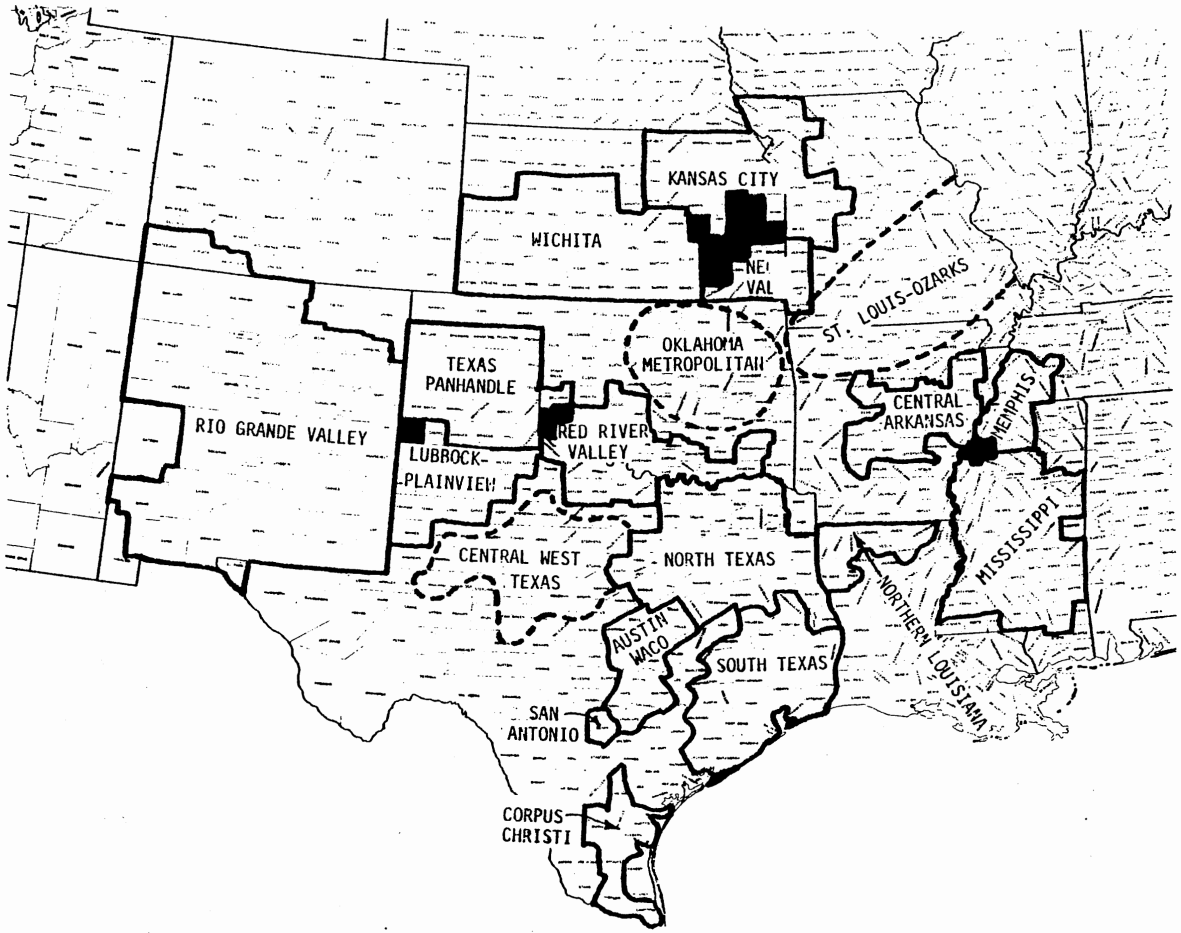


Figure 9. Selected Federal Order Milk Marketing Areas, January, 1969

in 1968. Since individual firm data are not published or available, it was decided to specify the firm structure not through individual firm data, but through groups of firms categorized by size. Comparing 1978 with 1968, there was a steady decrease in total firm numbers and a move toward more larger firms and fewer smaller firms. This reflects a growing ability on the part of processors to adjust to economies of size gained through technological advancements in the last few decades. Size category definitions were determined according to three objectives:

1. to have enough categories so that the data would be spread across a range wide enough to provide some detail as to the distribution of the firms,
2. to have few enough categories to avoid exposing individual firm data,
3. to be consistent where possible with one or more of the size categorization groupings of other authors.

Some data and analysis on numbers of fluid milk processors have been published. Manchester (24) has published a breakdown by federal order area of the number of pool and non-pool fluid milk processors existing in that area. The years included in this data series ranged from 1950 to 1965 and provided a reference for total numbers of firms by federal order area. In a later report, Manchester presented total numbers of fluid milk processing plants on a national basis for the years 1948-1971 (25). These figures were updated through 1977 by Cook (11) and can be obtained through 1979 from unpublished records referred to by Manchester.

Firm level data have been reported by firm size categories, where each category represents a range of volumes. This effectively masks individual contributions while at the same time allows information to be provided in more detail than total figures permit. Parker (28) has worked with numbers of processing firms on a national basis for the years 1950, 1961, 1965, and 1971, and he has categorized them into four size groups. These estimates are shown in Table III, along with figures derived by other researchers in the area. The estimates are shown in original units and also are converted to million lbs. per month to permit comparisons. Conversions were performed using 21.67 processing days per month; 8.6 lbs./gallon was used to convert from gallons to pounds. Parker's size groups were expressed in terms of quarts processed per day, and he assumed there are 260 processing days per year. Manchester (24) set up eleven size groups to describe his work and included national numbers of processing firms, for the years 1965 and 1970. He expressed his volume figures in terms of million pounds per month. His groups showed how the national numbers of processing firms changed between 1965 and 1970 and also how the firm size distribution changed. Mueller (26) defined six size categories for the years 1971 and 1975 and used volume figures in terms of million gallons annually to set his size categories.

The relative size categories derived by each of the authors mentioned above are shown along with those of this study in Figure 10. The size categories chosen for use here fit Mueller and Manchester better than they fit Parker. The attempt made here to standardize size categories may allow further research to combine information from several sources.

TABLE III

FLUID MILK PROCESSOR PLANT SIZE CATEGORIES
FROM SELECTED STUDIES

Single Group	Parker		Manchester	Mueller		This Study
	Original Units 1,000qts/day	Equivalent Units million lbs/month	Original Units million lbs/month	Original Units million gal/year	Equivalent Units million lbs/month	Units million lbs/month
1	< 4.0	<.2[a]	<.1	<.1	<.1[b]	<.1
2	4.0-20.0	0.2-0.9	.1 < .5	.1 < .3	.1 < .2	.1 < .2
3	20.1-40.0	0.9-1.9	.5 < 1.0	.3 < 1.5	.2 < 1.1	.2 < 1.0
4	40.1 and over	>1.9	1.0 < 2.0	1.5 < 5.0	1.1 < 3.6	1.0 < 2.0
5			2.0 < 3.0	5.0 < 15.0	3.6 < 10.8	2.0 < 4.0
6			3.0 < 4.0	15.0 and over	10.8 and over	4.0 < 7.0
7			4.0 < 5.0			7.0 < 12.0
8			5.0 < 10.0			12.0 < 24.0
9			10.0 < 15.0			24.0 and over
10			15.0 < 20.0			
11			20.0 < 30.0			
12			30 and over			

[a] actual figure .186
[b] actual figure .072

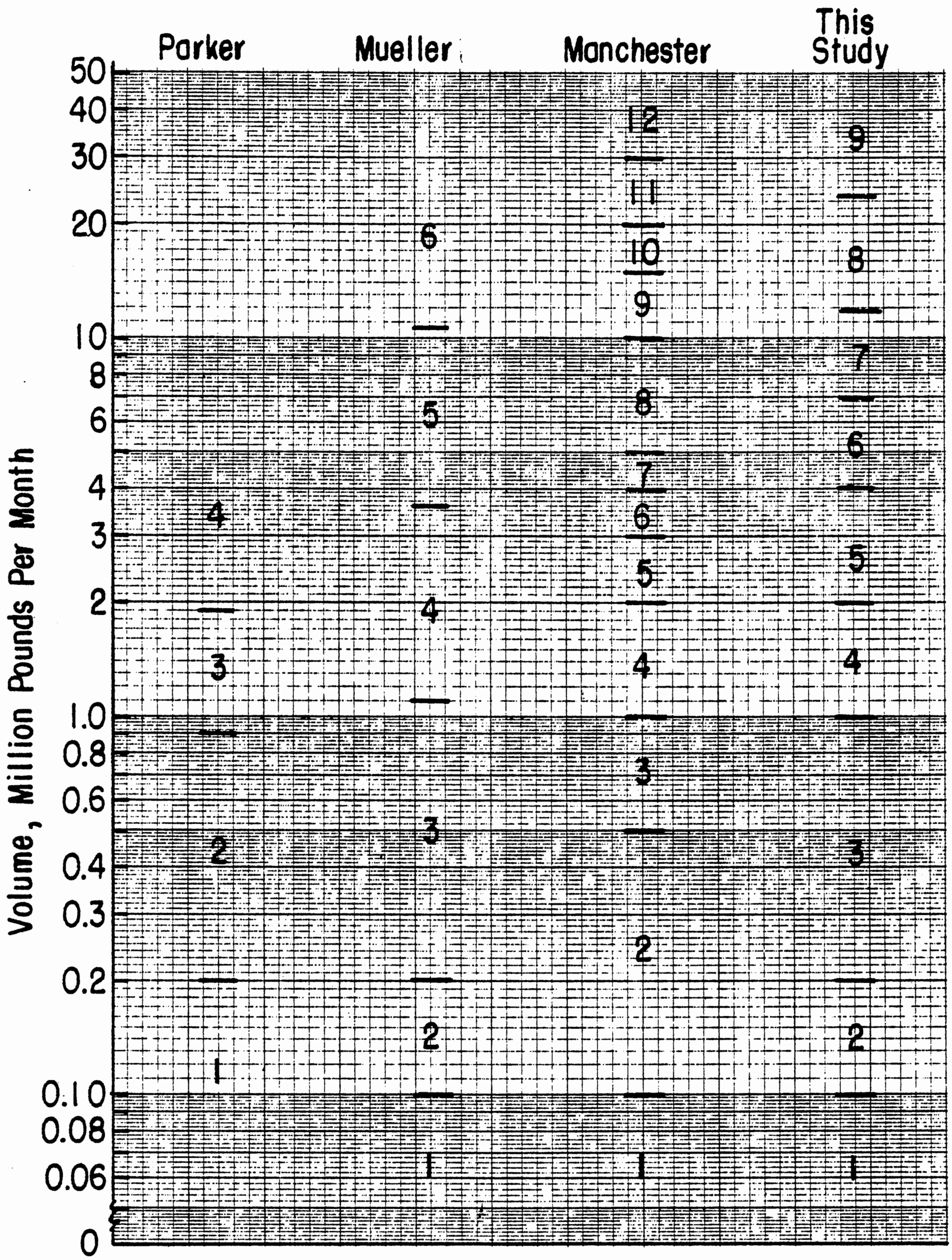


Figure 10. Fluid Milk Processing Plant Size Categories from Selected Studies. Number Size Category For the Range In Volume

<u>Estimate of Distribution</u>. The next step in preparing to model the 1968 demand structure was to estimate the numbers of firms by size category serviced by AMPI. Market Administrator data were obtained giving the number of firms by size category and by federal order area for 1969 and 1978. The 1969 structure was assumed to be about the same as the pre-merger structure effective in 1968. These data included all pool handlers and reflected size based on December volumes. The Market Administrator data are shown for selected markets in aggregate form in Table IV. The 1978 AMPI sales data were categorized by size category. Since actual firm sizes were not available, they were categorized on the basis of the larger of the total quantities of milk they took in October or May. The categorization of the 1978 AMPI data was shown in aggregate form for selected markets in Table V. The 1978 AMPI firm distribution, the 1978 Market Administrator data and the 1968 Market Administrator data provided the necessary information for estimating the 1968 AMPI demand by numbers of firms and size categories.

Estimation of numbers of sizes of firms was done in two steps. First the Market Administrator data were used to compute the ratio of the 1978 firm numbers to the 1969 firm numbers for each size group within each market area. Then, where possible, these ratios were used to estimate 1969 AMPI firm numbers from actual 1978 firm numbers for each size category and market. Several problems arose during this procedure.

The procedural problems encountered stemmed from several sources. One problem came from spot markets. Many firms did not take full supply from AMPI, so these firms may have been categorized into smaller size groups than they actually were. Also, firms having more than one

TABLE IV

FIRM NUMBERS BY SIZE, SELECTED MARKETS, 1969 AND 1978

	Firm Size Code								
	1	2	3	4	5	6	7	8	Total
Texas									
1969									
N. Texas					7	5			16
S. Texas			5						14
Corpus Christi					3				7
Central W. Texas									4
Austin-Waco									3
San Antonio						3			9
Total	a	a	9	7	15	12	5	a	53
1978									
Total	a	a	a	6	7	12	6	4	36
Oklahoma-Kansas									
1969									
Okla. Metropolitan					4	6			11
Wichita	3	4							13
Neosho Valley									5
Red River					3				6
Total	4	5	5	3	11	7	a	a	35
1978									
Okla. Metropolitan					3		4		9
Wichita									8
Neosho Valley									4
Red River									3
Total	3	a	4	3	5	3	4	a	24
Rio Grande Valley									
1969									
Rio Grande		4	7	3	5				20
1978									
Rio Grande	a	a	a	a	4	3	a	a	12

a) Includes 0, 1 or 2 firms

TABLE V

FIRM NUMBERS BY SIZE BASED ON AMPI SOUTHERN REGION SALES, SELECTED MARKETS, 1969 AND 1978

	Firm Size Code								
	1	2	3	4	5	6	7	8	Total
Texas									
1969									
N. Texas			6		7	3			23
S. Texas									9
Corpus Christi				3					8
Central W. Texas					4				5
Austin-Waco									2
San Antonio									8
Total	2	3	12	8	17	7	4	2	55
1978									
N. Texas			4		3	4	3		18
S. Texas									6
Corpus Christi				3					6
Central W. Texas									3
Austin-Waco									2
San Antonio									5
Total	0	3	6	7	8	7	5	3	39
Oklahoma-Kansas									
1969									
Okla. Metropolitan						8			13
Wichita						4			13
Neosho Valley									5
Red River									4
Total	5	3	4	4	6	12	1	0	35
1978									
Okla. Metropolitan						3	3		10
Wichita									8
Neosho Valley									4
Red River									2
Total	3	0	4	4	3	5	5	0	24
Rio Grande Valley									
1969									
Rio Grande	a	3	6	4	3	a	a	0	17
1978									
Rio Grande	a	a	a	a	3	a	a	0	10

plant location have been listed by AMPI as more than one firm, whereas Market Administrator data combined them as one firm. Further size distortions could have been caused by a firm overordering one day and underordering at a later date. Sometimes firms were categorized into size categories due to some of these factors when Market Administrator data showed no firms in that category. Judgement was used to modify estimates when the ratios did not give results which appeared logical. For example, zero entries in some 1978 size categories represented problems. An example can be seen in the Oklahoma Metropolitan Area. The AMPI 1978 data showed three firms in category six. The corresponding slot for the Market Administrator data has less than three, while in 1968 it had six firms. The method of proportion failed here, and judgement was used to estimate that eight firms were in size category six in 1969 for AMPI. In refining estimates an effort was made to maintain integrity of total firm numbers as well as proportions where possible, while conforming to numbers of firms known from experience.

An additional problem arose in terms of geographical compatibility, because all the Texas orders were combined into one order in 1974. The Market Administrator data in 1978 therefore reflected the total Texas order, instead of the separate orders that existed in Texas in 1969. This was handled by breaking the 1978 totals for Texas into the same proportions that existed among the Texas orders in 1969, and using those figures for the individual federal order figures.

The estimate of firm numbers comprising the AMPI demand in 1969 are shown in Table V. They exhibit the same tendencies over time as do the Market Administrator data: firm numbers in general decrease for 1969 to 1978, although the numbers of larger firms increase. These estimates represent the aggregate of the individual estimates that were used in this study; individual figures are not published.

Firm Structure-Manufacturing Plants. The last element needed to specify the 1968 market structure was the manufacturing plant configuration. Manufacturing facilities would have changed between 1968 and 1978 in one manner under local cooperative operation and changed in an entirely different way under central coordination. For the model under local cooperative organization, manufacturing plants would have undergone some natural attrition as some plants exited from the industry, and this was reflected between 1968 and 1978 in the model. Under central coordination the number of manufacturing plants changed from sixteen to five between 1968 and 1978 as AMPI phased out uneconomical facilities, and increased to six as AMPI built one new plant. The information concerning these plants and locations was estimated by Stellmacher (34), and is shown in Table VI.

Demand Structure 1978

The geographical market areas in 1978 were set up in the same manner as for 1968. The numbers and sizes of firms were determined by AMPI sales data using the same process as for 1968. The manufacturing plant locations along with capacities are as shown in Table VI.

Demand Variability

The aspect of demand equal in importance to quantity is variability. Satisfaction of handler demand would be straightforward if the same quantities were demanded from day to day and from month to month,

TABLE VI

MANUFACTURING PLANT LOCATIONS AND CAPACITIES
UNDER LOCAL COOPERATIVE ORGANIZATION
AND CENTRAL COORDINATION
1968 AND 1978

	Capacity			
	Local Cooperative Organization		Central Coordination	
	1968	1978	1968	1978
	(mil. lbs.)			
Linn, KS	7.6	7.6	7.6	-
Hillsboro, KS	13.8	13.8	13.8	28.3
Ark. City, KS	6.47	-	6.47	-
Wichita Falls, TX	1.342	1.342	1.342	-
Oklahoma City, OK	19.4	19.4	19.4	16.0
LaGrange, TX	1.175	-	1.175	-
Muenster, TX	18.4	18.4	18.	27.2
Fort Worth, TX	.583	-	.583	-
Sulphur Springs, TX	16.0	16.0	16.0	21.5
Jacksonville, TX	1.309	-	1.309	-
Round Rock, TX	.267	-	.267	-
Ballinger, TX	.305	.305	.305	-
San Antonio, TX	8.2	8.2	8.2	-
El Paso, TX	-	-	-	11.5
Enid, OK	4.025	4.025	4.025	-
Mangum, OK	2.916	2.916	2.916	-
Tulsa, OK	12.6	12.6	12.6	14.1

for any given location. Demand would be known with certainty and flexibility in meeting it would be unnecessary. Neither local cooperative organization nor central coordination would hold an advantage over the other in ability to meet demand.

Sources of Variability

There is substantial variability in demand by processing firms. The variability stems from several sources, one of which is the variation in consumer purchases. Handlers typically adjust processing schedules to meet consumption patterns in the individual markets. For example, certain areas have large demands on Saturdays as household shoppers make their weekly grocery purchases. In that event the handlers in this area might load demand on Thursdays and Fridays as they process in order to meet their own high demands on Saturday. Day to day variation is also present as handlers decrease the number of processing days they have during a week. A trend towards fewer processing days has been in progress, which increases the day-to-day variability in demand at the first handler level.

Another source of demand variability lies in the seasonal consumption patterns of the population. October has been a traditionally high consumption period, as school lunch programs are underway and people settle into fall and winter schedules. The vacation period ends for most of the population, and more milk is consumed as families resume routine schedules.

Still a third source of variability in demand is geographical rather than temporal. Different areas are characterized by differing consumption patterns and by different processing patterns by handlers.

This leads to peaks and valleys in handler demands that do not necessarily move together over a geographical region.

Variability is also affected differently by different sizes of firms. Firm behavior reflects different processing patterns. Smaller firms have less ability to buffer changes in the demands that they face than do larger firms.

Firms also display different purchasing patterns. Some purchase virtually all of their milk supply through AMPI, whereas other firms, referred to as spot markets, rely on other sources of milk for most of their needs and purchase from AMPI only in a more sporadic fashion. Variability in AMPI sales is affected differently through these two types of purchasing patterns.

It is helpful to visualize how variability actually appears in sales. Figures 11 and 12 show average May deliveries for each day of the week for the Oklahoma City Market and for the Dallas-Ft. Worth area. The average levels in the Oklahoma City area range from 978,000 lbs. on Friday to 1,115,000 lbs. on Wednesday, an increase of 14 percent from low to high. The variability around these means is at a minimum on Thursday with a standard deviation of 32,000 lbs., and peaks on Fridays with a standard deviation of 130,000 lbs. Assuming for illustrative purposes that the sales here are distributed normally, it can be said that approximately 95 percent of the variation is included within two standard deviations taken on either side of the mean. In the extreme limits, then, this would lie in a range bounded for the week by 718,000 lbs. on the lower end and 1,295,000 on the high end. That represents an 80.4 percent increase between the extremes in a relatively stable market.

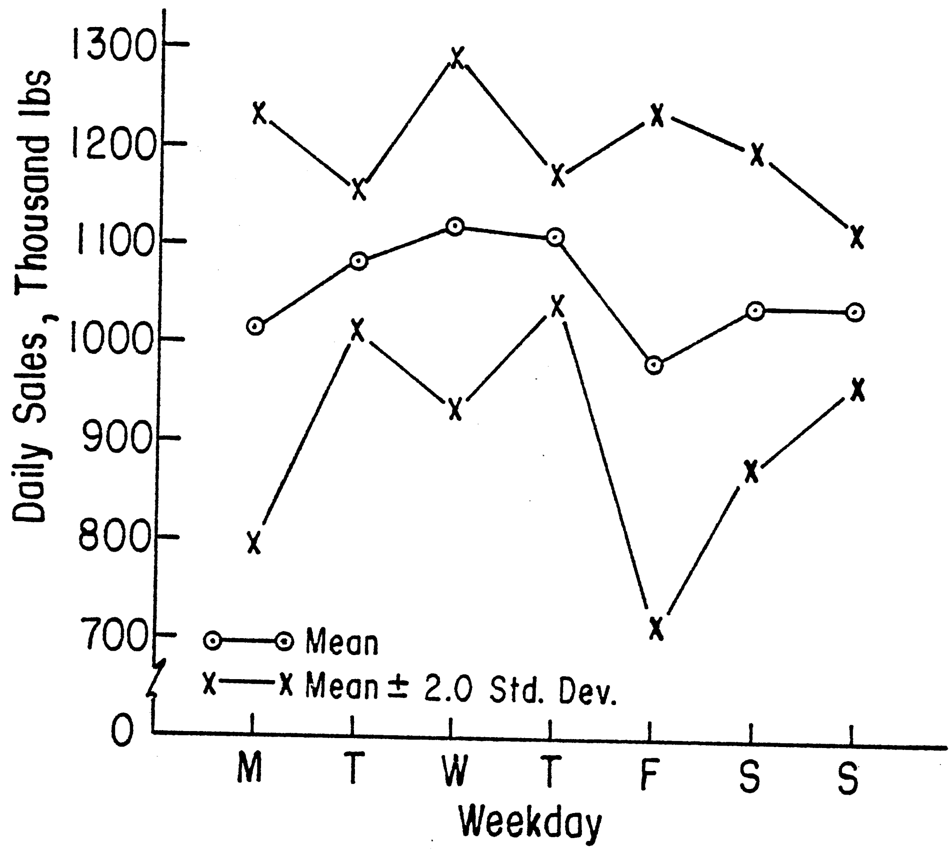


Figure 11. Variability of AMPI Southern Region Daily Sales to Plants, Oklahoma City Market, May, 1978

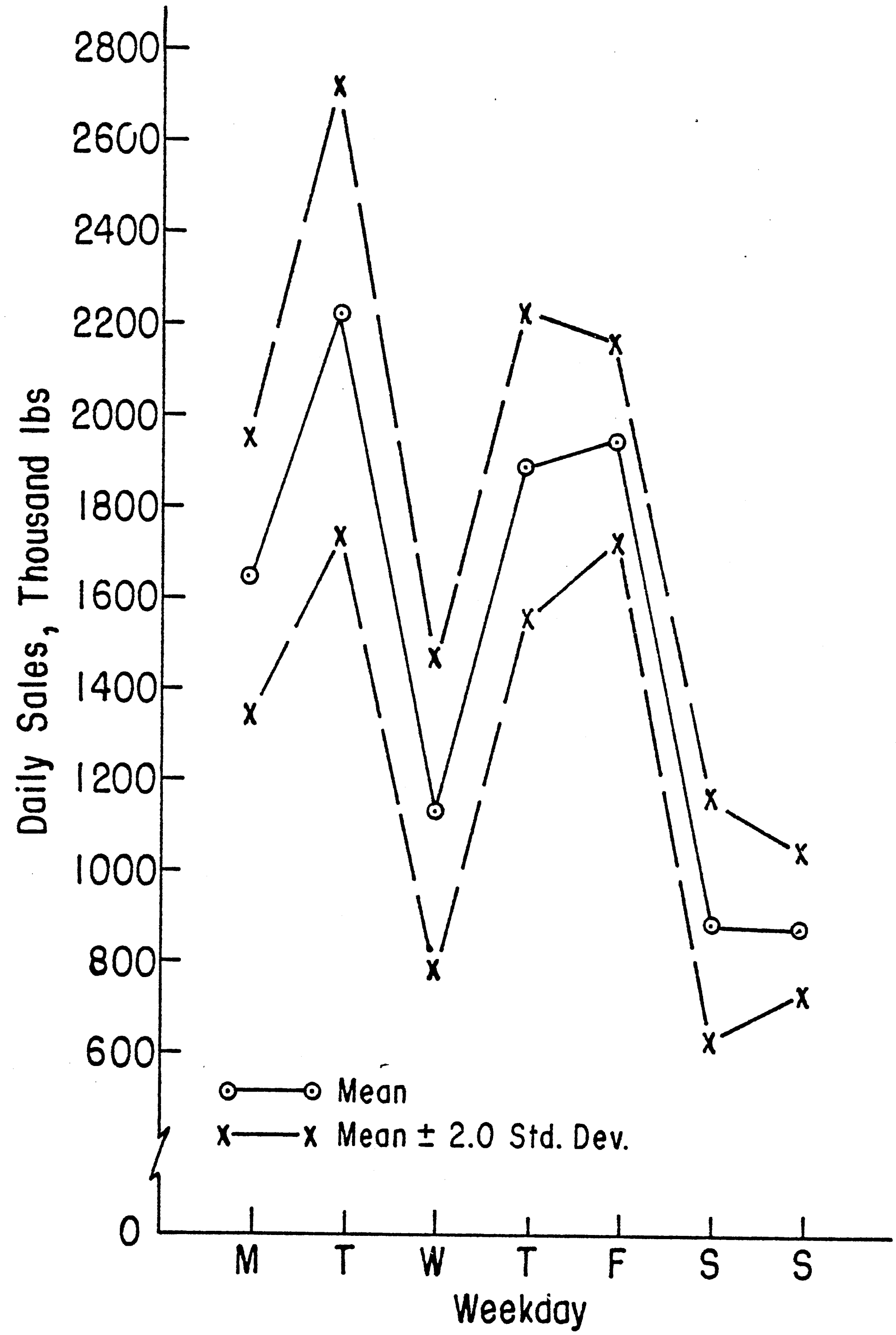


Figure 12. Variability of AMPI Southern Region Daily Sales to Plants, Dallas-Fort Worth Market, May, 1978

The Dallas-Ft. Worth market shows considerably more variability than the Oklahoma City market. The average levels throughout the week range from a Sunday low of 892,000 lbs. to a Tuesday high of 2,226,000 lbs. - an increase of 150 percent from low to high as compared with 14 percent in the Oklahoma City market. The extremes encompassing 95 percent of the variability for the week would be 619,000 lbs. and 2,718,000 lbs. Looking at these figures in an alternative fashion, the demand level at the lower extreme would require fifteen truckloads of milk per day to fill; the upper figure about sixty-eight truckloads. Ability to work with ranges such as this requires substantial flexibility in the available supply.

Analysis of Variability

Building an approximation of variability required a detailed analysis of the relationships in the 1978 demand data. The following section provides the results of this analysis and gives some insights into the behavior of different markets and different size groups. The data presented here represent the total Class I fluid milk sales by AMPI to processing firms in the Southern Region during October 1977 and May 1978. Table VII tabulâtes the daily data by month for the entire region. The range in total sales is from 8.255 million pounds to 13.539 million pounds in October, and from .592 to 12.542 million pounds in May. The average coefficient of variation is 97 for October and 90 for May, indicating that on the average there is more variability in October. The number of firms taking delivery varies in October from 64 to 86, and in May from 60 to 81. This wide range in numbers of firms from day to day is the main cause of the total variation in the Southern Region.

TABLE VII

AMPI SOUTHERN REGION DAILY DELIVERIES TO PLANTS SOUTHERN REGION, OCTOBER, 1977 AND MAY, 1978

	October					May				
Day	Total Deliveries	Std. Dev.	CV	N	Day Of Week	Total Deliveries	Std. Dev.	CV	N	Day Of Week
	(1,000 lbs.)					(1,000 lbs.)				
1	9,480	129	96	70	Sa	11,193	111	79	80	M
2	9,086	124	95	70	Su	12,541	147	95	81	Tu
3	13,169	149	96	85	M	10,450	124	83	70	W
4	12,244	147	94	78	Tu	12,463	135	85	79	Th
5	11,716	160	101	74	W	11,458	156	97	71	F
6	12,039	136	90	80	Th	8,634	139	97	60	Sa
7	12,305	160	103	79	F	592	118	90	63	Su
8	9,976	157	104	66	Sa	636	127	83	76	M
9	9,139	122	94	70	Su	12,526	170	102	75	Tu
10	13,539	149	94	85	M	10,730	130	84	69	W
11	12,346	158	104	81	Tu	12,188	140	86	75	Th
12	10,937	150	100	73	W	10,870	131	86	71	F
13	12,453	156	100	80	Th	8,345	118	89	63	Sa
14	11,372	152	101	76	F	8,217	120	90	62	Su
15	8,434	130	102	66	Sa	10,796	125	86	74	M
16	9,736	142	99	68	Su	12,028	148	95	77	Tu
17	12,215	140	90	79	M	10,272	138	90	67	W
18	12,352	161	107	82	Tu	11,554	136	89	76	Th
19	11,072	145	105	80	W	10,450	134	93	72	F
20	12,342	141	89	78	Th	8,238	125	93	61	Sa
21	11,036	144	98	75	F	7,889	117	89	70	Su
22	8,255	121	94	64	Sa	10,833	126	88	76	M
23	8,870	121	94	69	Su	11,450	142	95	77	Tu
24	11,708	119	77	76	M	10,151	142	99	71	W
25	12,379	151	101	83	Tu	11,280	126	88	79	Th
26	11,461	159	101	73	W	10,343	136	90	68	F
27	12,330	148	98	82	Th	7,719	120	95	61	Sa
28	11,747	134	88	78	F	8,042	108	85	63	Su
29	9,131	131	92	64	Sa	9,300	117	90	72	M
30	9,314	130	94	67	Su	10,600	141	97	73	Tu
31	12,360	140	98	86	M	9,104	125	96	70	W

Although many of the firms take all of their Class I milk from AMPI, there are also substantial numbers that take milk only when they cannot obtain it elsewhere. Since the behavior of these two groups is different, the firms have been designated as standard markets and spot markets, respectively. A standard market is a processing firm that takes delivery from AMPI 17 or more days a month; spot markets take delivery on fewer than 17 days. The 17 day break was chosen because a market that has a four, five, six or seven processing day week would have at least 17 days of delivery during these months.

The number of firms included in this study are broken down in Table VIII by size, type of market and month. As would be expected there are more firms taking delivery in October when fluid milk is in short supply than in May when it is abundant and more supply alternatives are available. It should be mentioned that the set of firms taking delivery in May does not on a one-to-one basis also take delivery in October. Firms may take delivery only in October, or only in May, or in both months. The net effect of the changes in numbers of firms is approximately a ten percent increase in total numbers from May to October. Furthermore all firms do not take deliveries every day. It can be seen from Table VII that in October an average of 75 firms out of 107 possible take deliveries on any given day, and in May an average of 71 firms out of a possible 97 take deliveries on any day. Much of this is due to the spot markets, of which there are 27 in October and 23 in May.

The individual firms shown in Table VIII appear to behave somewhat differently according to their size designation. The two largest categories remain constant in numbers between May and October, exhibiting a

TABLE VIII

NUMBER OF PROCESSING FIRMS BY SIZE AND MARKET CLASSIFICATION BASED ON AMPI SOUTHERN REGION SALES, OCTOBER, 1977 AND MAY, 1978

	October, 1977									May, 1978								
	Firm Size Code									Firm Size Code								
	1	2	3	4	5	6	7	8	Total	1	2	3	4	5	6	7	8	Total
Spot Markets																		
No. of Processors	9	6	8	1	3	0	0	0	27	5	6	9	0	2	1	0	0	23
Standard Markets																		
No. of Processors	0	1	8	16	21	18	12	4	80	3	0	3	15	20	17	12	4	74
All Markets																		
No. of Processors	9	7	16	17	24	18	12	4	107	8	6	12	15	22	18	12	4	97

stability that is not true in the other categories. There are no spot markets at this volume. Size group six has the same total number of firms in October and May, but in May one of the firms is a spot market. Looking at the remaining five categories in decreasing order of size shows there are definitely fewer firms taking deliveries in May than in October. The number of spot markets in these categories increases in October, indicating firms will buy from AMPI in times of short supply when they might not under other circumstances. Furthermore, the number of spot markets in these five categories exhibits a tendency to increase as firm size decreases. This would be expected if firms are filling out needs not quite met by their major suppliers by purchasing the remainder from AMPI.

Tables IX and X present the daily deliveries for the Southern Region by month and by type of market. The total deliveries for spot markets exhibit a much wider range than do those for the standard markets. October is characterized by a range of .036 million pounds delivered to four firms and 1.119 million pounds delivered to 13 firms; May has a low of .018 million pounds delivered to two firms and a high of .618 million pounds delivered to 10 firms. Standard markets range from 7.993 to 12.412 million pounds in October and from 7.509 to 12.152 million pounds in May. The average number of spot markets is eight in October and six in May; for standard markets the average is 68 in October and 65 in May. The coefficients of variation show that the variability in standard markets is less in May with an average of 86 than in October where the average is 92. For spot markets the variability is also greater in October with an average standard deviation of 89 compared with 84 in May.

TABLE IX

AMPI SOUTHERN REGION DAILY DELIVERIES
TO PLANTS BY MARKET CLASSIFICATION,
OCTOBER, 1977

	Spot Markets					Standard Markets				
Day	Total Deliveries	Std. Dev.	CV	N	Day Of Week	Total Deliveries	Std. Dev.	CV	N	Day Of Week
	(1,000 lbs.)					(1,000 lbs.)				
1	439	39	63	7	Sa	9,042	133	93	63	Sa
2	243	42	103	6	Su	8,843	126	91	64	Su
3	921	89	106	11	M	12,248	154	93	71	M
4	341	57	116	7	Tu	11,903	149	89	71	Tu
5	305	39	104	8	W	11,411	163	94	66	W
6	607	68	100	9	Th	11,432	139	87	71	Th
7	469	37	80	10	F	11,836	165	96	69	F
8	359	43	61	5	Sa	9,617	161	102	61	Sa
9	297	32	98	9	Su	8,842	124	86	61	Su
10	1,119	81	94	13	M	12,420	155	90	72	M
11	413	45	87	8	Tu	11,933	162	99	73	Tu
12	329	45	81	6	W	10,608	153	96	67	W
13	371	57	139	9	Th	12,083	158	93	71	Th
14	417	24	52	9	F	10,995	156	96	67	F
15	205	17	41	5	Sa	8,229	133	98	61	Sa
16	31	13	82	2	Su	9,705	143	97	66	Su
17	666	104	125	8	M	11,549	142	87	71	M
18	348	220	63	10	Tu	12,003	165	99	72	Tu
19	506	28	67	12	W	10,567	151	97	68	W
20	560	51	91	10	Th	11,783	144	83	68	Th
21	341	31	54	6	F	10,696	147	95	69	F
22	262	32	62	5	Sa	7,993	124	91	59	Sa
23	36	8	87	4	Su	8,835	120	89	65	Su
24	557	110	79	4	M	11,151	120	78	72	M
25	565	60	107	10	Tu	11,813	156	96	73	Tu
26	478	58	85	7	W	10,983	163	98	66	W
27	474	41	103	12	Th	1,856	151	89	70	Th
28	519	47	91	10	F	11,228	136	83	68	F
29	208	58	111	4	Sa	8,923	133	90	60	Sa
30	49	20	126	3	Su	9,265	131	90	64	Su
31	606	54	107	12	M	11,754	144	91	94	M

TABLE X

AMPI SOUTHERN REGION DAILY DELIVERIES
TO PLANTS BY MARKET CLASSIFICATION
MAY, 1978

	Spot Markets					Standard Markets				
Day	Total Deliveries	Std. Dev.	CV	N	Day Of Week	Total Deliveries	Std. Dev.	CV	N	Day Of Week
	(1,000 lbs.)					(1,000 lbs.)				
1	618	67	108	10	M	10,575	112	74	70	M
2	428	53	111	9	Tu	12,113	149	89	72	Tu
3	307	51	116	7	W	10,143	125	77	63	W
4	395	40	92	9	Th	12,068	136	79	70	Th
5	205	35	102	6	F	11,253	158	91	65	F
6	92	16	89	5	Sa	8,541	140	90	55	Sa
7	46	14	90	3	Su	8,282	118	86	60	Su
8	345	69	119	6	M	11,211	128	80	70	M
9	373	99	158	6	Tu	12,152	172	98	69	Tu
10	434	94	131	6	W	10,296	131	80	63	W
11	241	49	123	6	Th	11,947	140	81	69	Th
12	128	33	129	5	F	10,742	131	80	66	F
13	78	14	53	3	Sa	8,268	119	86	60	Sa
14	18	8	86	2	Su	8,199	119	87	60	Su
15	435	73	117	7	M	10,361	127	82	67	M
16	255	61	168	7	Tu	11,773	149	88	70	Tu
17	171	15	43	5	W	10,101	139	85	62	W
18	300	45	105	7	Th	11,254	137	84	69	Th
19	203	28	96	7	F	10,247	135	86	65	F
20	50	16	95	3	Sa	8,190	125	89	58	Sa
21	36	19	105	2	Su	7,852	117	86	58	Su
22	353	60	118	7	M	10,480	127	84	69	M
23	358	57	96	6	Tu	11,093	144	92	71	Tu
24	104	21	83	4	W	10,047	143	95	67	W
25	393	43	111	10	Th	10,887	127	81	69	Th
26	145	37	101	4	F	10,198	137	86	64	F
27	210	59	113	4	Sa	7,509	123	93	57	Sa
28	236	58	98	4	Su	7,806	109	83	59	Su
29	336	53	105	7	M	8,944	119	86	65	M
30	216	31	86	6	Tu	10,444	143	92	67	Tu
31	308	24	71	9	W	8,797	128	88	61	W

Initially it was decided to maintain separate months, separate markets, and eight size categories to preserve their contributions to variability. However, not enough data existed for spot markets and the markets were pooled.

The data were analyzed to determine whether or not the data should be pooled across days of the week. The analysis was accomplished through testing the hypothesis that the variances of k populations were equal. If they were, then the data could be pooled without losing contributions to variability. The variance was estimated using s^2. If two populations are being considered, e.g. if k=2, then the null hypothesis becomes H_0: $s_1{}^2 = s_2{}^2$, the two variances are estimated by $s_1{}^2$ and $s_2{}^2$, respectively, and the appropriate test statistic becomes the ratio of the variances, $F=s_1{}^2/s_2{}^2$. F is distributed according to the standard F-distribution which was originally developed by R. A. Fisher (16). If k is greater than two, however, a more general method must be used. Such a method has been proposed by Bartlett (3), who generated a statistic which is distributed as the χ^2 distribution and may be written as

$$\chi^2 = \frac{k}{1 + L}$$

with k-1 degrees of freedom, where

$$k = 2.3026\left[\left(\sum_{i=1}^{k} n_i\right) \log_{10} s_p{}^2 - \sum_{i=1}^{k} \left(n_i \log s_i{}^2\right)\right]$$

and

$$L = \frac{\sum_{i=1}^{k} \frac{1}{n_i} - \frac{1}{\sum_{i=1}^{k} n_i}}{3(k-1)}$$

where s_p^2 is the pooled variance estimate, n_i is the number of observations for the $_i$th population, and 2.3026 is a constant used to convert the common logarithm to the natural logarithm. This process is detailed in Statistics In Research by Bernard Ostle (27).

Bartlett's test statistic is large when H_0 should be rejected, as it is a one-tailed test, and has a value of 0 when all the sample variances are equal. Bartlett's test assumes that the k populations are normally distributed, and it is suggested that the k populations have four or more degrees of freedom. A modified Bartlett's test statistic is available (6), which is to be used for populations that are not normally distributed.

Tests were run on the data to determine whether they were normally distributed. If the number of observations is less than or equal to 50, the Shapiro-Wilk W-Statistic (2) was generated; if the sample size exceeds 50 the Kolmogorov-Smirnov D-Statistic was used. The null hypothesis would be rejected for small values of W, and would be rejected for large values of D.

In considering whether or not the AMPI sales data represented a normal distribution it was analyzed in two ways. When broken down by month and by day of week, but pooling size categories and type of market, most subgroups were found to be normally distributed at the .01 confidence level. It was then divided into size categories. Relative to a 15 percent confidence level several size categories were not normally distributed. A typical table showing these results for a Monday is shown in Table XI. Similar tables for Tuesday through Sunday are shown in the Appendix. A summary of test results is shown in Table XII, where "a" means the population was normal relative to a 15 percent

TABLE XI

SELECTED STATISTICS FOR TESTING DISTRIBUTION OF DAILY SALES BY AMPI SOUTHERN REGION, MONDAYS, OCTOBER, 1977 AND MAY, 1978

	Firm Size Code							
	1	2	3	4	5	6	7	8
				All Markets October, 1977				
N	8	12	44	74	106	90	57	20
D	-	-	-	.196	.169	.119	.060	-
W	.498	.866	.514	-	-	-	-	.905
Probability	.01	.06	.01	.01	.01	.01	.15	.05
				All Markets May, 1978				
N	7	9	20	61	106	88	60	20
D	-	-	-	.155	.138	.066	.107	.842
W	.881	.467	.854	-	-	-	-	-
Probability	.29*	.01	.01	.01	.01	.15	.09	.01

*Rejected at the .15 significance level

N is the number of observations; D is the Kolmogorov-Smirnov D-Statistic; W is the Shapiro-Wilk W-Statistic

TABLE XII

SUMMARY RESULTS OF NORMAL POPULATION TESTS, AMPI SOUTHERN REGION SALES, BY DAY OF WEEK AND FIRM SIZE, OCTOBER, 1977 AND MAY, 1978

Size	M	Tu	W	Th	F	Sa	Su
			October, 1977				
1	a	a	b	b	b	a	a
2	a	a	a	b	a	b	a
3	a	a	a	a	a	a	a
4	a	a	a	a	a	a	a
5	a	a	a	a	a	a	a
6	a	a	a	a	a	a	a
7	a	b	b	a	b	a	a
8	a	b	a	b	a	b	a
All	a	a	a	a	a	a	a
			May, 1978				
1	b	a	b	b	a	-	a
2	a	a	a	b	a	a	a
3	a	a	a	a	b	a	a
4	a	a	a	b	a	b	a
5	a	a	a	a	a	a	a
6	a	a	a	a	a	a	a
7	a	a	a	a	a	a	a
8	a	b	a	a	a	b	a
All	a	a	a	a	a	a	a

[a]Normally distributed at .15 significance level
[b]Rejected at the .15 significance level

confidence level, and "b" means it was rejected at the 15 percent significance level. It was decided on the basis of these tests to compute the modified Bartlett's statistic to allow for non-normality of populations.

Bartlett's test was run for each model to test the hypothesis that the variances across the days of the week for each size group were the same. Table XIII shows the results. The statistic χ^2 is the adjusted statistic to be used for non-normal populations. The tabulated Chi-square value for a 1% confidence level against which the calculated statistics are compared is 15.09 for five degrees of freedom and 16.81 for six degrees of freedom. Both calculated statistics reflect an overwhelming difference in variance across the days of the week in all cases except firm sizes 6 and 8 in October, and for sizes 4, 6 and 8 in May. The results of Bartlett's test suggested that for the most part there were substantial differences in variability across days of the week, and that it would be better to treat days of the week separately in the model in order to maintain their separate contributions to the variability of demand.

Estimation of Variability

Prior to building the variability into the demand several assumptions were made regarding 1968. First, the total quantity of milk marketed in the Southern Region was assumed to be the same in 1968 as in 1978. Historical data indicated that although per capita consumption of milk had decreased between 1968 and 1978, total population in the Southern Region had increased in such a way as to leave total consumption approximately constant. Second, it was assumed that the market

TABLE XIII

RESULTS OF BARTLETT'S TEST FOR EQUAL VARIANCES ACROSS DAYS OF THE WEEK BY FIRM SIZE CATEGORY, AMPI SOUTHERN REGION DAILY SALES, OCTOBER, 1977 AND MAY, 1978

	Firm Size Code								
	1	2	3	4	5	6	7	8	Total
October, 1977									
Adjusted χ^2	59.1*	35.1*	151.9*	98.0*	29.1*	7.2	20.5*	7.6	18.3*
d.f	5	6	6	6	6	6	6	6	6
May, 1978									
Adjusted χ^2	27.3*	53.9*	28.5*	9.3	43.1*	6.9	39.7*	7.7	29.4*
d.f	5	6	6	6	6	6	6	6	6

*Rejected at the .01 level

variability in 1968 held the same relationship to the behavior of the individual firm sizes as it did in 1978. There were no data to either support or reject this assumption. Third, it was assumed that the number and sizes of firms comprising the AMPI demand could be used as estimated earlier in Table V.

The relationship of the variability of the market as a whole on any given day of the week to that of the individual firms comprising that market was studied. The estimate of the market standard deviation by day (S_m) was to be represented in the model as some function of the sum of the standard deviations of the individual firms comprising the market for that day (S_f).

As an example, consider once again the Dallas-Fort Worth Market area in May. Figure 13 shows for this market the relationship of one sum of the standard deviations of the individual firms to two market standard deviations. The lines connecting the X's represent two market standard deviations on either side of the mean, while the line connecting the 0's is one sum of the individual firm standard deivations. For the market there are eight firms, and Table XIV presents for each day of the week the market mean, the sum of the firm standard deivations and the market standard deviation. The relationship between the market mean plus two market standard deviations and the market mean plus one sum of firm standard deviations was explored for this market to see whether or not a relationship held throughout the week. The former became the dependent variable in a linear regression and the latter the independent variable. The resulting equation was $Y=113+.9X$ with the coefficient significant at the .01 level and an R^2 value of .98. The strength of this relationship and others in different markets suggested

TABLE XIV

MARKET MEAN, TWO MARKET STANDARD DEVIATIONS, AND SUM OF FIRM STANDARD DEVIATIONS FOR DALLAS-FORT WORTH MARKET, MAY, 1978

	Day of Week						
	M	Tu	W	Th	F	Sa	Su
	(1,000 lbs.)						
Market Mean	1,643	2,226	1,125	1,887	1,943	893	892
Market S.D.	151	246	168	173	111	137	80
Sum of Firm S.D.'s	339	646	580	392	419	250	97
Market Mean + 2 Market S.D.'s	1,945	2,718	1,461	2,233	2,165	1,167	1,052
Market Mean + Sum of Firm S.D.'s	1,982	2,871	1,705	2,279	2,362	1,143	989

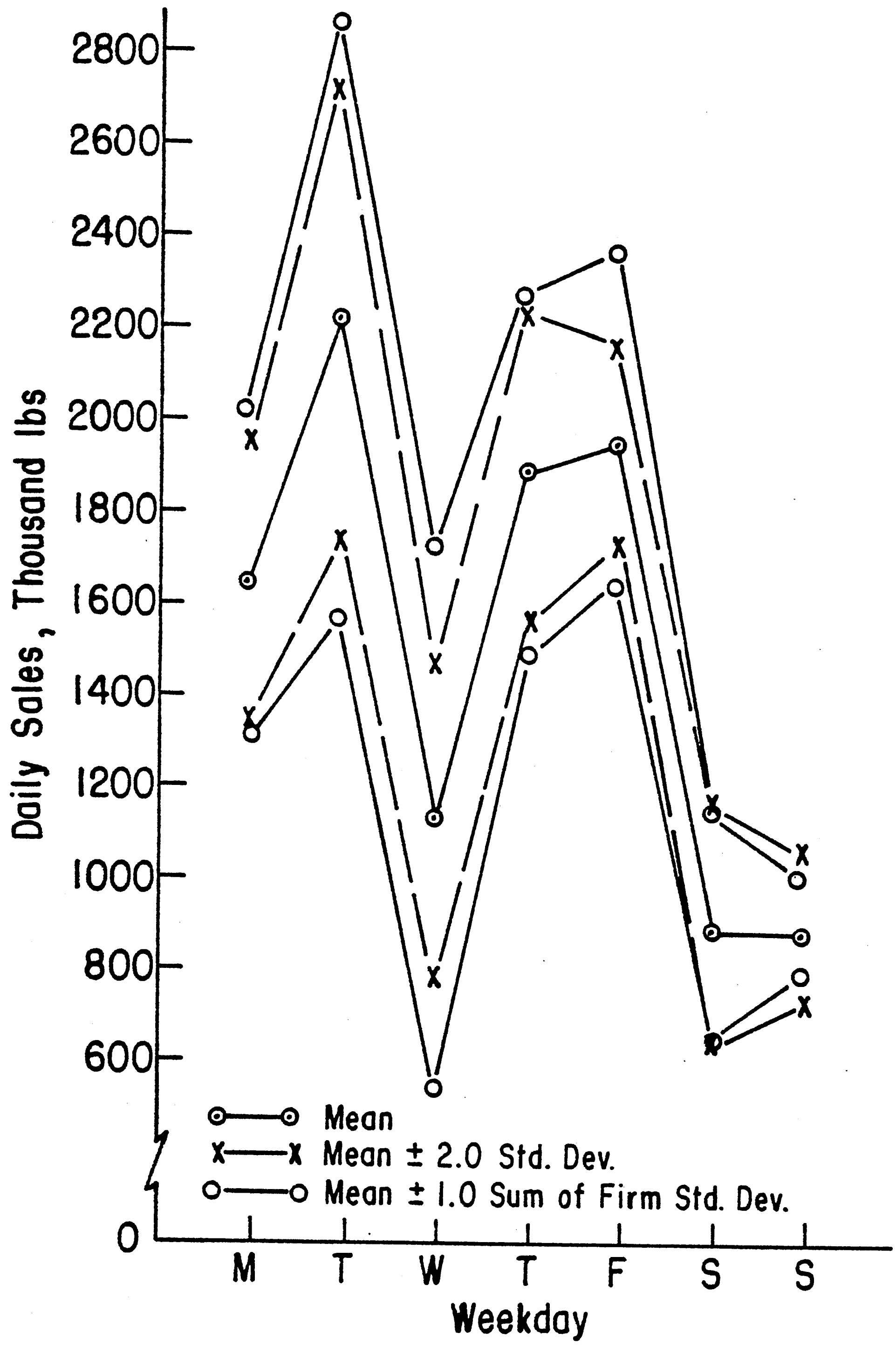
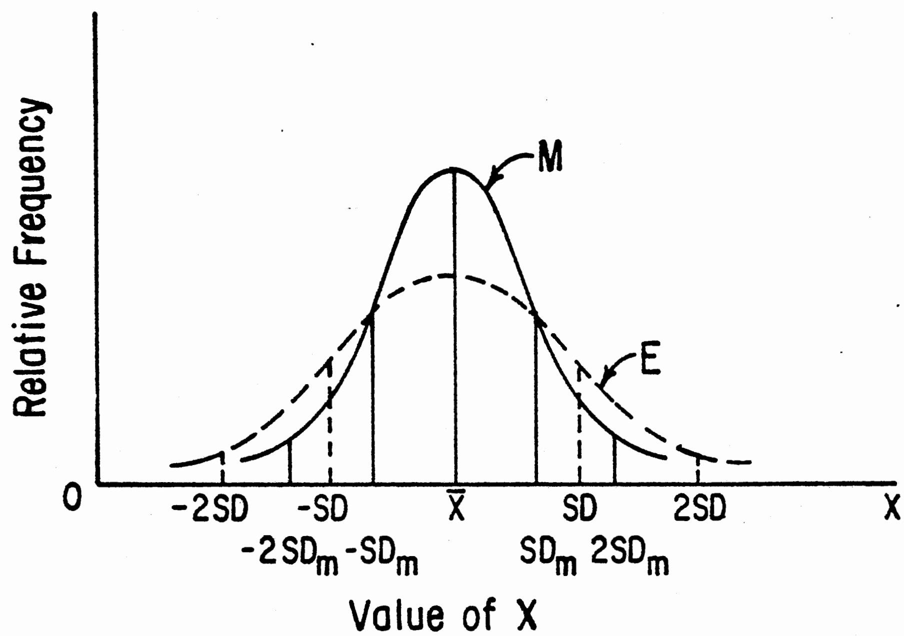


Figure 13. Relationship of Two Market Standard Deviations to One Sum of Firm Standard Deviations for the Dallas-Fort Worth Market Area, May, 1978

that an estimate formed in this way might be feasible if it could be shown to hold across markets for each day of the week instead of across days of the week for each market. The functional form selected for the demand estimate was $S_m=kS_f$, where k was an adjustment factor. This relationship was designed to be specific to the data used in this study and hopefully would permit approximation of 1968 data based on 1978 data and relationships. It was decided to build estimates based on two market standard deviations on either side of the market mean for each day of the week. The range, therefore, would include 95.45 percent of the variability of the market.

Figure 14 shows graphically the relationship of the desired estimate to the market distribution. The normally distributed curve M represents the market demand with a mean of $\overline{X}$. The standard deviation is SD_m. The ranges of market variability are $\overline{X} \pm 2SD_m$ for the 95.45 percent level. Also shown is a normally distributed curve E which represents the summation of the data generated from the individual firm size categories. The means are assumed to be equal for the market and the firm size aggregations. Summation of the standard deviations of the individual firms in a market would give one estimate of SD_m for the market. In this figure, SD represents the summation of the standard deviations for the individual firms.

An estimate of k was needed to relate SD with SD_m. Several tests were made. First, regressions were run with the independent variable being the sum of the standard deviations SD and the dependent variable the market standard deviation SD_m. The Southern Region was divided into three areas containing 5, 5, and 6 market areas, respectively. Regressions were run by month and day of week for each area. Table XV



Source: Snedecor (32, p. 34)

Figure 14. Relationship of Two Normal Curves With Different Standard Deviations

TABLE XV

SELECTED STATISTICS FOR REGRESSION OF SUM OF FIRM STANDARD DEVIATIONS ON MARKET STANDARD DEVIATIONS FOR FOUR MARKET GROUPINGS, AMPI SOUTHERN REGION, OCTOBER, 1977 AND MAY, 1978

		Texas Panhandle, South and West Texas, N. Mexico				Central Texas, North (East half) Texas, Oklahoma				Houston, Austin-Waco, Dallas-Ft. Worth, San Antonio, Oklahoma				All Major Markets			
		N	a	b	R^2	N	a	b	R^2	N	a	b	R^2	N	a	b	R^2
	M	5	17.7	.27 (.14)	.53	5	49.0	.26 (.11)	.66	6	48.5	.32 (.05)	.92	12	19.8	.40 (.09)	.70
	Tu	5	3.8	.59 (.18)*	.78	5	46.0	.30 (.09)	.77	6	30.8	.33 (.06)	.89	12	25.0	.34 (.05)	.83
	W	5	8.2	.55 (.13)	.85	5	35.0	.28 (.04)	.93	6	39.9	.22 (.02)	.95	12	29.1	.31 (.03)	.90
May	Th	5	21.0	.22 (.07)	.75	5	8.5	.44 (.08)	.90	6	29.5	.34 (.13)	.64	12	6.6	.44 (.04)	.93
	F	5	29.2	.27 (.14)*	.55	5	42.4	.28 (.16)*	.48	6	70.35	.15 (.09)*	.38	12	28.3	.31 (.06)	.72
	Sa	5	6.6	.33 (.14)	.66	5	32.6	.34 (.20)*	.48	6	9.76	.48 (.18)	.65	12	7.8	.45 (.07)	.80
	Su	5	5.3	.29 (.04)	.94	5	29.9	.28 (.28)*	.25	6	11.05	.42 (.27)*	.36	12	10.2	.38 (.12)	.54
	M	5	4.2	.55 (.12)	.87	5	-30.1	.54 (.09)	.92	6	-3.23	.57 (.04)	.97	12	-5.0	.50 (.05)	.89
	Tu	5	-1.2	.71 (.10)	.94	5	74.6	.14 (.05)	.68	6	45.0	.23 (.06)	.80	12	52.7	.19 (.04)	.70
	W	5	18.9	.33 (.10)	.77	5	32.6	.31 (.15)*	.58	6	7.9	.35 (.04)	.94	12	20.8	.32 (.07)	.66
October	Th	5	26.5	.16 (.16)*	.23	5	1.26	.26 (.11)	.66	6	13.0	.26 (.07)	.79	12	16.9	.22 (.05)	.65
	F	5	59.0	.02 (.05)*	.06	5	22.5	.28 (.07)	.85	6	23.7	.33 (.04)	.94	12	41.8	.24 (.06)	.59
	Sa	5	14.2	.29 (.04)	.95	5	-27.5	.61 (.09)	.94	6	8.1	.55 (.09)	.91	12	-6.5	.58 (.06)	.90
	Su	5	7.4	.46 (.07)	.93	5	-26.3	.62 (.09)	.93	6	8.7	.48 (.13)	.76	12	-3.25	.51 (.05)	.91

*Rejected at the .10 significance level
N is number of observations; a is intercept term; b is coefficient term; numbers in parentheses are the standard errors

TABLE XVI

RATIOS OF SUM OF FIRM STANDARD DEVIATIONS TO MARKET STANDARD DEVIATION FOR SELECTED MARKETS BY DAY OF WEEK, AMPI SOUTHERN REGION, OCTOBER, 1977 AND MAY, 1978

Market Code	M	Tu	W	Thu	F	Sa	Su	Avg
				October, 1977				
1	1.9	4.3	2.9	3.3	3.4	1.7	1.7	2.7
2	2.3	2.9	4.5	1.9	1.8	2.3	2.1	2.5
3	1.9	1.7	2.2	6.2	2.1	1.9	1.9	2.6
4	1.5	1.3	2.5	3.2	1.2	2.7	2.1	2.1
5	3.9	2.7	5.5	3.9	2.7	1.6	2.2	3.2
6	2.5	2.6	6.5	14.7	7.9	2.4	3.3	5.7
7	1.4	2.2	1.0	1.7	1.9	1.7	2.4	1.8
8	1.4	2.0	1.1	1.1	1.1	1.0	1.0	1.2
9	3.7	1.2	1.2	1.0	1.1	1.6	1.4	1.6
10	1.3	1.4	1.2	1.1	1.3	1.8	1.8	1.4
11	2.0	1.5	2.2	3.9	2.7	2.6	1.8	2.4
12	1.6	2.1	1.6	2.2	1.3	1.3	2.8	1.8
13	2.4	2.6	1.6	5.2	2.7	2.3	1.7	2.6
Avg	2.1	2.2	2.6	3.8	2.4	1.9	2.0	
				May, 1978				
1	2.9	2.7	3.0	2.2	3.1	2.3	4.6	3.0
2	1.7	2.0	2.4	1.6	2.1	4.2	1.4	2.2
3	1.7	1.3	1.7	1.9	3.5	1.9	1.7	2.0
4	1.4	3.5	3.0	3.0	1.5	4.2	1.6	2.6
5	1.3	2.9	1.6	1.9	2.0	1.4	2.3	1.9
6	1.9	3.6	2.5	2.7	1.7	2.1	3.7	2.6
7	2.1	1.2	2.8	1.7	1.2	1.2	3.9	2.0
8	1.3	1.0	1.0	1.0	1.1	1.0	1.0	1.1
9	1.0	1.1	1.2	1.3	1.3	1.0	1.3	1.2
10	1.5	1.5	1.0	2.0	1.5	1.3	1.0	1.3
11	3.2	1.5	1.6	2.6	2.7	2.3	3.1	2.4
12	1.2	1.2	1.2	1.3	1.3	1.5	1.9	1.4
13	1.4	2.8	1.6	2.4	1.7	1.1	2.8	2.0
Avg	1.7	2.0	1.9	2.0	1.9	2.0	2.3	

shows the resultant coefficients and R^2 values. Although some of the relationships are weak, most of them display a strong positive relationship. A second test involved dividing the sum of the firm standard deviations by the market standard deviations for the largest markets on each day of the week for each month. These figures are shown in Table XVI. With ratios of about 2.0 for most comparisons, the estimate of one sum of firm standard deviations to represent two market standard deviations represented fairly well the averages by market and by day of the week. Therefore k was set to be 1.0.

The estimate k can now be specifically related to the E curve of Figure 14. SD can be located at a distance from the mean of two standard deviations (SD_m) on either side. Generating levels of demand on the basis of E would mean that 68.27 percent of the variability in the E distribution would be included, which would contain 95.45 percent of the variability in M. It follows that 31.73 percent of the generated observations would lie outside the desired range in M, but only half of these, or 15.865 percent would be larger than 95.45 percent of the market observations, as the remainder would be smaller and would present no problems as far as demand satisfaction is concerned.

The procedure for using k in developing the 1968 and 1978 demand structures for use in the model can now be discussed. An illustration of the technique is shown in Table XVII for one market area for a Monday in October. The data for the other days of the week are included in the Appendix Tables. For each size category the number of firms in 1978 and the projected number of firms for 1968 were recorded in columns 1 and 6. The average deliveries in 1978 for the particular month, size category and weekday are shown in column 2. The standard

TABLE XVII

ILLUSTRATION OF PROCEDURE USED TO ESTIMATE MARKET VARIATION EACH DAY BASED ON FIRM SIZES, 1968 AND 1978

	1978					1968		
Size	#firms n	Monday Average (1,000 lbs.) q	Sum Of Firm SD (1,000 lbs.)	n·q	n·SD	#firms n'	n'·q	n'·SD
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			(1,000 lbs.)				(1,000 lbs.)	
1	0	0	0	0	0	1	7[a]	8[b]
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	2	43	3	86	6	1	43	3
5	2	65	23	130	46	2	130	46
6	3	138	19	414	57	8	1104	152
7	3	251	80	753	240	1	251	80
8	0	0	0	0	0	0	0	0
Sum:				1383	349		1535	289
Adjust (times .90 for 1968 only):				1383	349		1383	260
Adjust (times 31):				42873	10819		42873	8063
Adjust (times .765):				32798	8276		32798	6168

[a]Monday average for size category 1 for the Southern Region was used.
[b]Monday standard deviation for size category 1 for the Southern Region was used.

deviation corresponding to the weekday average appears in column 3. The average deliveries by size category for 1978 are computed in column 4 by multiplying the number of firms (column 1) by the average delivery for that size category (column 2). The estimate of the standard deviation for the size group in column 5 is arrived at by multiplying the standard deviation for the group by the number of firms. This is equivalent to summing the standard deviations of the individual firms in the size category and following the method described above. Columns 7 and 8 are computations for 1968 comparable with those in columns 4 and 5 for 1978.

At this point aggregation across size groups is made to generate the market estimates for the 1978 and 1968 structures. Column 4 is summed to produce the estimate of the 1978 market mean. The sum of column 5 estimates for the 1978 market the standard deviation according to the procedure described above. The sum of columns 7 and 8 estimate the mean and standard deviation for the 1968 market. Where there are firms in a size category for 1968 but not for 1978, the mean and standard deviation of the size group for the entire region that month and that weekday is used in the appropriate place in columns 7 and 8.

By assumption, the market means were to be the same for 1968 as they were for 1978, so the generated market mean for 1968 (sum of column 7) was multiplied by a factor which would make the 1968 mean equal the 1978 mean. For this example the factor is .9. The 1968 generated market standard deviation was then multiplied by the same factor to preserve its relationship to the adjusted 1968 generated mean. The generated means and standard deviations were then multiplied by 31 to obtain monthly representations of the figures. One last adjustment was needed, and that was to multiply all four column totals by the quotient of the actual market mean and the generated market mean. This insured that the 1978 estimates of the market mean were equal to the actual market mean, and that the remaining three values were adjusted accordingly to preserve relationships.

The final result of Table XVII is a set of four estimates: 1968 and 1978 market means which are equal, the 1968 and the 1978 standard deviations. The 1968 standard deviation bears the same relationship to the 1968 mean that the 1978 standard deviation bears to the 1978 mean. These parameters describe normal distributions with means and standard deviations that were used to generate random levels of demand in the simulator. The estimates are consistent in their relationships between 1968 and 1978 and therefore permit comparisons across the years. Use of the same random levels in the simulator for both local cooperative organization and central coordination facilitate comparison of cost and quantity estimates between the two to draw conclusions regarding each scenario's relative efficiencies within the simulated market structure.

The application of this method separately to each market area for seven days of the week and for October and May built the market mean and standard deviation estimates that were used to generate the variability in the model. In summary, the steps of the procedure were as follows.

Step 1. The Southern Region was divided into individual market areas for use in local cooperative organization and for building the variability into the demand.

Step 2. The firms in the 1978 data were categorized by size group, with the size category based on the larger amount of milk the firm purchased in October or May.

Step 3. The numbers and sizes of firms were projected by market for 1968.

Step 4. The average quantities purchased during May and October in 1978 were computed by market, size category, and weekday.

Step 5. The market means were estimated by market for October and May of 1968 and 1978 by multiplying the number of firms in each size category by the average deliveries for that weekday.

Step 6. The market standard deviations were estimated by market for October and May of 1968 and 1978 in a similar fashion.

Step 7. The results of Steps 5 and 6 were each summed across size categories as the first approximation to the final market estimates.

Step 8. The 1968 mean and standard deviation were multiplied by the factor necessary to equalize the 1968 and 1978 means.

Step 9. The two means and standard deviations were multiplied by the factor necessary to equalize the 1978 generated mean and the mean of the actual data.

Step 10. The four values were multiplied by 31 to convert daily estimates to monthly estimates.

Steps 8 and 9 are the equivalent of applying the coefficient of variation of the generated distribution to the actual mean of the data to generate the properly adjusted standard deviations.

There were two separate phases of this study in which the sum of the firm standard deviations was used to derive an estimate of the variability of the market as a whole. The first phase was in the simulator when a mean and standard deviation estimate was used to describe each market area, and a random normal number was generated to specify the demand level for that particular simulation run. The second phase was in developing necessary operating reserves under each scenario.

Supply

The variability in producer deliveries on the supply side is not as complex as that of sales on the demand side, but production patterns do vary across geographical areas and may differ different years. Producer delivery curves also reflect seasonal production patterns. These considerations must be borne in mind when modeling the supply side of the model. If it could be determined that an average producer delivery curve could be used in conjunction with available raw data to produce an accurate supply representation for the study, then accuracy in supply could be obtained with a generalized supply curve. If an average curve cannot be used, it would be necessary to estimate a separate producer delivery curve for each time period and possibly for each market area.

Based on yearly producer delivery data for 1968-1978 for the federal order areas in Texas and Oklahoma, average producer delivery curves were generated for Oklahoma and for the combined markets in the region for three time periods: 1968-1971, 1971-1975, and 1975-1978. The functional form that best described the curves was a polynomial of degree five. Using the method of orthogonal polynomials, curves were fitted to the twelve monthly values for each average. Various groups of years and markets were pooled and the variance of the individual groups was tested against the pooled variance to determine whether or not the variances of the individual groups differed from the pooled variance. There were six individual producer delivery curves estimated: 1968-1971, 1971-1975, and 1975-1978 for Oklahoma, and the same three periods for the combined Texas and Oklahoma orders. The producer delivery curves were classified and labeled 1-6, respectively, then tested to determine variability differences across years within the same market, and across markets for the same years. Tests of hypotheses were run for seven groupings of the producer delivery curves: 1 and 2, 1 and 3, 4 and 5, 4 and 6 representing within-market tests. Across-market tests were conducted through 1 and 4, and 2 and 5. The error sums of squares were used to generate standard F-statistics which were compared against the tabulated value of F of 4.82 at a .01 confidence level for degrees of freedom of (6,12). In each case the variances of the involved producer delivery curves were not significantly different. The results of these tests are shown in Table XVIII.

Based on the conclusions that both seasonal variation and the levels of production were essentially unchanged from 1968 through 1978, the AMPI average producer delivery curves for the 1971-1975 period were selected for use in specifying the supply side of the model.

The Southern Region was divided into four geographically independent areas as far as the level of supply was concerned in order to let

TABLE XVIII

ANALYSIS OF VARIANCE OF PRODUCER DELIVERIES, THREE TIME PERIODS AND TWO MARKETS, AMPI SOUTHERN REGION, 1968-1978

Groups Pooled[a]	ESS_1 A	ESS_2 B	ESS_{pooled} C	X (C-(A+B))/6.	Y (A+B)/12.	F X/Y
1 and 2	23.5	89.2	350.9	39.7	9.4	4.2
1 and 3	23.5	112.0	276.4	23.5	11.3	2.1
4 and 5	53.7	96.0	156.4	1.1	12.5	.1
4 and 6	53.7	76.2	154.7	4.1	10.8	.4
1 and 4	23.5	53.7	118.6	6.9	6.4	1.1
2 and 5	89.2	96.0	396.1	35.2	15.4	2.3

[a]Groups are as follows: 1 - Oklahoma Market, 1968-1971;
2 - Oklahoma Market, 1975-1978;
3 - Oklahoma Market, 1971-1975;
4 - Oklahoma and Texas Markets, 1968-1971;
5 - Oklahoma and Texas Markets, 1975-1978;
6 - Oklahoma and Texas Markets, 1971-1975.

weather affect the areas independently. The areas were defined to approximate areas of known differing weather patterns and are as follows:

1. North of the New Mexico-Oklahoma-Arkansas border
2. The Texas Panhandle, Oklahoma, Arkansas, and Tennessee
3. New Mexico and West Texas
4. Eastern Texas, Louisiana, and Mississippi

Producer delivery data were obtained for the years 1971-1975 from AMPI records. The Kansas Division was defined as area 1; the total of the Oklahoma and Arkansas Divisions was area 2; area 3 was obtained by taking one-half of the North Texas Division aggregate to represent West Texas. West Texas and East Texas display different weather patterns and they were to be allowed to vary separately in the model. Area 4 contained the Southern Division plus one-half of the North Texas Division aggregate, which would place East Texas into area 4. The data were used as indicated above and were averaged across the years to find the mean and standard deviation of the supply distribution for each of the four areas. Supply was assumed to be normally distributed within those parameters. The data used to generate the four supply curves are shown in Table XIX.

The Model

The model was constructed to meet several basic objectives. First, all of the data had to be drawn together and used in an organized fashion when and where required. Second, there had to be an optimization section designed to compute optimum transportation costs. Third, a matrix generator was required to build in constraints and

TABLE XIX

DAILY PRODUCER DELIVERY DATA BY AMPI SOUTHERN REGION DIVISION, MAY AND OCTOBER, 1971-1975

	Division						
	Southern	North Texas	Total	Oklahoma	Arkansas	Total	Kansas
	(mil. lbs.)						
	May						
1971	3.244	4.116	7.960	2.114	1.251	3.365	1.464
1972	3.166	4.505	7.671	2.223	1.156	3.379	1.381
1973	3.033	4.556	7.589	2.072	1.198	3.270	1.323
1974	2.999	5.056	8.055	2.117	1.307	3.424	1.383
1975	2.757	4.973	7.730	2.003	1.362	3.365	1.483
	October						
1971	2.894	4.135	7.029	1.946	.990	2.936	1.241
1972	2.823	3.938	6.761	1.883	1.029	2.912	1.200
1973	2.575	4.100	6.675	1.699	1.061	2.760	1.197
1974	2.675	4.489	7.164	1.818	1.149	2.967	1.225
1975	2.322	4.180	6.502	1.628	1.176	2.804	1.273

right hand side levels for input into the optimizer. Fourth, a simulation was needed to model the changing relationships of supply and demand under variability which could exist over time. Finally an analysis program and report writer was necessary to produce the final results.

In order to arrive at the estimates set forth in the research objectives, the model functioned for eight situations. First, there were two scenarios, local cooperative organization and central coordination. These two distinct marketing frameworks were constructed differently in the model. The local cooperative organization functioned within federal order areas and communicated formally among them. The central coordination framework was allowed to move milk as needed throughout the geographical region of the model. Secondly, two years, 1968 and 1978, were processed, but the basic model framework was unchanged between the two. The differences between the two years occurred in numbers and sizes of plants, in the standard deviations in demand levels, and in the number and locations of manufacturing facilities. The last situations were found in the seasonality approached by the model; these were present in the two months, October and May in which the contraseasonal pattern of supply and demand were at the extremes in their relationship to each other. The seasonality was represented through quantitative changes in data in each section of the model.

Data Management

Figure 15 is a flow diagram which maps the essential workings of the system. Three sets of raw data marked the beginning for the model. Daily sales to plants by AMPI in the Southern Region for October, 1977,

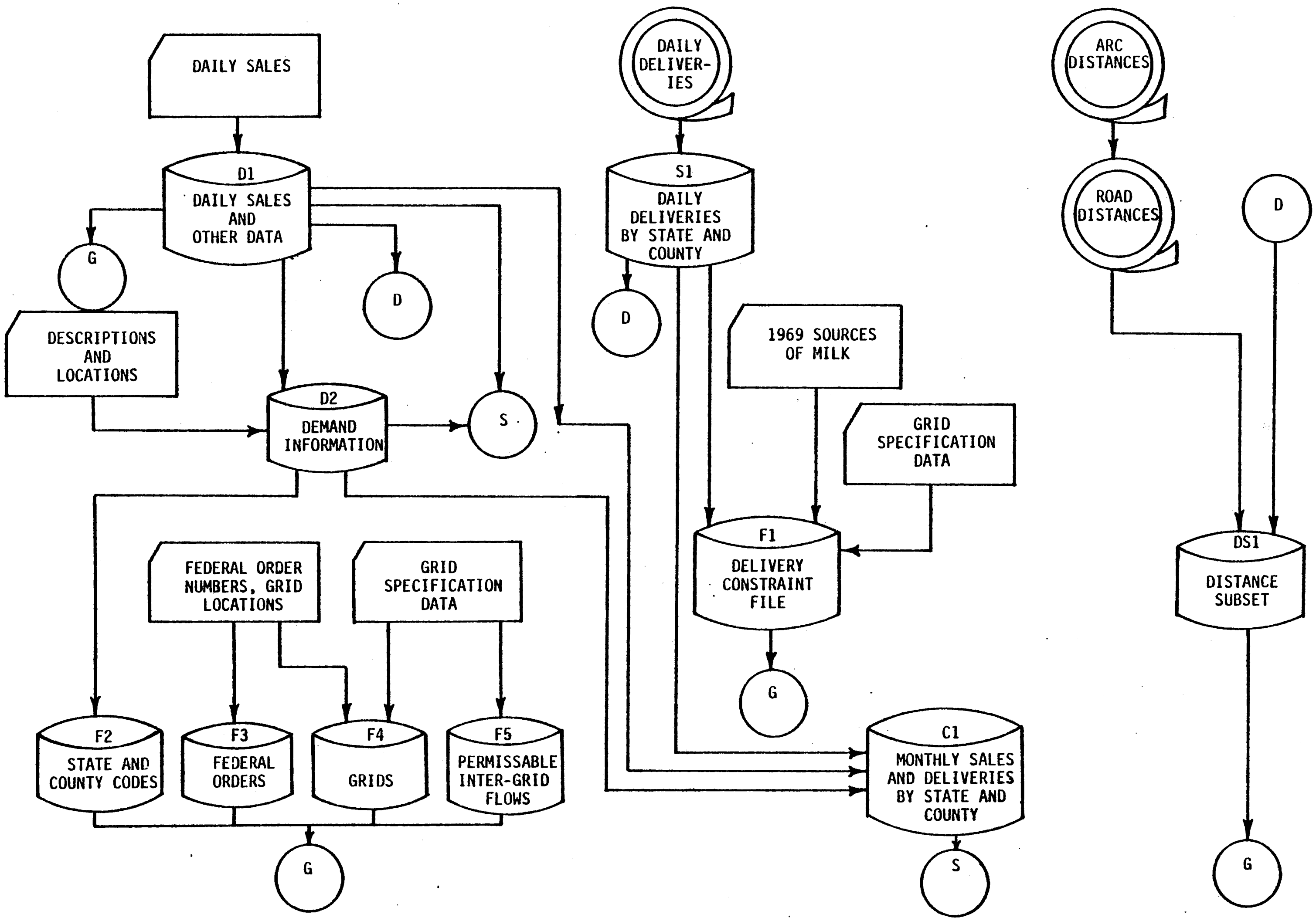
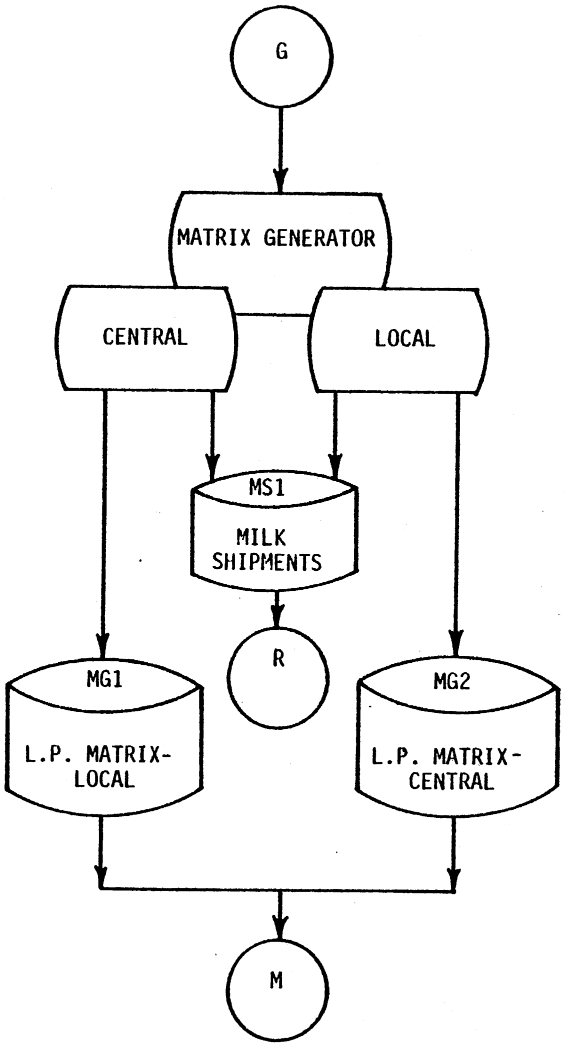


Figure 15. Flow Diagram for Computer Modeling Process



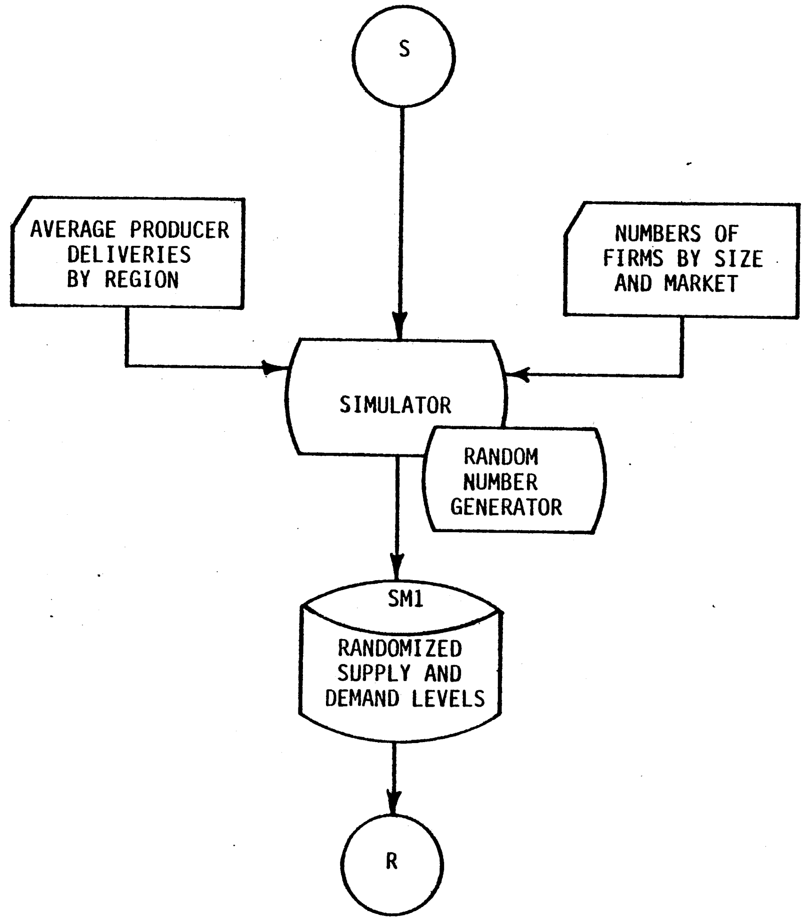


Figure 15 (Continued)

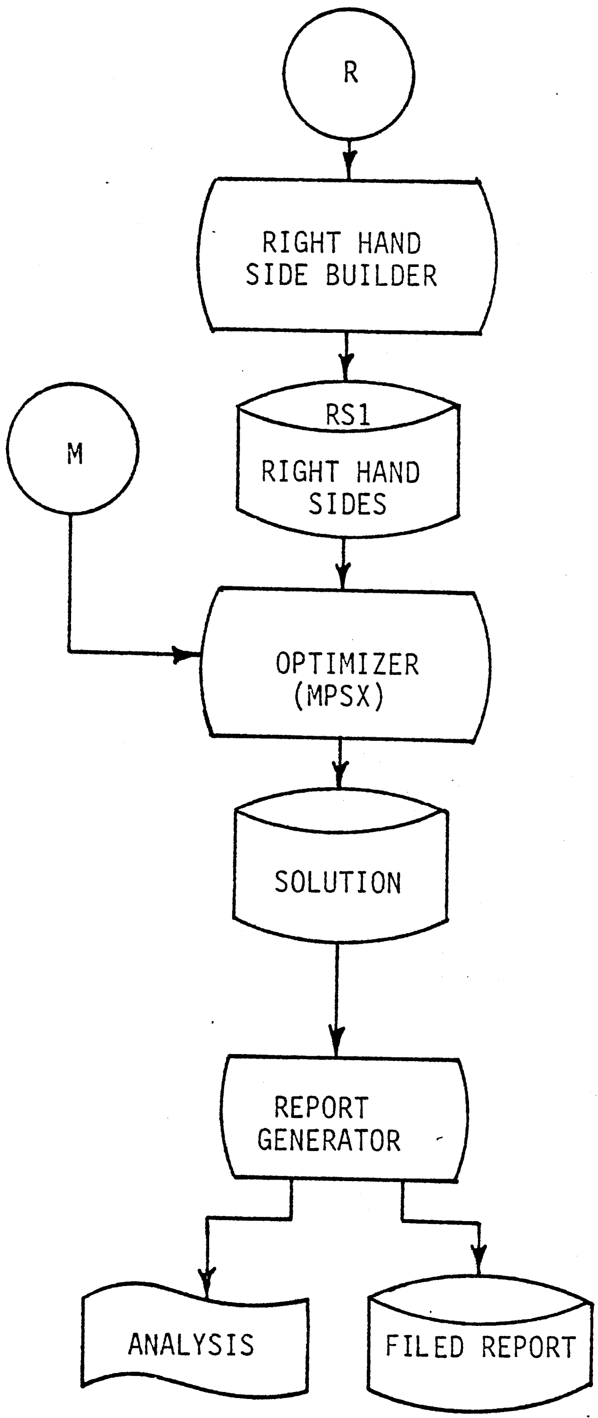


Figure 15 (Continued)

and May, 1978 formed the basic demand of the project; daily producer deliveries to AMPI in the Southern Region for the same time periods became the supply; and a county by county distance matrix formed the transportation cost basis for the optimizer. The first step towards building a working model was to transform the data into the proper forms, combine it with additional data mandated by chosen procedures, and store the results for use in later phases of the model. This was accomplished through several sets of computer programs which are not shown in Figure 15 as they represent a relatively minor part of the model.

Daily sales to plants were aggregated by state and county since county level was to be the smallest division handled in the model. Dummy variables were created for spot markets, week day and month, and the resultant data set, D1, became the basic demand data set used throughout the model. Information from here was combined with some additional descriptive information to form a data set D2 that was stored for later use.

Several data sets were created for use with the intention of decreasing costs associated with the computational aspects of the model. Data set F2 was one of these and in a straightforward structure contained simply the state and county code combinations of those counties having a non-zero fluid demand. This enabled the model to identify quickly and easily counties that should be processed on the demand side. Data sets F3 and F4 categorized the demands by federal order area number (used in the cooperative organization submodel) and by grid number (used in the central coordination submodel). (These grid numbers are discussed later in this section.) Structurally they were direct access data sets which provided immediate access to entries, thereby minimizing search time.

Daily producer deliveries were aggregated by month and by state and county from data set S1. This data set formed the basic supply information used throughout the model.

The original mileage matrix was large and expensive with which to work. It contained mileages in terms of Great Arc distances, which were first converted to road mileages for better approximation of actual conditions. From the modified data set a sub-matrix was built; it consisted of road distances among only those counties in the model which had supply or demand. This cut down substantially on the cost of developing the model, as this information was heavily drawn on to generate objective function cost values by the matrix generator. Consequently data set D1 and S1 were used to generate possible supply-demand combinations; the transportation costs for these activities were stored in data set DS1.

Supply and demand data used on a daily basis were drawn from data sets D1 and S1. The actual measurements of the coordination process, however, were based on monthly flows, as daily flows were cumbersome as far as processing and analysis were concerned. Information from data sets D1 and S1 were combined with some adjunct information from data set D2 to produce data set C1 which contained the total production and sales data aggregated by month for each state and county. These totals were used in the simulation portion of the model as a basis for the stochastic changes in supply-demand relationships.

The major difference between the two scenarios emerged in the way milk was allowed to flow to satisfy demand. Data sets F1 and F5 held the results of quantifying the constraints for the local cooperative organization and central coordination models, respectively. These rules were used by the matrix generator in building the input to the optimizer, and in building the milk shipment quantities input to the right hand side generator.

The Optimizer

The IBM linear programming package MPSX was chosen to perform the optimization. This was chosen over a transportation algorithm for several reasons. First it allowed great flexibility in setting up non-constraint rows to "compute" total milk shipments made by various groups of activities. These rows were designed to track all the desired results from the optimization, and then stored to keep a record of the final solution. Secondly, the transshipment points were easily set up through MPSX. Third, through MPSX the flexibility was maintained to do sensitivity analysis should it be desired. Fourth, MPSX required no development time, and is widely used at other installations.

The linear programming package was used with each of the situations set up by the simulator. It provided, along with flows and other descriptive quantities, costs of transporting milk as new supply and demand levels were set by the simulator. Desired results were stored for later analysis.

The Matrix Generator

The matrix generator had two parts, one for each scenario. The two sections used some common data, and some specific to the particular scenario to produce a linear programming matrix for each scenario specifying the particular problem to be optimized. Along with the matrices a set of multipliers was generated for the right hand side levels, and these were stored in data set MS1. These multipliers were a function of the milkshed for each federal order and represented the proportionality constraints associated with the local cooperative organization. In the case of central coordination they were a vector of ones (1.0), as there were no operational constraints. The constants for local cooperative organization proportioned the milk from each county among federal order area where necessary to reflect the actual marketing of the milk; in the case of central coordination each county shipped to the market(s) which provided the least-cost solution to the problem.

The matrix generated for the local cooperative organization contained 3,045 rows and 7,717 columns compared with a matrix of 3,356 rows and 24,373 columns constructed for the central coordination scenario. The local cooperative organization matrix was technically more difficult to generate because of the complexity of milk movements but the central coordination matrix was much larger since milk flows were unconstrained by anything except cost.

The Local Cooperative Organization Matrix

Table XX gives a compact picture of the matrix as it was built for local cooperative organization. There are six groups of linear programming activities, or variables as they are sometimes called. The first set is of the form $S_c$sss$S_t$ddd and represents permissible milk shipments from state S_c, county sss to state S_t, county ddd.

TABLE XX

MATRIX SUMMARY FOR LINEAR PROGRAMMING MODEL,
LOCAL COOPERATIVE ORGANIZATION

	$S_c$sss$S_t$ddd	$S_c$sssM$S_t$xx	TR$S_c$xx$S_t$yy	T$S_t$yy$S_c$sss	IMPRT$S_c$xx	RHS
(N) OBJ						
(L) SUPLS$_c$sss	1	1				Level
(L) DEMDStddd	1			1		Level
(L) MANUMS$_c$xx		1	−1		1	Capacity
(L) MANUMS$_t$yy			1	−1		Capacity
(N) IMPORTED					1	
(E) SUPPLY	1	1				Total Supply
(E) DEMAND	1			1		Total Demand
(N) Accounting Rows						

sss = County Supplying Milk
ddd = County Demanding Milk
S_c = State from which milk is leaving
S_t = State into which milk is moving   or vice versa
xx = Manufacturing facility code
yy = Same only different facility from XX

The second set of activities represents the flow of milk not immediately used for fluid demand, but shipped to a manufacturing facility for processing or to an assembly center to await disposition. These activities are of the form $S_c$sssM$S_t$xx.

Activities of the form TR$S_c$ss$S_t$yy provide the transfer mechanisms for the milk to be moved from division to division. These are sometimes called transshipment activities in the context of transportation problems of this sort. In transferring across divisions milk must be moved through the assembly centers in order to fulfill local cooperative organization operating characteristics.

The fourth group, T$S_t$yy$S_c$sss, allows milk to be shipped from an assembly center or a manufacturing center to a final fluid demand point within the divison in which the assembly center or manufacturing facility is located. These activities would be used in deficit areas. Milk would be brought to the area assembly center through a transfer of surplus milk from the assembly center of another division; then it would be sent from the assembly center, usually the local cooperative, to the demand areas within that area.

The last two groups of activities, IMPRT$S_c$xx and EXCESSSP, allow the model to import milk when needed from a point external to the model and to dispose of surplus milk that exceeds the capacities of the manufacturing facilities.

The rows of the linear programming matrix are composed of several constraint groups designed to force disposition of all producer deliveries, and several non-constraint groups used primarily for accounting purposes. These rows were set up to aggregate statistics on subgroups of the column activities such that final stored solutions could be done for the rows only. This cut down substantially on storage needs.

The objective row contains the transfer costs of all of the activities and is minimized to find the optimal solution to the linear programming problem. It is a non-constraint row and its final level is the total cost of moving all of the milk in the system.

The set of rows $SUPLS_c sss$ are associated with the supply points. They represent the producer deliveries by state and county. The right-hand side quantities associated with these rows are the actual producer deliveries used in the problem. These rows are composed of two types of supply counties: those that ship to only one demand area, and those that split their shipments to more than one area. The latter are referred to as swing counties. The righthand side level of the former is equal to the total production of that county. A swing county has one row for each different federal order area to which it ships, and the righthand side level for each row is equal to the proportion of milk that is marketed in that area. In the model a swing county's rows are actually named $SWG{*}S_c sss$, where the * ranges from one to the total number of different areas to which it ships. The greatest number of shipments that occurred was five. The swing county rows allowed for proportioning the total supply among several demand areas, while at the same time building the matrix in the correct fashion for each of the rows.

There is a coefficient of 1.0 in the matrix for each activity that moves milk from the particular state and county. Consequently each unit of milk moved by an activity from a state and county adds one unit to the quantity of milk that has been marketed for that state and county. The rows are type L, which in a linear programming context means that the total quantity of milk moved from each state and county cannot exceed the total supply located there.

The demand rows, $DEMDS_t$ddd, include one row for each state and county having a fluid demand. There are only two sets of activities that can move milk into a county to satisfy fluid demand: these are the first set and the fourth set. Demand in a federal order area can either be satisfied by a producer delivery from within that federal order area, or by milk delivered from the local cooperative. These rows are also of type L, indicating that the amount of milk shipped to a particular state and county to satisfy fluid demand cannot exceed the fluid demand level of that county.

The next two groups of rows, $MANUMS_c$xx and $MANUMS_t$yy, control the use of the manufacturing facilities in the model. Milk can be transferred into a manufacturing facility by activities in groups two, three and five; and can be transferred out by those in groups three, four, and six. Each manufacturing plant has a capacity which cannot be exceeded; that forms the righthand side level, and the row types are all L. Thus a manufacturing facility can be used up to, but not exceeding, its capacity. A companion set of activities not shown in the table, $MANLMS_c$xx, requires the levels to be non-negative, thereby preventing the model from "creating" milk as an illicit import.

The rows IMPORTED AND EXCESSSP are used only for totaling any imported milk or any excess supplies and are not constraints in the model. The group of rows AS_czz contains one row for each assembly center is set equal to zero. This prevents milk from either being left in the assembly center or being "created" there. An element was needed to force the model to market all of the supply and not leave unallocated portions in the county where it was produced. With the less-than constraint in both supply and demand, the model has no incentive to market any milk at all. The two rows SUPPLY and DEMAND are the motivating force. They are both type G rows and the righthand sides are set to total supply and total fluid demand, respectively. A total of ten units was subtracted from each of the totals to provide a tolerance for handling any rounding errors that might occur. The "G" type row means that the level reached by the row must be greater than the righthand side. Each activity that moves milk adds one unit to these two rows as a unit of milk is marketed or as a unit of demand is satisfied. The total supply for the model is larger than the total demand, which means that both rows are necessary. The total demand row is necessary to insure that all fluid demand is met exactly, and all supplies are not sent to manufacturing facilities instead. The total supply row is necessary to insure that all milk is marketed, and not fluid use milk only.

The last group of rows is a set of accounting rows designed to track interstate and interdivision flows of milk. They are non-constraint rows and do not influence the solution in any way.

The Central Coordination Matrix

This matrix has the same basic format as the previous case, but the changes in the marketing structure produced major changes in the actual matrix. First, the local cooperative organization matrix was based on federal order areas. All flows were constrained by rules based on that structure. For the central coordination matrix these areas are not relevant. Flows were permissible throughout the Southern Region, and there were no assembly areas through which milk had to be sent initially to await further disposition.

Other changes in the matrix had to do with assembly centers. These were non-existent under central coordination. In addition, the manufacturing plant configuration changed between organizations in the manner discussed earlier.

The types of rows present under local cooperative organization were all present under central coordination except for the $AS_c zz$ rows which had no meaning under central coordination. All the accounting rows were built on a state basis for possible comparison with local cooperative organization.

There were two different data sets generated for the scenarios. Data sets MG1 and MG2 were the actual matrices for local cooperative organization and central coordination, and MS1 held the right hand side multipliers defining the milksheds. The matrices were used as input to the optimizer and MS1 became input to the right hand side generator.

The Right Hand Side Generator

The function of the right hand side generator was to take the supply and demand levels generated by the simulator, and combine them with the proportionality constraints of data set MS1 to produce a set of demand and supply right hand sides for use in the optimizer. It also determined which year was being run and added to the model the correct manufacturing plants and their capacities. These together were stored on data set RS1 and provided direct input into the optimizer.

The Simulator

The simulator took data prepared in the data organization step of the model and combined it with regional supply averages and standard deviations and numbers of firms by size category. It used the data to generate random demand and supply levels by region for 1968 and 1978, October and May for different time periods.

For each simulation the level of demand in each market was set by two randomized draws. The first, drawn from a uniform distribution, was converted to choose a value from 1 to 7, thus choosing randomly a specific day of the week. The second, drawn from a normal distribution, was used with the generated estimates of mean and standard deviation for 1968 and 1978 for that day of the week to create a level for each market. These regional values were used to adjust quantities and the county level for each simulation run.

The number of simulation runs to be made was determined in part by sample size criteria developed by Snedecor (32). Given a tabulated t-value for a particular confidence level, t; an average value for the variable under consideration, x; a standard deviation associated with that, sd; and a percentage within which the generated mean is to approach the actual mean in n iterations, p; then the formula for sample size is

$$n = \frac{t^2 s^2}{p^2}$$

It was decided to set p to 10 percent and t to 1.72. This particular t-value would reflect a .10 confidence level for twenty degrees of freedom. With these parameters and the actual averages and standard deviations of costs on the average runs for the eight situations, the

TABLE XXI

ESTIMATED SAMPLE SIZES REQUIRED, TWO CONFIDENCE LEVELS, ORGANIZATION TYPES, MONTHS AND YEARS

Student's t		1.72	1.72
Probability		10%	7%
Confidence level		.05	.10
1968			
	October		
	Local	13	18
	Central	19	26
	May		
	Local	14	19
	Central	6	8
1978			
	October		
	Local	11	15
	Central	17	24
	May		
	Local	6	8
	Central	1	2

sample sizes are as shown in Table XXI. These sample sizes will ensure that the generated mean is within 10 percent of the actual, at the given confidence level. A sample size of 20 would ensure a 7 percent tolerance in all cases except for October of both years, when 10 percent is the guaranteed range of the generated mean to the actual.

The simulator ran for 20 periods and randomly generated supply and demand levels for each period for the two scenarios, both years, and both months. For each of the eight situations, then, were stored 20 random supply-demand relationships. Each of these was submitted to the linear programming portion of the model to obtain an optimal solution to determine nature and costs of milk flows. Twenty MPSX runs were made for each situation to attempt to characterize the cost distribution over time. A total of 160 runs were made. All of the rows were stored for each optimal solution, and information was compiled on means and standard deviations of the various row variables. The subsequent analysis is reported in Chapter IV.

Milk Movements

The specification of demand and supply for October and May for both time periods sets up the necessary framework in which to move the milk. Local cooperative organization and central coordination function differently in how they market milk, and rules had to be formulated to simulate each scenario.

Under local cooperative organization, there were twenty-two individual markets comprised of seventeen federal order areas and five local markets, each of which pulled milk from the surrounding counties and either satisfied fluid demand or moved the surplus milk to

TABLE XXII

LOCATION OF ASSEMBLY CENTERS UNDER LOCAL COOPERATIVE ORGANIZATION, AMPI SOUTHERN REGION, 1968 AND 1978

Federal Order Area	Assembly Center	Secondary Assembly Center
St. Louis-Ozarks	Springfield, MO	
Kansas City	Kansas City, KS	
Neosho Valley	Pittsburg, KS	
Wichita	Wichita, KS	Hillsboro, KS
Memphis	Memphis, TN	
Red River Valley	Lawton, OK	
Oklahoma Met.	Oklahoma City, OK	
Central Arkansas	Little Rock, AR	
Lubbock-Plainview	Lubbock, TX	
South Texas	Houston, TX	
North Texas	Fort Worth, TX	Muenster, Sulphur Springs, Jacksonville, TX
San Antonio	San Antonio, TX	
Central-West Texas	Abilene, TX	Ballinger, TX
Austin-Waco	Austin, TX	Round Rock, TX
Corpus Christi	Corpus Christi, TX	
Texas Panhandle	Amarillo, TX	
Rio Grande Valley	Albuquerque, NM	
	El Paso, TX	
	Enid, OK	
	Linn, KS	
	Mangum, OK	
	Tulsa, OK	

manufacturing facilities to be processed into cheese or butter. Each of the 22 markets had a local cooperative or a small manufacturing facility that functioned as an assembly center. Any inter-market movements of milk occurred between assembly centers and was disposed of from that assembly center. For example, in a deficit area such as the Corpus Christi area, fluid demands above the produced supply would be satisfied by a shipment of milk from some other assembly center to Corpus Christi; from the Corpus Christi assembly center the necessary fluid milk was then moved to the fluid demand point. Table XXII lists the assembly centers of the model. Milk movement rules under local cooperative coordination, then allowed fluid demand within an individual market to be satisfied in one of two ways:

1. a direct shipment from a producer within that market area
2. a shipment from the assembly center for that market area.

Milk produced in a market area was used either to satisfy a fluid demand within that market area, or it was shipped to the assembly center for that market area. Milk could be shipped between assembly centers.

In some instances an assembly center chose to assemble milk not at the assembly center per se, but at a manufacturing plant some distance away. Wichita, for example, assembled some milk at Hillsboro instead of at Wichita. This was modeled by allowing these assembly centers to move milk back and forth between them and particular manufacturing centers at no cost. This simulated the efficiencies that local cooperatives were able to bring about by using a secondary assembly point for their pick-up routes. Table XXII indicates the assembly centers where this took place.

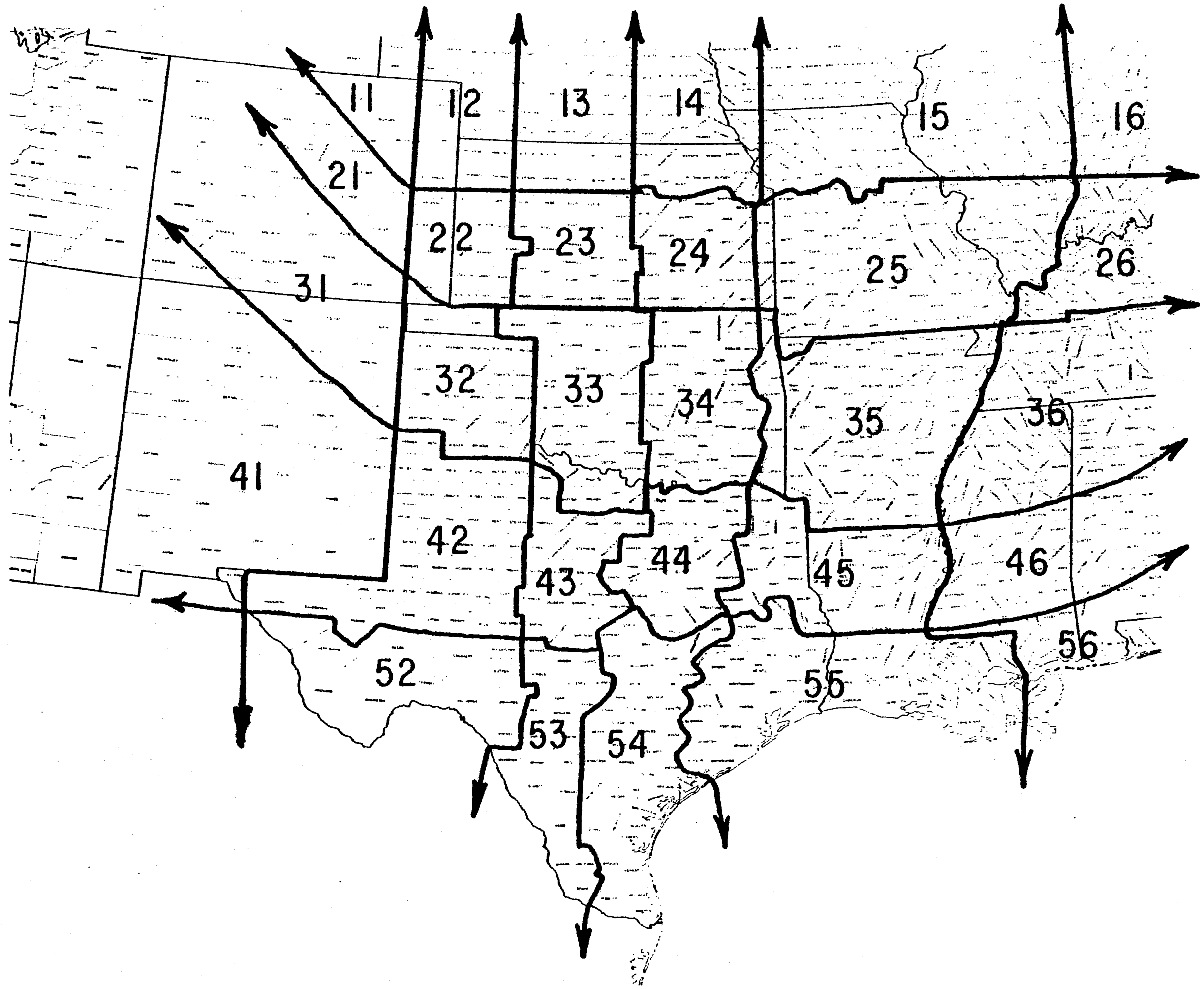


Figure 16. Grid Framework for Central Coordination, AMPI Southern Region

Under central coordination there were no longer geographical barriers to markets. AMPI functioned as a central manager that could move milk throughout the Southern Region to satisfy demand, and it could move surplus milk to the most economical manufacturing plant.

In the actual computer model it was not practical to allow the possibility of milk to flow from any county to any other county, as it would have produced a problem far larger than it already was. Some decision rules were defined regarding milk flows. To implement these, the Southern Region was conceptually divided into a system of grids, shown in Figure 16, and flow rules were determined in terms of grid to grid movements. Adjacent grids were allowed to ship directly to each other, and grids were permitted to ship directly to certain known deficit areas. Movements spanning more than one grid moved in segments between adjacent grids but since there were no loading charges or transshipment fees there was little change in the cost of marketing the milk. A great deal was gained from an operational cost standpoint.

Exports from the system were set up to occur if surplus milk exceeded the total capacity of all of the manufacturing plants. For both scenarios this was set up through the Hillsboro plant and allowed to occur only when necessary. Imports were allowed through any assembly area at an increased cost. The cost formula for imports under both scenarios was a conservative estimate of the actual cost of imports and was represented by

$$I = .001 + 1.333D$$

where I = per unit cost of the imports, .001 represents a handling charge of $0.10 per hundredweight, and D represents the transportation cost from Kansas City, where the imports to the Southern Region originated, to the point of entry.

The operation of the model is summarized as follows: the input data were restructured and augmented to form a data base for the model. The model was comprised of five component parts: the optimizer (MPSX), the matrix generators (FORTRAN programs), the simulator (A SAS program), the righthand side builder (A FORTRAN program), and the report writer (A PL/I program). These were used to make twenty simulation runs for each of the eight situations in the research project. The results of the twenty runs were stored for each situation, and the report writer analyzed the results.

CHAPTER IV

ANALYSIS AND RESULTS

The central objective of this research project was to measure the effects of coordination in the fluid milk market. The measurement of coordination benefits occurred through the comparison of central quantitative estimates computed under the central coordination scenario with those generated under the local cooperative organization scenario. Changes due to central coordination were then evaluated using the local cooperative scenario as a base. Since local cooperative organization was the marketing framework prior to 1968 and central coordination is in effect today, selected comparisons between the two scenarios suggest direction and amounts of change in efficiency. In addition these comparisons provide estimates of how local cooperative organization might handle milk movements in today's world as well as how central coordination might have performed in the 1968 market.

Sources of Savings

As stated in the research objectives in Chapter I, there are four sources of the savings which could be realized in a regionally coordinated market as compared with locally organized markets. First, savings are associated with lower transportation costs at the stages of assembly and delivery to first-level handlers, as well as in the movement of surplus milk to manufacturing plants. Second, potential savings are associated with processing costs which change with size and location of processing plants. A third source of savings comes from the elimination of unnecessary imports through coordinating markets. The fourth area is in the reduced reserve requirements associated with coordinated markets. This study has quantified the savings from these four sources that have been brought about through the regional coordination accomplished by AMPI.

Estimates of Savings

Transportation

Savings. The primary measure of the impact of central coordination is in the assembly and delivery transportation costs incurred in marketing the milk. Table XXIII presents the average transportation cost figures for the twenty simulation runs along with the associated standard deviations and ranges for each of the eight situations described in Chapter III.

In all eight cases central coordination represents an improvement over local cooperative organization from a transportation cost standpoint. The absolute improvement ranges from 30.5 percent decrease in costs for October of 1968 to 41.5 percent decrease in May of 1978.

The coefficient of variation is a measure of the variability in the costs incurred for twenty simulation periods. When the range of costs is large, it may reflect the ability of the particular organization to more effectively reduce costs given certain supply-demand relationships. Some market situations would allow particularly significant transportation cost savings due to the locational aspects of the

TABLE XXIII

AVERAGE MONTHLY ASSEMBLY AND DELIVERY TRANSPORTATION COSTS, LOCAL COOPERATIVE ORGANIZATION AND CENTRAL COORDINATION, MAY AND OCTOBER, 1978 AND 1978

	Average Total Cost	Standard Deviation	C.V.	Range in Cost High	Range in Cost Low	% Improvement in costs of Central over Local
1968	(mil. dol.)			(mil. dol.)		
October						
Local	1.345	0.171	13	1.840	1.126	
Central	0.935	0.205	22	1.649	0.726	30.5
May						
Local	1.465	0.177	12	1.905	1.243	
Central	0.953	0.114	12	1.235	0.805	34.9
1978						
October						
Local	1.328	0.157	12	1.726	1.139	
Central	0.905	0.197	22	1.543	0.703	31.9
May						
Local	1.434	0.114	8	1.673	1.242	
Central	0.839	0.043	5	0.930	0.752	41.5

associated supply-demand relationships. The reverse is also true; some supply-demand relationships may be characterized by high transportation costs due to their locational aspects. A large range of costs and a variable coefficient of variation across months or years, could imply that the particular organization had the flexibility to take advantage of potentially low-cost situations.

Consider, for example, the coefficients of variation compared across months. Local cooperative organization displayed a coefficient of variation that was about the same between months in 1968 and showed a modest decline between October and May in the 1978 situation. Central coordination was characterized by a ten point drop from October to May in the 1968 situation and by a seventeen point drop between months in the 1978 situation. Since the upper limit of the range associated with central coordination is lower than that for local cooperative organization, it may be said that central coordination was able to effect significant transportation cost decreases by taking advantage of the locational nature of the supply-demand interrelationships and the sometimes particularly advantageous proximity of seasonal surpluses to manufacturing facilities.

In comparing coefficients of variation between the two organizations it can be seen that the coefficient of variation for central coordination is significantly higher than that of local cooperative organization in October. In May of 1968 there is no difference, but in May of 1978 that of central coordination is signficantly lower than that of local cooperative organization. This is explained in part by noting that the difference in the range for May of 1978 is a low .18 as compared with ranges from .43 to .92 for the other situations. Central coordination succeeded in reducing the high end of the range from 1.235 in May of 1968 to .93 in May of 1978 indicating that through restructuring plant sizes and locations it was able to reduce significantly the number of high cost situations that arose due to the locational aspects of supply-demand relationships.

The nature of the range in transportation costs supports the above conclusions. The low end displayed wider absolute differences between local cooperative organization and central coordination for October than does the high end, showing that central coordination minimizes costs more effectively at times when transportation costs are generally low than does local cooperative organization. Furthermore, differences at the high end of the range in May between central coordination and local cooperative organization are significantly higher than those in October (.7 compared with .2) showing that for May central coordination is better able to minimize costs than local cooperative organization when transportation costs are generally high due to locational aspects of the supply-demand relationships.

The per hundredweight costs for 1968 and 1978 can be computed for local cooperative organization and central coordination by averaging the total costs for the two months, and dividing by the average total producer deliveries for the year, 381.2 million pounds per month. The per hundredweight costs for local cooperative organization are $.369 per cwt. for 1968 and $.362 per cwt. for 1978; for central coordination they are $.248 per cwt. for 1968 and $.229 per cwt. for 1978. The savings gained by central coordination over local cooperative organization are about $.121 per cwt. for 1968, and $.133 per cwt. in 1978. An average producer delivery level of 381.2 million pounds per month, or

4574.4 million pounds annually, would yield savings in transportation cost due to central coordination of $5,535,000 in 1968 and $6,084,000 in 1978.

Flow Patterns. Figures 17 through 20 show movements of milk for May of 1978 as it is marketed under local cooperative organization and central coordination. The flow maps emphasize the differences in milk shipments between the two market organizations.

Figure 17 maps the flows which directly satisfy the fluid demand of processing firms under local cooperative organization. This type of flow is allowed to occur only within a geographical market. Any milk crossing markets must be transshipped through the associated assembly centers. Swing counties are required to ship proportionately to the federal order areas as dictated by published milkshed data in 1967 (40).

Under local cooperative organization crosshauling is prevalent and can be seen in Figure 17. For example, Cleveland County, Oklahoma, ships to Comanche County and vice versa. Kay County, Oklahoma, ships to Sedgwick County, Kansas, and vice versa. Some notable flow patterns include Hinds County, Mississippi, which pulls milk from Northwest Arkansas. Oklahoma County, Oklahoma, draws from the Texas and Oklahoma Panhandles, as well as from Western Arkansas. The Dallas-Fort Worth area pulls milk from as far north as Kay County, Oklahoma; and Bexar County, Texas, the San Antonio area, pulls milk from extreme Northern Texas. Lubbock County, Texas obtains milk from as far away as the Western tier of counties in Oklahoma as well as from the Oklahoma Panhandle. In general, milk flows from North to South with some marked

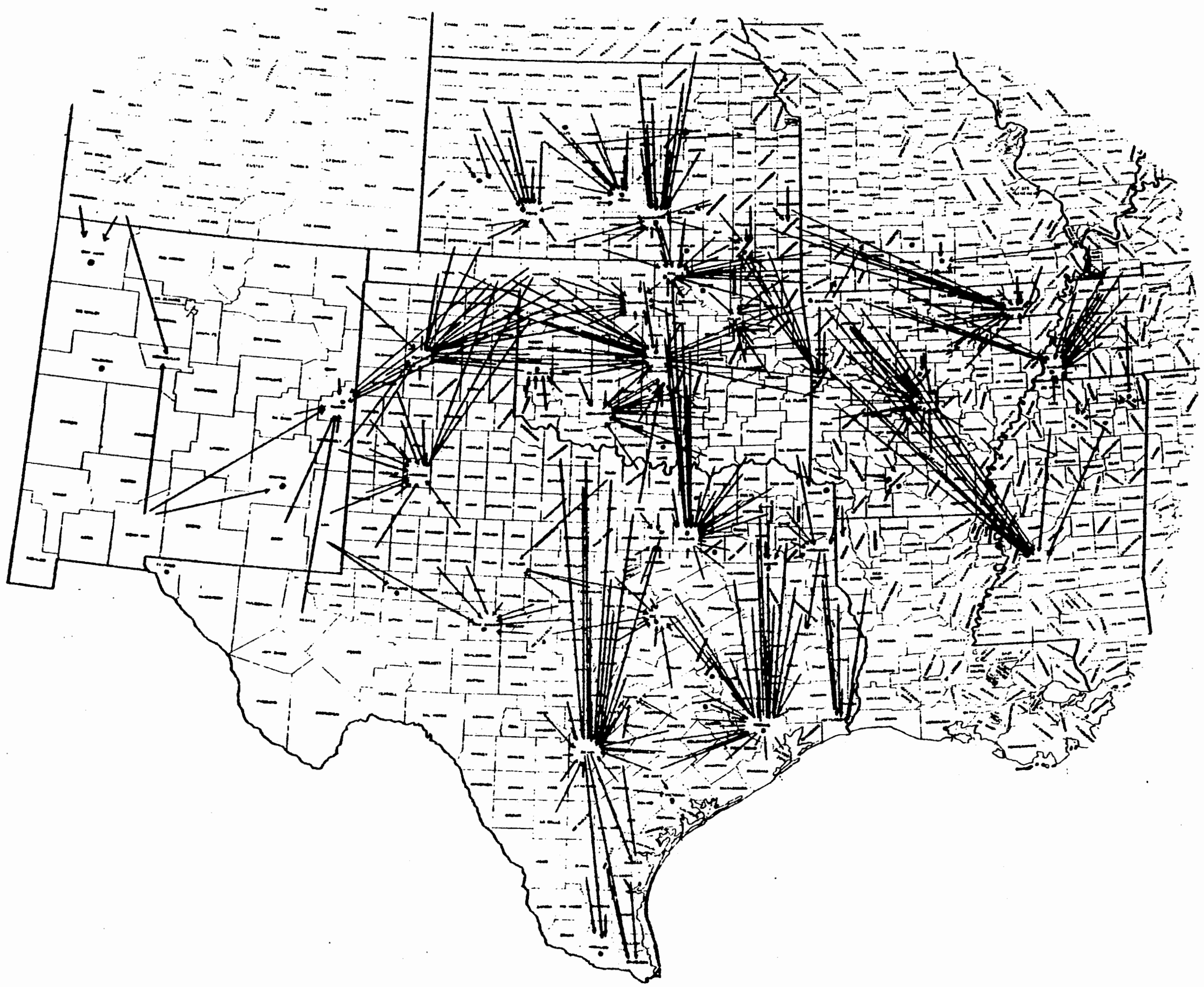


Figure 17. Minimum Cost Fluid Milk Movements, Assembly and Delivery to Processing Plants, Local Cooperative Organization, AMPI Southern Region, May, 1978

Figure 18. Minimum Cost Fluid Milk Movements, Assembly and Delivery to Processing Plants, Central Coordination Organization, AMPI Southern Region, October, 1978

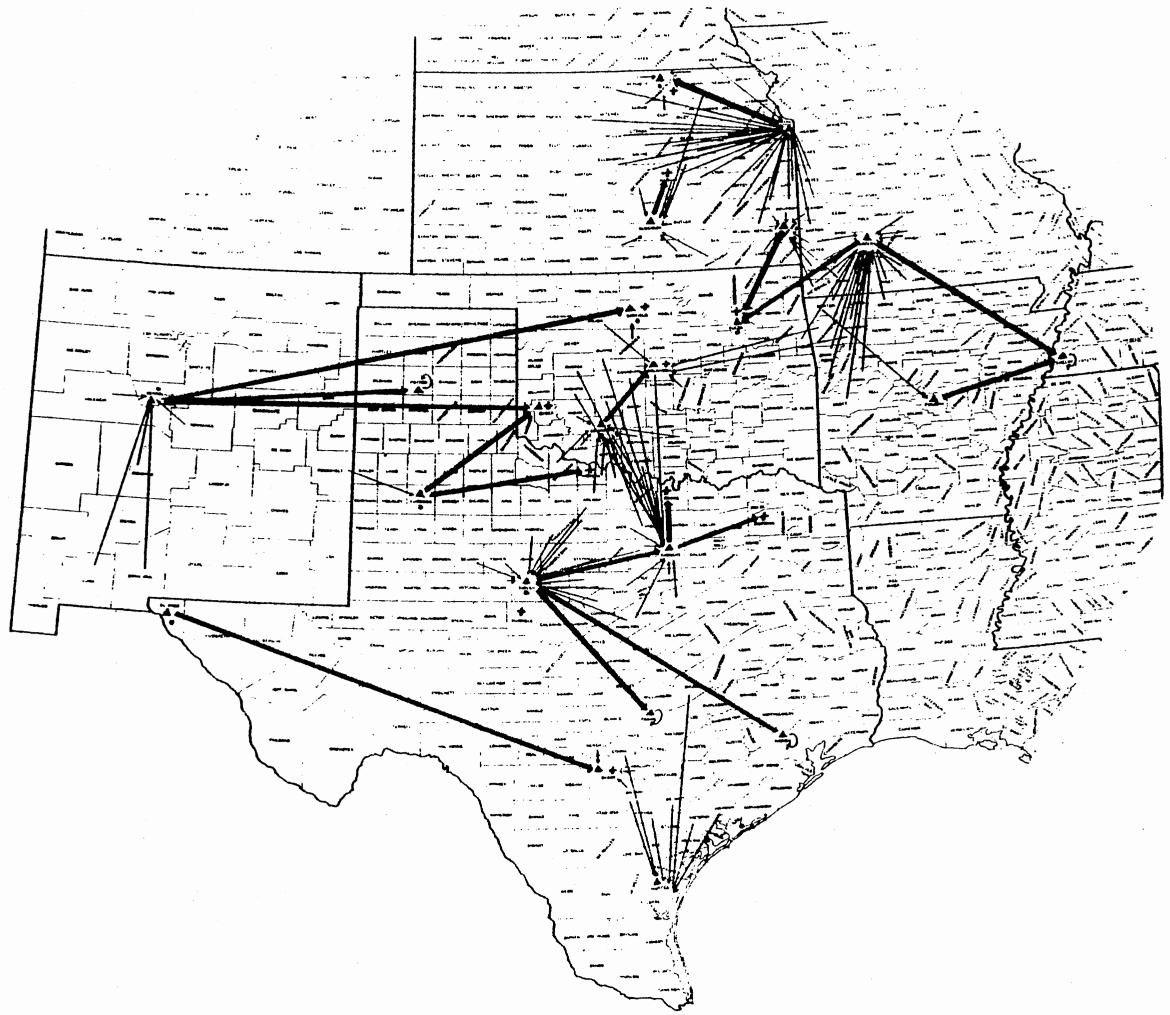


Figure 19. Minimum Cost Fluid Milk Movements to Manufacturing Plants, Local Cooperative Organization, AMPI Southern Region, May, 1978

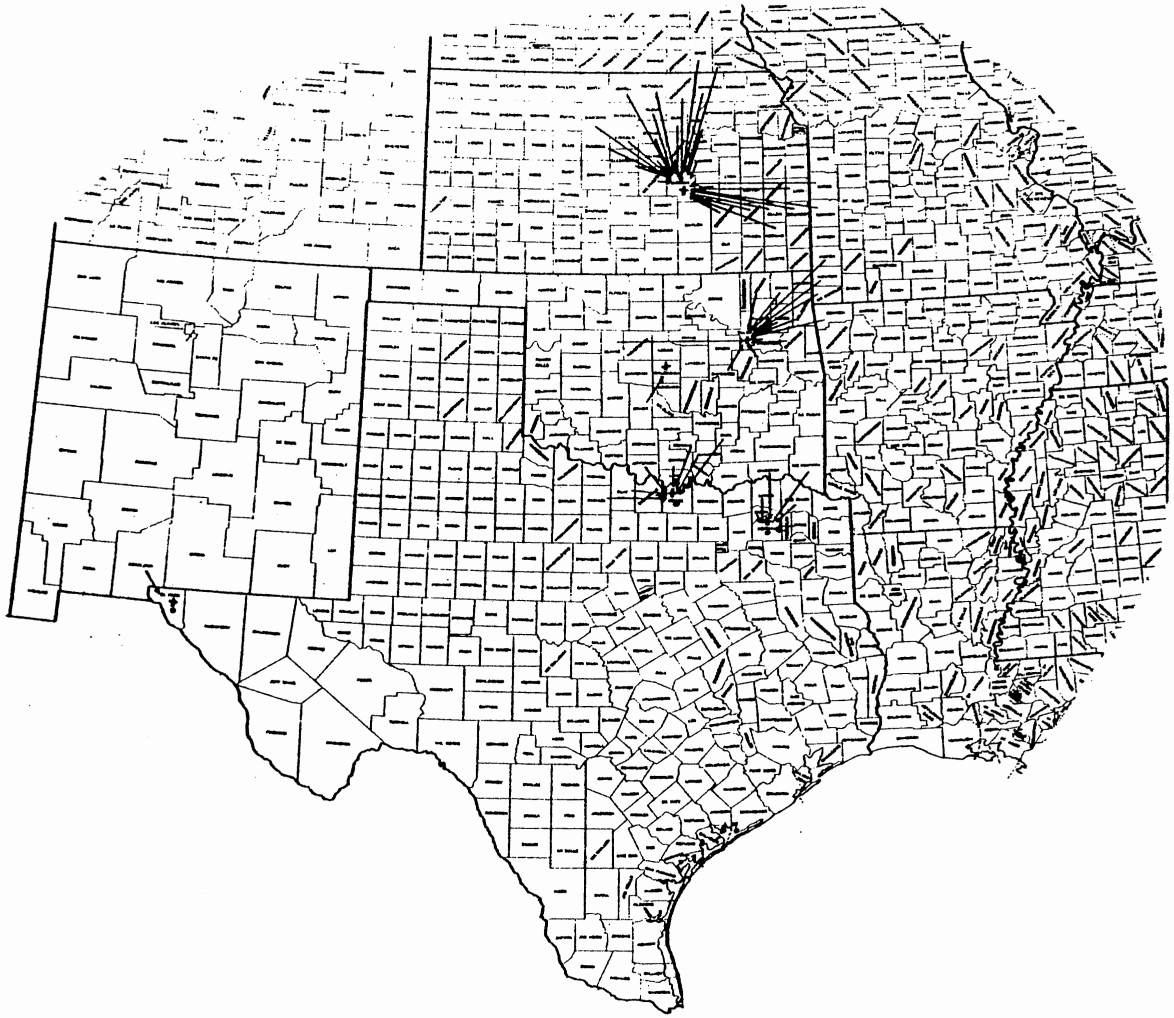


Figure 20. Minimum Cost Fluid Milk Movement to Manufacturing Plants, Central Coordination Organization, AMPI Southern Region, May, 1978.

movements to the Southeast in certain large population centers such as Harris County, Texas (Houston), Hinds County, Misissippi (Jackson), and Shelby County, Tennessee (Memphis).

Figure 18 presents flow patterns of milk used to satisfy fluid demands under central coordination. The flows are still basically North to South but the Southeasterly flows are more noticeable. No flows cross one another, which emphasizes the orderly movements brought about by central coordination. Flow patterns are much cleaner and the market areas are much more regular than they were under local cooperative organization. Hinds County, Mississippi draws from Southern Arkansas, and Central and Northern Arkansas are able to supply of their own needs. When Northern Arkansas falls short it draws from Southern Missouri. Oklahoma County, Oklahoma, draws only from neighboring counties, and receives no milk from Texas or Arkansas. The Dallas-Fort Worth area also is served by neighboring counties and has no long hauls from Northern Oklahoma. The Bexar County market is much more contained, going no further North than Comanche County, Texas. Lubbock County, Texas does not draw from Northwestern Oklahoma or from the Oklahoma Panhandle. The Market areas under central coordination look very much like those discussed in Chapter II and pictured in Figure 8.

Figure 19 represents three kinds of flows for local cooperative organization. The single flow lines map flows of milk from counties to assembly centers. These amounts of milk represent surpluses not needed to satisfy demand in that particular market area, so they were transshipped to the assembly center. The heavy use of Wyandotte County, Kansas, and Greene County, Missouri, as assembly centers is noteworthy.

This use was caused by the swing counties as they shipped milk to simulate the 1968 milksheds.

The heavy solid lines show subsequent movement of surplus milk from particular assembly centers to other assembly centers or to manufacturing facilities. The curved arrows, of which there are four, are located in the Texas counties of Travis, Harris and Potter; and Shelby County, Tennessee. These represent deficit areas under local cooperative organization which are supplied by shipments of milk acquired by their local cooperatives from cooperatives in other market areas and distributed to the final demand points by their local cooperatives. The May situation which is mapped here has only four deficit areas; the October situation is characterized by many deficit areas. The four deficit areas for May are Austin, Houston, Amarillo, and Memphis, and are, predictably, large population centers.

Figure 20 presents the flows of surplus milk to manufacturing plants under central coordination. There is no surplus in Texas except for small amounts in Cooke County, which come mainly from Southern Oklahoma; and in Hopkins County, which come from Northeast Texas and Southeastern Oklahoma. Arkansas has surplus only in Benton County which utilizes the manufacturing facility at Tulsa. The Hillsboro plant is quite active, and processes all of the milk for Northern and Eastern Kansas. Tulsa, too, is highly utilized, and takes in surplus for Northeastern Oklahoma and Southwestern Missouri.

The usage of the new manufacturing plant built at El Paso is somewhat deceptive. It is supplied by two counties, but Dona Ana County, New Mexico, supplies approximately 10.5 million pounds of milk. The capability of the El Paso plant is 11.5 million pounds, so it functions near capacity in May. This plant makes quite an impact in milk flows. Under local cooperative organization when the El Paso plant was not there, Dona Ana County shipped all of its surplus milk to the Bernalillo County assembly center, which in turn shipped it to Mangum, Oklahoma, and Enid, Oklahoma for processing. Central coordination eliminated these two plants, but put in the one at El Paso as an improvement in the locational configuration of manufacturing facilities.

Processing Costs

Processing of surplus milk is another area in which the potential for improvement in efficiency is present. Cost savings can be realized in some cases by relocating plants, or by shutting down inefficient operations; savings can also be brought about by operating plants at higher (or lower) levels in order to maximize returns from economies of size. Table XXIV presents utilization figures for the 16 manufacturing plants for the eight situations. The variable N indicates in how many of the 20 simulation runs the manufacturing facilities were used, and the volumes are average use figures based on N. A later table converts these averages to relate to the twenty periods and works with processing cost figures. Table XXIV also shows ranges and standard deviations of the volumes; these figures are based on the number of times the facility was used. This table provides a picture of the relative use of the various manufacturing plants.

Tables XXV through XXVIII convert the volumes in Table XXIV to a measure of average use for the twenty periods of this study. Resultant processing cost figures are presented based upon the volume being

TABLE XXIV

MANUFACTURING PLANT UTILIZATION STATISTICS, LOCAL COOPERATIVE ORGANIZATION AND CENTRAL COORDINATION, MAY AND OCTOBER 1968 AND 1978

	Linn		Hillsboro		Arkansas City		Wichita Falls		Okla. City	
	Local	Central	Local	Central	Local	Central	Local	Central	Local	Central
					(Quantities in mil. lbs.)					
May, 1968										
X	5.6	4.2	8.4	10.2	4.4	3.8	1.3	1.3	15.8	6.9
SD	1.2	1.5	4.1	3.0	3.2	2.3	0	0	4.2	6.1
H	7.6	7.6	13.8	13.8	6.5	6.5	1.3	1.3	19.4	19.4
L	1.6	2.9	2.8	2.0	.01	.6	1.3	1.3	8.2	.4
N	20	20	19	20	6	19	20	20	20	16
Capacity	7.6	7.6	13.8	13.8	6.5	6.5	1.3	1.3	19.4	19.4
May, 1978										
X	5.9	a	8.2	15.5	a	a	1.3	a	16.6	4.9
SD	.9	a	4.0	4.3	a	a	0	a	3.3	5.6
H	7.6	a	13.8	24.3	a	a	1.3	a	19.4	16.0
L	4.9	a	.6	8.8	a	a	1.3	a	9.2	.1
N	20	a	20	20	a	a	20	a	20	15
Capacity	7.6	-	13.8	28.3	-	-	1.3	-	19.4	16.0
October, 1968										
X	2.4	2.8	5.8	6.2	0	1.3	1.2	1.3	8.7	.2
SD	1.4	.6	3.4	2.3	0	1.0	.3	0	5.6	0
H	4.3	3.3	11.7	10.4	0	2.8	1.3	1.3	18.2	.2
L	.1	.4	.8	4.0	0	.3	.3	1.3	.8	.2
N	18	16	15	14	0	7	9	8	9	1
Capacity	7.6	7.6	13.8	13.8	6.5	6.5	1.3	1.3	19.4	19.4
October, 1978										
X	2.4	a	5.7	8.1	a	a	1.3	a	7.5	.1
SD	1.3	a	3.5	3.8	a	a	0	a	4.9	.02
H	4.4	a	11.8	14.6	a	a	1.3	a	15.0	.1
L	.2	a	.6	1.1	a	a	1.3	a	.003	.1
N	19	a	15	14	a	a	9	a	9	2
Capacity	7.6	-	13.8	28.3	-	-	1.3	-	19.4	16.0

TABLE XXIV (Continued)

	LaGrange		Muenster		Fort Worth		Sulphur Spgs.		Jacksonville	
	Local	Central	Local	Central	Local	Central	Local	Central	Local	Central
	(Quantities in mil. lbs.)									
May, 1968										
X	1.1	1.2	13.7	14.8	.6	.6	14.0	15.3	1.3	1.2
SD	.2	0	5.1	5.5	.1	0	4.0	1.4	0	.2
H	1.2	1.2	18.4	18.4	.6	.6	16.0	16.0	1.3	1.3
L	.7	1.2	5.1	1.8	.2	.6	3.5	11.2	1.3	.6
N	5	5	14	20	17	12	20	20	17	12
Capacity	1.2	1.2	18.4	18.4	.6	.6	16.0	16.0	1.3	1.3
May, 1978										
X	a	a	14.1	17.3	a	a	14.3	17.8	a	a
SD	a	a	4.7	8.3	a	a	3.9	3.2	a	a
H	a	a	18.4	27.2	a	a	16.0	21.5	a	a
L	a	a	4.4	1.7	a	a	3.3	12.2	a	a
N	a	a	15	20	a	a	20	20	a	a
Capacity	-	-	18.4	27.2	-	-	16.0	21.5	-	-
October, 1968										
X	1.2	0	9.7	13.1	.6	.6	9.8	8.9	1.3	1.2
SD	0	0	8.0	4.3	0	0	7.1	5.0	0	.1
H	1.2	0	18.4	18.4	.6	.6	16.0	16.0	1.3	1.3
L	1.2	0	2.9	7.4	.6	.6	1.8	.6	1.3	1.1
N	2	0	5	7	4	2	5	8	5	2
Capacity	1.2	1.2	18.4	18.4	.6	.6	16.0	16.0	1.3	1.3
October, 1978										
X	a	a	9.0	11.7	a	a	14.1	7.7	a	a
SD	a	a	8.0	6.1	a	a	2.0	4.6	a	a
H	a	a	18.4	21.0	a	a	16.0	14.5	a	a
L	a	a	.4	6.1	a	a	12.1	2.8	a	a
N	a	a	5	6	a	a	3	8	a	a
Capacity	-	-	18.4	27.2	-	-	16.0	21.5	-	a

TABLE XXIV (Continued)

	Round Rock		Ballinger		San Antonio		El Paso		Enid	
	Local	Central	Local	Central	Local	Central	Local	Central	Local	Central
	(Quantities in mil. lbs.)									
May, 1968										
X	.3	.3	.3	.3	6.3	5.3	b	b	2.9	3.7
SD	0	0	0	0	2.4	3.6	b	b	1.2	.8
H	.3	.3	.3	.3	8.2	8.2	b	b	4.0	4.0
L	.3	.3	.3	.3	.1	.3	b	b	1.3	1.1
N	17	10	20	13	18	5	b	b	20	19
Capacity	.3	.3	.3	.3	8.2	8.2	-	-	4.0	4.0
May, 1978										
X	a	a	.3	a	6.8	a	b	9.4	3.0	a
SD	a	a	0	a	2.0	a	b	3.0	1.2	a
H	a	a	.3	a	8.2	a	b	11.5	4.0	a
L	a	a	.3	a	2.2	a	b	1.2	1.3	a
N	a	a	20	a	18	a	b	20	20	a
Capacity	-	-	.3	-	8.2	-	-	11.5	4.0	-
October, 1968										
X	.3	.3	.3	.3	3.9	2.8	b	b	1.9	2.0
SD	0	0	0	0	3.3	0	b	b	1.5	1.5
H	.3	.3	.3	.3	8.2	2.8	b	b	4.0	4.0
L	.3	.3	.3	.3	.2	2.8	b	b	.1	.3
N	7	2	12	5	8	1	b	b	10	7
Capacity	.3	.3	.3	.3	8.2	8.2	-	-	4.0	4.0
October, 1978										
X	a	a	.3	a	3.7	a	b	6.2	1.5	a
SD	a	a	.1	a	3.0	a	b	3.1	1.1	a
H	a	a	.3	a	8.2	a	b	10.5	4.0	a
L	a	a	.01	a	.5	a	b	.7	.1	a
N	a	a	13	a	8	a	b	16	12	a
Capacity	-	-	.3	-	8.2	-	-	11.5	4.0	-

TABLE XXIV (Continued)

	Mangum		Tulsa	
	Local	Central	Local	Central
	(Quantities in mil. lbs.)			
May, 1968				
X	2.9	2.7	7.3	12.5
SD	0	.6	3.3	.1
H	2.9	2.9	12.6	12.6
L	2.9	.1	.8	11.9
N	20	20	20	20
Capacity	2.7	2.9	12.6	12.6
May, 1978				
X	2.9	a	7.5	13.6
SD	0	a	3.3	1.1
H	2.9	a	12.6	14.1
L	2.9	a	.8	10.8
N	20	a	20	20
Capacity	2.9	-	12.6	14.1
October, 1968				
X	2.7	1.8	4.5	7.0
SD	.6	1.3	1.4	3.7
H	2.9	2.9	8.0	12.6
L	.9	.1	1.4	.1
N	11	11	13	15
Capacity	2.9	2.9	12.6	12.6
October, 1978				
X	2.5	a	4.4	7.1
SD	.9	a	1.9	4.7
H	2.9	a	8.0	14.1
L	.1	a	.1	.1
N	11	a	14	12
Capacity	2.9	-	12.6	14.1

a) Plant exited from the industry
b) Plant not yet entered the industry

TABLE XXV

PROCESSING COSTS BY PLANT, LOCAL COOPERATIVE ORGANIZATION AND CENTRAL COORDINATION, OCTOBER 1978

	Linn (Cheese)	Hillsboro (Butter)	Ark. City (Butter)	Wichita Falls (Butter)	Okla. City (Butter)	LaGrange (Butter)
Local Cooperative Organization						
Monthly Volume (mil. lbs.)	2.3	4.3	a	.6	3.4	a
Per Cwt. Cost (dol.)	2.59	1.01		5.08	1.19	
Monthly Total Cost (thous. dol.)	59.0	43.4		29.7	40.0	
Central Coordination						
Monthly Volume (mil. lbs.)	a	5.7	a	a	.01	a
Per Cwt. Cost (dol.)		.86			275.89	
Monthly Total Cost (thous. dol.)		48.5			27.6	

TABLE XXV (Continued)

	Muenster (Cheese)	Fort Worth (Cheese)	Sul Spgs (Butter)	Jacksonville (Butter)	Round Rock (Cheese)	Ballinger (Cheese)
<u>Local Cooperative Organization</u>						
Monthly Volume (mil. lbs.)	2.3	a	2.1	a	a	.2
Per Cwt. Cost (dol.)	2.60		1.67			3.54
Monthly Total Cost (thous. dol.)	58.4		35.4			6.9
<u>Central Coordination</u>						
Monthly Volume	3.5	a	3.1	a	a	a
Per Cwt. Cost	2.19		1.26			
Monthly Total Cost (thous. dol.)	76.9		38.9			

TABLE XXV (Continued)

	San Antonio (Cheese)	El Paso (Cheese)	Enid (Butter)	Mangum (Cheese)	Tulsa (Cheese)	Total
<u>Local Cooperative Organization</u>						
Monthly Volume (mil. lbs.)	1.5	b	.9	1.4	3.1	22.1
Per Cwt. Cost (dol.)	2.91		3.43	2.95	2.32	2.08
Monthly Total Cost (thous. dol.)	43.0		30.9	40.6	71.3	458.6
<u>Central Coordination</u>						
Monthly Volume (mil. lbs.)	a	5.0	a	a	4.3	21.6
Per Cwt. Cost (dol.)		1.84			2.00	1.71
Monthly Total Cost (thous. dol.)		91.5			85.0	368.4

TABLE XXVI

PROCESSING COSTS BY PLANT, LOCAL COOPERATIVE ORGANIZATION AND CENTRAL COORDINATION MAY 1978

	Linn (Cheese)	Hillsboro (Butter)	Ark. City (Butter)	Wichita Falls (Butter)	Okla. City (Butter)	LaGrange (Butter)
Local Cooperative Organization						
Monthly Volume (mil. lbs.)	5.9	8.2	a	1.3	16.6	a
Per Cwt. Cost (dol.)	1.68	.71		2.49	.54	
Monthly Total Cost (thous. dol.)	98.9	57.9		32.4	88.9	
Central Coordination						
Monthly Volume (mil. lbs.)	a	15.5	a	a	3.7	a
Per Cwt. Cost (dol.)		.55			1.12	
Monthly Total Cost (thous. dol.)		84.9			41.1	

TABLE XXVI (Continued)

	Muenster (Cheese)	Fort Worth (Cheese)	Sul Spgs (Butter)	Jacksonville (Butter)	Round Rock (Cheese)	Ballinger (Cheese)
Local Cooperative Organization						
Monthly Volume (mil. lbs.)	10.6	a	14.3	a	a	.3
Per Cwt. Cost (dol.)	1.25		.56			3.48
Monthly Total Cost (thous. dol.)	132		80.4			10.4
Central Coordination						
Monthly Volume	17.3	a	17.8	a	a	a
Per Cwt. Cost	1.07		.53			
Monthly Total Cost (thous. dol.)	184.3		93.4			

TABLE XXVI (Continued)

	San Antonio (Cheese)	El Paso (Cheese)	Enid (Butter)	Mangum (Cheese)	Tulsa (Cheese)	Total
<u>Local Cooperative Organization</u>						
Monthly Volume (mil. lbs.)	6.1	b	3.0	2.9	7.5	76.7
Per Cwt. Cost (dol.)	1.64		1.29	2.37	1.47	1.07
Monthly Total Cost (thous. dol.)	100.5		38.6	68.8	110.1	818.9
<u>Central Coordination</u>						
Monthly Volume (mil. lbs.)	a	9.4	a	a	13.6	77.3
Per Cwt. Cost (dol.)		1.31			1.15	.88
Monthly Total Cost (thous. dol.)		123.3			156.1	683.1

TABLE XXVII

PROCESSING COSTS BY PLANT, LOCAL COOPERATIVE ORGANIZATION AND CENTRAL COORDINATION, OCTOBER 1968

	Linn (Cheese)	Hillsboro (Butter)	Ark. City (Butter)	Wichita Falls (Butter)	Okla. City (Butter)	LaGrange (Butter)
Local Cooperative Organization						
Monthly Volume (mil. lbs.)	2.2	4.4	0	.5	3.9	.1
Per Cwt. Cost (dol.)	2.63	1.00		5.47	1.07	23.33
Monthly Total Cost (thous. dol.)	56.8	43.4		29.5	42.0	28.0
Central Coordination						
Monthly Volume (mil. lbs.)	2.2	4.3	.5	.5	.01	0
Per Cwt. Cost (dol.)	2.60	1.01	6.43	5.67	275.89	
Monthly Total Cost (thous. dol.)	58.3	43.6	29.2	29.5	27.6	

TABLE XXVII (Continued)

	Muenster (Cheese)	Fort Worth (Cheese)	Sul Spgs (Butter)	Jacksonville (Butter)	Round Rock (Cheese)	Ballinger (Cheese)
Local Cooperative Organization						
Monthly Volume (mil. lbs.)	2.4	.1	2.5	.3	.1	.2
Per Cwt. Cost (dol.)	2.53	3.58	1.49	8.85	3.59	3.55
Monthly Total Cost (thous. dol.)	61.4	4.3	36.6	28.8	3.8	6.4
Central Coordination						
Monthly Volume	4.6	.1	3.6	.12	.03	.1
Per Cwt. Cost	1.92	3.62	1.14	23.33	3.63	3.61
Monthly Total Cost (thous. dol.)	88.1	2.2	40.7	28.0	1.1	2.7

TABLE XXVII (Continued)

	San Antonio (Cheese)	El Paso (Cheese)	Enid (Butter)	Mangum (Cheese)	Tulsa (Cheese)	Total
Local Cooperative Organization						
Monthly Volume (mil. lbs.)	1.6	b	1.0	1.5	2.9	23.7
Per Cwt. Cost (dol.)	2.87		3.27	2.90	2.37	2.23
Monthly Total Cost (thous. dol.)	44.8		31.1	43.1	69.2	529.2
Central Coordination						
Monthly Volume (mil. lbs.)	.1	b	.7	1.0	5.3	23.2
Per Cwt. Cost (dol.)	3.57		4.31	3.13	1.79	2.20
Monthly Total Cost (thous. dol.)	5.0		30.1	31.0	93.9	511.0

TABLE XXVIII

PROCESSING COST BY PLANT, LOCAL COOPERATIVE ORGANIZATION AND CENTRAL COORDINATION MAY 1968

	Linn (Cheese)	Hillsboro (Butter)	Ark. City (Butter)	Wichita Falls (Butter)	Okla. City (Butter)	LaGrange (Butter)
Local Cooperative Organization						
Monthly Volume (mil. lbs.)	5.6	8.0	1.3	1.3	15.8	.3
Per Cwt. Cost (dol.)	1.73	.72	2.49	2.49	.54	10.39
Monthly Total Cost (thous. dol.)	96.6	57.1	32.4	32.4	86.0	28.6
Central Coordination						
Monthly Volume (mil. lbs.)	4.2	10.2	3.6	1.3	5.5	.3
Per Cwt. Cost (dol.)	2.01	.64	1.13	2.49	.87	9.55
Monthly Total Cost (thous. dol.)	84.5	365.3	40.9	32.4	48.0	28.7

TABLE XXVIII (Continued)

	Muenster (Cheese)	Fort Worth (Cheese)	Sul Spgs (Butter)	Jacksonville (Butter)	Round Rock (Cheese)	Ballinger (Cheese)
Local Cooperative Organization						
Monthly Volume (mil. lbs.)	9.6	.5	14.0	1.1	.3	.3
Per Cwt. Cost (dol.)	1.30	3.37	.57	2.86	3.51	3.48
Monthly Total Cost (thous. dol.)	124.7	17.2	79.3	31.6	8.9	10.4
Central Coordination						
Monthly Volume	14.8	.4	15.3	.7	.2	.2
Per Cwt. Cost	1.12	3.45	.55	4.20	3.56	3.54
Monthly Total Cost (thous. dol.)	165.7	12.4	84.1	30.2	5.3	6.9

TABLE XXVIII (Continued)

	San Antonio (Cheese)	El Paso (Cheese)	Enid (Butter)	Mangum (Cheese)	Tulsa (Cheese)	Total
Local Cooperative Organization						
Monthly Volume (mil. lbs.)	5.7	b	2.9	2.9	7.3	76.9
Per Cwt. Cost (dol.)	1.71		1.32	2.37	1.49	1.19
Monthly Total Cost (thous. dol.)	97.2		38.3	68.8	108.7	918.2
Central Coordination						
Monthly Volume (mil. lbs.)	1.3	b	3.5	2.7	12.5	76.7
Per Cwt. Cost (dol.)	2.97		1.15	2.44	1.18	1.17
Monthly Total Cost (thous. dol.)	39.4		40.5	65.8	147.2	897.3

processed by the plant. These cost figures are computed from formulas derived by Stellmacher (34), and represent figures on the long run average cost curve for the facilities. Also shown in this group of tables are the total monthly costs of operating each plant along with the totals. The volume figures are in millions of pounds, the unit costs are in dollars per hundredweight, and the total cost figures are in thousands of dollars. To obtain the total cost as it appears on the table the volumes were multiplied by 10,000 to convert them to total cost in thousands. Any differences are due to rounding errors, as the original calculations were performed with greater precision than is shown in the tables.

Table XXIX summarizes the per hundredweight and total processing costs for local cooperative organization and central coordination for each time period. Central coordination effects some savings in all four time periods, with May savings exceeding October savings for both years. The savings associated with 1978 are considerably greater than those for 1968. These came about as economies of size were realized due to the decrease in number of manufacturing plants, the addition of the El Paso plant, and the increased capacities of plants remaining in the system.

Savings due to central coordination in 1968 were \$.03 per cwt. in October and \$.02 per cwt. in May. Those for 1978 were \$.37 per cwt. in October and \$.19 per cwt. in May. Annual average savings for the two years are \$.025 per cwt. and \$.275 per cwt. respectively. The average monthly volumes processed were 50.1 million lbs. during 1968 and 49.4 million pounds during 1978. These figures were derived by averaging the local cooperative organization and central coordination volume

TABLE XXIX

TOTAL, PER CWT. PROCESSING COSTS, LOCAL COOPERATIVE ORGANIZATION AND CENTRAL COORDINATION, AMPI SOUTHERN REGION, MAY AND OCTOBER, 1968 AND 1978

	Average Processing Costs	Total Processing Costs	Differences Between Local and Central
1968	(dol./cwt.)	(mil. dol.)	(dol./cwt.)
October			
Local	2.23	.5292	
Central	2.20	.5110	.03
May			
Local	1.19	.9182	
Central	1.17	.8973	.02
1978			
October			
Local	2.08	.4586	
Central	1.71	.3684	.37
May			
Local	1.07	.8189	
Central	.88	.6831	.19

figures for May and October for each of the two years. Total annual savings were computed by multiplying the savings per hundredweight and the total monthly volume; these were annualized by multiplying by twelve. The total annual savings in processing brought about by central coordination are $150,300 in 1968 and $1,630,200 in 1978.

Imports and Exports

The third area of measurement relates to the ability of each scenario to satisfy first-level demand requirements when faced with unpredictable shifts in supply-demand relationships. The simulation provided the framework for this evaluation through representations of supply-demand action and interaction. For each simulated period total demand and supply were recorded along with milk movements and any imports that were required to satisfy first level demand.

Tables XXX through XXXIII detail for October and May of 1968 and 1978 the levels of total supply and demand for each simulation run and related aggregate statistics. The coefficients of variation are indicative of variability characteristics in supply and demand. For both markets and years the coefficient of variation associated with supply is virtually constant at about three. The coefficient of variation for demand for October is roughly the same for both years at seven, but for May decreases from twelve to five. The demand variability has decreased over time as the firm structure has changed. Over all, however, the coefficient of variation for demand averages 7.5 while that of supply averages 2.5. This demonstrates that demand in general displays considerably more variability than does supply.

TABLE XXX

ESTIMATED SUPPLIES, ULTILIZATION, AND COSTS,
TWENTY SIMULATION RUNS, LOCAL COOPERATIVE
ORGANIZATION AND CENTRAL COORDINATION,
AMPI SOUTHERN REGION, MAY 1968

Run	Supply	Demand	Imports Local	Imports Central	Exports Local	Exports Central	Cost Local	Cost Central
			(mil. lbs.)				($1,000)	
1	400.2	327.2					1502.5	937.5
2	389.7	297.7					1386.1	882.5
3	403.7	275.4			14.1	14.1	1889.6	1232.5
4	397.0	312.9					1491.6	965.4
5	394.4	345.6					1324.2	884.0
6	397.5	309.4					1377.8	877.5
7	404.9	339.6					1363.0	910.6
8	395.2	281.2					1584.3	1013.2
9	385.2	329.4					1351.2	916.9
10	383.0	341.5					1242.7	856.9
11	396.5	302.6					1608.5	1049.7
12	398.2	332.3					1392.3	898.2
13	406.3	336.2					1293.9	804.8
14	405.3	323.7					1497.1	979.3
15	392.0	310.5					1904.7	1234.6
16	405.1	331.4					1356.1	875.8
17	399.3	339.7					1402.8	925.5
18	407.1	329.8					1567.7	1038.5
19	400.2	319.1					1411.8	911.0
20	396.3	321.1					1345.0	859.0
S	397.9	320.3			14.1	14.1	1464.6	952.7
SD	6.8	19.5			0	0	177.1	114.4
H	407.1	345.6			14.1	14.1	1904.7	1234.6
L	383.0	275.4			14.1	14.1	1242.7	804.8
CV	2	12					12	12

TABLE XXXI

ESTIMATED SUPPLIES, UTILIZATION, AND TRANSPORTATION COSTS, TWENTY SIMULATION RUNS, LOCAL COOPERATIVE ORGANIZATION AND CENTRAL COORDINATION, AMPI SOUTHERN REGION, MAY 1978

Run	Supply	Demand	Imports Local	Imports Central	Exports Local	Exports Central	Cost Local	Cost Central
			(mil. lbs.)				($1,000)	
1	400.2	326.3					1483.3	797.6
2	389.7	298.2					1393.7	751.7
3	403.9	292.7			6.6		1640.3	856.7
4	397.0	314.7					1488.9	799.0
5	394.4	340.0					1293.5	867.8
6	397.5	307.9					1384.1	801.9
7	404.9	335.0					1457.8	864.1
8	395.2	288.1			2.4		1585.1	817.5
9	385.2	328.9					1340.4	852.1
10	383.0	334.2					1242.2	840.6
11	396.5	309.1					1508.4	842.5
12	398.2	324.0					1318.5	837.4
13	406.3	332.3					1346.1	782.7
14	405.3	326.5					1472.7	842.8
15	392.0	322.6					1673.5	930.3
16	405.1	330.7					1368.0	841.6
17	399.3	332.6					1383.2	904.9
18	407.1	329.8					1514.3	878.5
19	400.2	319.1					1427.8	870.3
20	396.3	321.1					1351.2	802.8
S	397.9	320.7			4.5		1433.7	839.1
SD	6.8	14.6			2.9		113.9	42.6
H	407.1	340.0			6.6		1673.5	930.3
L	383.0	288.0			2.4		1242.2	751.7
CV	2	5					8	5

TABLE XXXII

ESTIMATED SUPPLIES, UTILIZATION, AND COSTS, TWENTY SIMULATION RUNS, LOCAL COOPERATIVE ORGANIZATION AND CENTRAL COORDINATION, AMPI SOUTHERN REGION, OCTOBER 1968

Run	Supply	Demand	Imports Local	Imports Central	Exports Local	Exports Central	Cost Local	Cost Central
			(mil. lbs.)				($1,000)	
1	366.5	356.4					1445.7	932.6
2	351.0	296.8					1126.4	725.5
3	373.7	324.0					1454.8	925.9
4	370.2	306.2					1414.0	875.7
5	362.8	362.4	5.5				1383.1	980.0
6	364.8	366.0	1.2	1.2			1324.0	943.6
7	372.4	359.5					1297.6	910.1
8	361.5	296.1					1226.4	770.1
9	349.5	370.1	20.7	20.6			1478.2	1219.0
10	346.8	388.3	41.5	41.5			1840.1	1648.3
11	361.1	346.9					1299.1	884.6
12	362.2	346.7					1221.0	845.2
13	377.3	342.0					1245.6	770.0
14	374.6	360.0					1284.8	913.4
15	347.9	351.2	7.3	3.3			1676.1	1140.9
16	374.0	328.0					1198.5	764.3
17	364.8	339.8					1227.6	836.5
18	381.6	340.0					1303.7	856.9
19	365.7	357.3					1243.7	912.8
20	362.2	357.1					1222.6	846.6
S	364.5	344.7	15.2	16.6			1345.7	935.1
SD	9.9	24.2	16.4	18.7			171.5	205.4
H	381.6	388.3	41.5	41.5			1840.1	1648.8
L	346.8	296.1	1.2	1.2			1126.4	725.5
CV	3	7					13	22

TABLE XXXIII

ESTIMATED SUPPLIES, UTILIZATION, AND COSTS, TWENTY SIMULATION RUNS, LOCAL COOPERATIVE ORGANIZATION AND CENTRAL COORDINATION, AMPI SOUTHERN REGION, OCTOBER 1978

Run	Supply	Demand	Imports Local	Imports Central	Exports Local	Exports Central	Cost Local	Cost Central
			(mil. lbs.)				($1,000)	
1	366.5	357.0					1431.4	881.4
2	351.0	299.4					1139.2	703.3
3	373.7	332.0					1406.5	831.7
4	370.2	307.5					1399.6	773.4
5	362.8	364.3	8.4	1.5			1384.8	1007.0
6	364.8	360.5					1270.5	895.4
7	372.4	356.6					1290.2	873.4
8	361.5	304.0					1222.4	731.0
9	349.5	367.9	18.7	18.5			1447.4	1177.8
10	346.8	382.4	35.6	35.6			1726.2	1543.1
11	361.0	347.5					1269.0	837.1
12	362.2	344.3					1171.9	829.5
13	377.3	346.4					1265.6	766.2
14	374.6	362.1					1272.9	883.1
15	347.9	354.0	7.6	6.0			1694.7	1188.0
16	374.0	329.5					1198.7	750.0
17	364.8	339.9					1201.6	827.5
18	381.6	350.0					1282.0	818.3
19	365.7	357.6					1259.0	925.8
20	362.2	357.7					1225.2	357.5
S	364.5	346.0	17.6	15.4			1327.9	905.0
SD	9.9	21.9	13.1	15.3			157.1	197.0
H	381.6	382.4	35.6	35.6			1726.2	1543.1
L	346.8	299.4	7.6	1.5			1139.2	703.3
CV	3	6					12	22

Also shown in Tables XXX through XXXIII are the system imports and exports. As one might expect, no imports occurred in the high surplus month in either year under either scenario. In October of 1968 the local cooperative organization imported fluid milk in five of the twenty iterations with an average of 15.2 million pounds when milk is imported. Central coordination also imported milk, but in four periods with an average over those four periods of 16.6 million pounds. A twenty-period average shows local cooperative organization importing an average of 3.8 million pounds -- roughly half a million pounds less imports per period on the average. For October of 1978 each scenario imported four times with a four-period average of 17.6 million pounds for local cooperative organization and 15.4 million pounds for central coordination. This yields a twenty-period average of 3.5 million pounds per period for local cooperative organization and 3.1 million pounds per period for central coordination -- slightly less than half a million pounds difference.

It is concluded that central coordination is slightly better able than local cooperative organization to meet demand requirements in the model. On the average 400,000 pounds less milk per year is imported from outside the system which implies increased stability within the Southwest region relative to the United States.

An interesting sideline here concerns the exports for the different scenarios. The exports, consisting of surplus milk above and beyond the combined capacities of the manufacturing plants, are identical between scenarios for May of 1968; the manufacturing plant structure is identical. In May of 1978, however, when both scenarios had changed the manufacturing structure and central coordination had made extensive changes, local cooperative organization was forced to export in two out of the twenty periods, or ten percent of the time; central coordination was able to process all of the surplus and did not export at all.

Reserves

The last area in which measures of coordination effects were made is in the reserve levels that must be maintained in order to meet demand requirements. Reserves are broken down into operating reserves and seasonal reserves, and the effect of coordination on each is measured.

Operating Reserves. The term "demand satisfaction" is difficult to define precisely, as "satisfying" is a matter of degree. For purposes of this paper it was determined that if orders made by processors were filled 83 percent of the time on the average, this would constitute demand satisfaction. The sales-to-plant data used here were distributed normally, so one standard deviation on either side of the mean encompassed roughly 66 percent of the variation involved. That left a remainder of 34 percent of which 17 percent was more than one standard deviation above the mean. Since demand levels falling below the mean could clearly be filled all of the time, and those above the mean failed to be filled only 17 percent of the time, demand requirements could then be filled 83 percent of the time. This was arbitrarily defined to be "demand satisfaction."

Tables XXXIV and XXXV show for each day of the week average sales plus one standard deviation for each market. Table XXXIV contains figures for October, and Table XXXV for May. These figures represent

TABLE XXXIV

AMPI SOUTHERN REGION AVERAGE DAILY SALES
PLUS ONE MARKET STANDARD DEVIATION,
SELECTED MARKETS, OCTOBER, 1978

	Okla. City	Houston	Austin-Waco	Corpus Christi	Hildago-Cameron	Dallas-Ft. Worth	San Antonio	Central Arkansas
				(1,000 lbs.)				
Sales to Plants Mean + 1 SD for								
Monday	968	1089	552	206	159	3007	732	729
Tuesday	1043	1146	563	195	169	2921	758	881
Wednesday	1008	1071	623	119	114	2334	604	803
Thursday	1043	939	602	172	111	2458	621	804
Friday	1166	946	535	193	151	2792	649	959
Saturday	1296	1191	567	221	159	1477	659	924
Sunday	1176	1121	588	127	111	985	483	860

TABLE XXXIV (Continued)

	Memphis	Tulsa	Lawton	Rio Grande Valley	Wichita	Amarillo	Lubbock	Central West Texas
				(1,000 lbs.)				
Sales to Plants Mean + 1 SD for								
Monday	861	133	229	688	968	469	160	540
Tuesday	831	248	253	749	808	407	196	456
Wednesday	560	0	230	734	1066	242	241	321
Thursday	851	132	247	737	987	305	230	579
Friday	1205	107	200	681	527	366	274	414
Saturday	1009	28	45	600	544	129	104	315
Sunday	614	0	255	490	996	54	183	196

TABLE XXXV

AMPI SOUTHERN REGION AVERAGE DAILY SALES
PLUS ONE MARKET STANDARD DEVIATION,
SELECTED MARKETS, MAY, 1978

	Okla. City	Houston	Austin-Waco	Corpus Christi	Hildago-Cameron	Dallas-Ft. Worth	San Antonio	Central Arkansas
	(1,000 lbs.)							
Sales to Plants Mean + 1 SD for								
Monday	1123	1258	478	99	153	1794	610	632
Tuesday	1119	1673	451	117	150	2472	671	542
Wednesday	1205	1502	435	91	110	1293	577	748
Thursday	1141	1448	466	84	125	2060	752	694
Friday	1108	1478	445	96	151	2054	490	649
Saturday	1122	1375	474	94	126	1030	374	484
Sunday	1078	1132	433	90	82	972	403	546

TABLE XXXV (Continued)

	Memphis	Tulsa	Lawton	Red Grande Valley	Wichita	Amarillo	Lubbock	Central West Texas
Sales to Plants				(1,000 lbs.)				
Mean + 1 SD								
Monday	808	233	275	661	942	479	140	492
Tuesday	736	268	305	789	934	383	182	375
Wednesday	806	239	290	758	887	205	246	299
Thursday	859	331	284	795	952	320	221	494
Friday	851	253	203	794	819	426	284	401
Saturday	738	311	35	542	945	95	50	290
Sunday	747	266	172	483	632	48	141	199

the amount of fluid milk in millions of pounds it would take to satisfy the particular demand according to the definition of "demand satisfaction" given above. Producer deliveries do not change very much from day to day over the course of a week, so the peak amount sold during any day of the week represents the maximum level of daily receipts that must be handled. Since the figures here represent averages for the month, a multiplication of the peak day requirements by thirty-one will produce a monthly figure that can be used in the subsequent estimates.

Computation of operating reserves under local cooperative organization requires the use of peak weekday averages for each individual market. The data are taken directly from Tables XXIV and XXXV. The Oklahoma City market, for example, had a peak demand level of sales of 1296 thousand pounds on Saturday; the Houston market also reached its maximum on Saturday at 1191 thousand pounds. Under local cooperative organization each individual market would have to supply that amount of milk in order to meet the demand satisfaction criterion. Summing these maximum values over all markets and multiplying them times thirty-one gives the total producer deliveries required during the month to satisfy demand. These values are 402,000 thousand pounds in October and 375,007 thousand pounds in May.

The operating reserves necessary here are defined to be the difference between this peak day demand level and the average demand level. The average demands as obtained form the twenty simulations were 346,000 and 320,700 thousand pounds for October and May, respectively. These numbers are detailed in Table XXXVI. Necessary operating reserves under local cooperative organization would have been 56,070 thousand pounds in October and 54,307 thousand pounds in May,

TABLE XXXVI

MONTHLY OPERATING RESERVES, LOCAL COOPERATIVE ORGANIZATION AND CENTRAL COORDINATION, AMPI SOUTHERN REGION, OCTOBER 1977 AND MAY 1978

	Local Cooperative Organization		Central Coordination	
	October	May	October	May
	(Quantities in 1,000 lbs.)			
Peak Day Demand Level	402,070	375,007	360,344	346,177
Simulated Demand Level	346,000	320,700	346,000	320,700
Needed Reserves	56,070	54,307	14,344	25,477
Reserve % Needed	16.2	16.9	4.1	7.9
Simulated Supply Level	364,500	397,900	364,500	397,900
Actual Reserves	18,500	77,200	18,500	77,200
Excess (Deficit)	(37,570)	22,893	4,156	51,723

which represent 16.2 percent and 16.9 percent above the average demand, respectively. The difference between average supply and average demand, as calculated by the simulator, show the actual reserves. Local cooperative organization would fall short of satisfying demand by 37,570 thousand pounds in October and would have had excess reserves of 22,893 thousand pounds in May. For local cooperative organization to have satisfied demand in October, producer deliveries would have had to have been increased by 10.3 percent.

Operating reserves computed for central coordination involve summing across the markets for each day of the week. Central coordination permits joining individual markets, thereby smoothing out individual market variations that must be contended with separately under local cooperative organization. The peak day requirements, Tuesday at 11,624 thousand pounds for October and 11,167 for May, are multiplied by thirty-one and the resulting figures are the producer delivery level required to satisfy demand. Calculating as for local cooperative organization gives the needed reserves and the actual reserves as shown in Table XXXVI. Needed reserves above average demand are 4.1 percent for October and 7.9 percent for May. These levels are less than one-half the levels required under local cooperative organization. For central coordination excess reserves in October were 4,156 thousand pounds, or about 1.1 percent above average demand. They were 51,723 thousand pounds in May, which is double the level under local cooperative organization. This relationship reflects a redefinition of reserves (operating versus excess) when demands and supplies were the same under the two organizations.

Seasonal Reserves. Seasonal reserves refers to the amount of surplus milk available during any given month in excess of operating reserves and produced by the same number of producers as in the month of lowest supply. This surplus comes about as a result of the contra-seasonal patterns of supply and demand and because milk production is naturally greater in the spring and early summer than it is in the fall and winter.

The seasonality considered in this study stems solely from the October and May daily sales and producer delivery data upon which this research is based. As a result, all seasonality measures in this study refer to the difference between the October, 1977, and May, 1978 data. The seasonality factor for supply is computed by dividing the simulation average for supply in May by the corresponding figure for October. The demand factor is obtained similarly by using the simulation averages for demand. These factors applied to October values in the fashion described below generate estimates of seasonal reserves.

The October peak demand as computed in the operating reserves section represents the point of the year when supply is generally seasonally lowest relative to demand. It is here, then, that seasonal reserves are in theory at a minimum. It is assumed that this quantity is the amount of producer deliveries necessary to satisfy demand at this point, and that the simulation average demand is the demand level. Using the factors derived above to find the May points on the producer delivery and sales curves, yields the figures designated Q' in Table XXXVII. These points are determined for both local cooperative organization and central coordination, and the difference between peak demands and simulated averages shows total reserve requirements of

TABLE XXXVII

AVERAGE DAILY RESERVES, LOCAL COOPERATIVE ORGANIZATION AND CENTRAL COORDINATION, AMPI SOUTHERN REGION OCTOBER 1977 AND MAY 1978

	Local Cooperative Organization			Central Coordination		
	October Quantity (Q)	Factor	May Quantity (Q')	October Quantity (Q)	Factor	May Quantity (Q')
	(1,000 lbs.)		(1,000 lbs.)	(1,000 lbs.)		(1,000 lbs.)
Peak Demand	402,070	1.093	439,463	360,344	1.093	393,856
Actual Demand	346,000	.923	319,358	346,000	.923	319,358
Total Reserves			120,105			74,498
Needed Operating Reserves			54,307			25,477
Seasonal Reserves			65,798			49,021
Seasonal Reserves as % of Demand			20.6			15.3

120,105 thousand pounds under local cooperative organization and 74,498 thousand pounds under central coordination. Subtracting the needed operating reserves produces a seasonal reserve of 65,798 thousand pounds for local cooperative organization and 49,021 thousand for central coordination. Local cooperative organization requires a 20.6 percent seasonal reserve compared with a 15.3 percent under central coordination.

Figure 21 presents a graphic picture of the operating and seasonal reserves under local cooperative organization and central coordination. The AMPI average monthly sales for the Southern Region are shown by curve AB. The curve CD estimates actual producer delivery curve for the year. The difference between curves EF and AB is the operating reserve required under central coordination, while the difference between curves GH and AB is operating reserve necessary for local cooperative organization. It can be seen that the amount of operating reserves under central coordination is EA in May and FB in October. For local cooperative organization, the operating reserves in May are GA, and in October would need to be EB. A shortage of HD characterizes local cooperative organization operating reserve levels in October, and to correct that, producer deliveries would have to increase to the level pictured by curve IH.

Seasonal reserves can be observed from Figure 21 to be quantity CE for central coordination in May, and DF in October. For local cooperative organization the May seasonal reserves were CG. There were negative reserves in October.

The figures involving reserve requirements are predicated upon

1. the definition of "satisfying demand" as meeting demand requirements 83 percent of the time on the average.

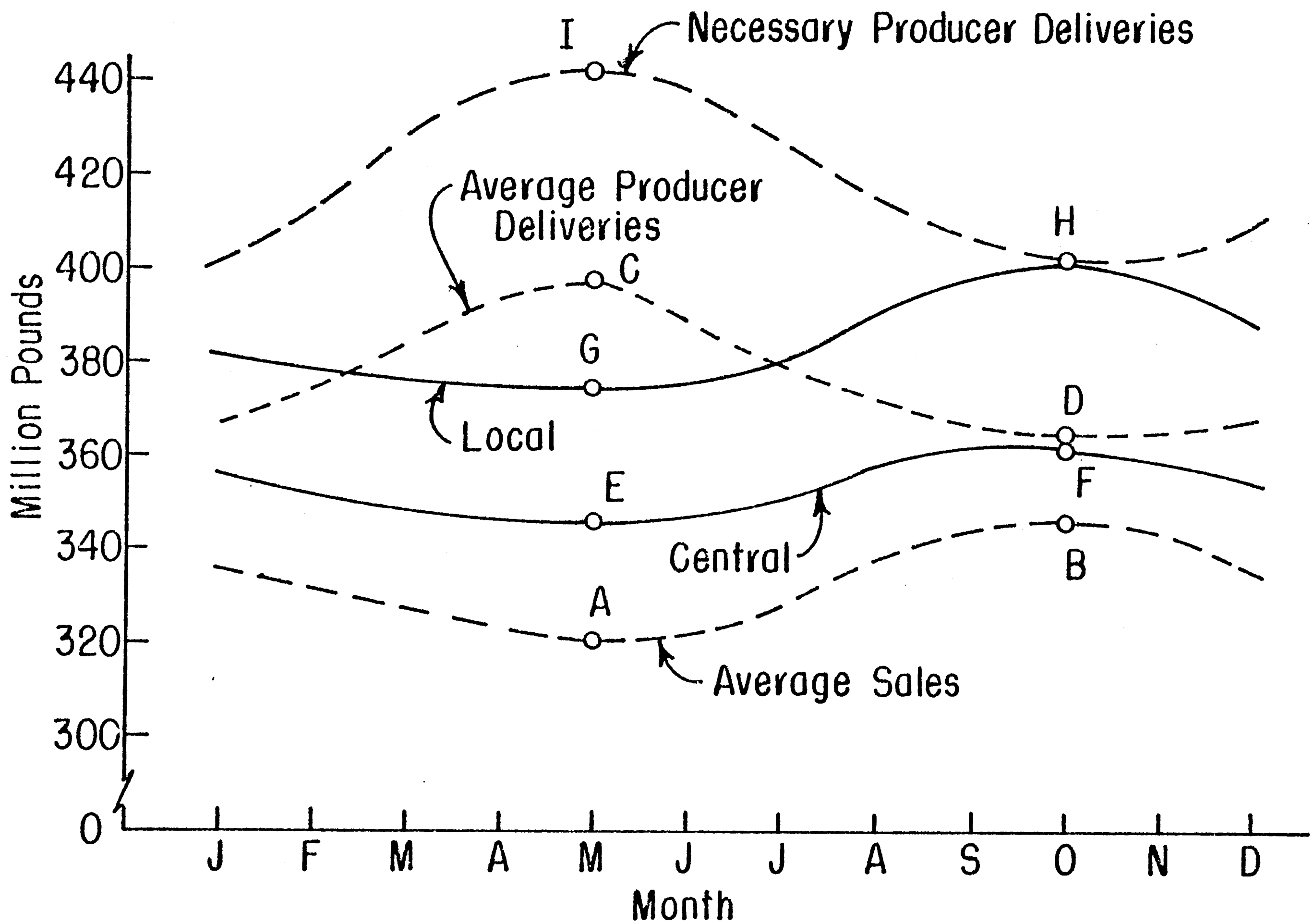


Figure 21. Seasonal and Operating Reserves, Local Cooperative Organization and Central Coordination, AMPI Southern Region, 1978

2. the use of daily sales and producer delivery data for October, 1977, and May, 1978, as the sole source of figures; no external estimates or parameters augmented this phase of the analysis

3. the computation of operating reserve levels from the weekday having the highest average level.

In summary it was found that for the Southern Region central coordination was able to reduce needed operating reserves by 53 percent in May of 1978 and by 75 percent in October of 1977. Actual reserves held under local cooperative organization would have been insufficient by 37,570 thousand pounds in October to satisfy demand; they were at a level of 22,893 thousand pounds in May. Central coordination held actual reserves of 4,156 and 51,723 thousand pounds in October and May, respectively. Seasonal reserves maintained under local cooperative organization would have been 20.5 percent of the May demand; for central coordination they were 15.3 percent. This represents a one-fourth reduction in seasonal reserve requirements under central coordination.

Cross-Haul Savings

One of the assumptions made by this research project is that transportation of milk under local cooperative organization was optimal in terms of cost within the local cooperative organization framework. In fact this was probably not the case. In a study made by Lamp (19) of Wisconsin's assembly patterns, he determined that a restructuring of milk procurement routes would result in an annual cost savings of 22 percent of the total milk hauling expenditures. These are, he states, a conservative estimate of savings that could be obtained by eliminating cross-hauling of milk and farm pickup route duplication in Wisconsin. If the same problems occurred to some degree in the Southern Region, then actual transportation costs for the local cooperative organization have been underestimated because this inefficiency due to cross-hauling was assumed away.

In order to estimate cross haul savings in the Southern Region for 1978, an average annual cost figure for 1978 was computed by averaging the monthly October and May local cost figures. The average of 1.328 million dollars and 1.424 million dollars is 1.376 million dollars; annualized it is 16.512 million dollars. The average annual volume is the average of the May and October producer deliveries, 397.9 and 364.5, respectively, multiplied times 12, or 4574 million pounds. Using Lamb's estimate of 22 percent to inflate the estimate of savings from central coordination would yield 3.646 million dollars, or about $.08 per cwt. for the Southern Region. This figure could overstate cross-haul savings for the Southern Region, as pickup routes within each local cooperative marketing areas were somewhat more structured than the Wisconsin system studied by Lamb. It is assumed for the estimations performed here that one-half of the potential economies found to hold in Wisconsin would apply to the area and situation of this study. The cross-haul savings under this assumption would be $.04 per cwt. for the 1978 period, or $1,829,600. Including the cross-haul savings, total annual transportation cost savings under central coordination would be $.173 per cwt., or $7,913,020, in 1978.

For 1968, the cross-haul savings that could have been effected by central coordination are computed in similar manner. The annualized average cost figure under local cooperative organization without cross-haul benefits is 16.86 million dollars. Lamb's estimate of 22 percent applied to this figure yields a total savings of 3,709 million dollars or about $.08 per cwt. Using a $.04 per cwt. expansion factor, the total annual transportation cost savings under central coordination for 1968 would have been $.161 per cwt., or $7,364.140.

Table XXXVIII summarizes in the Southern Region the savings due to central coordination in terms of assembly, cross-haul, and processing.

National Implications

The impact of savings through coordination as estimated for the Southern Region can be expanded to apply to the milk handled nationally by cooperatives. The producer deliveries of fluid milk in the U.S. totaled 77,091 million pounds in 1978 (39). Tucker (37) states that in 1973 some 76 percent of the total volume of milk produced by the nation's farmers was marketed by cooperatives. Cooperatives' share of this volume had been growing over time; it increased nine percent from 1957 to 1964, and nine percent between 1964 and 1973. Cook (11) estimated that nationally in 1974, 87.9 percent of all fluid milk was handled by cooperatives. This figure is used in conjunction with national production in 1978 to expand the results of this study to a national perspective. A total of 67,763 million pounds of milk was the resultant estimate marketed by cooperatives in 1978. Class I producer deliveries in 1978 were 41.43 million pounds (39) or 53.4 percent of total producer deliveries. Assuming that 10 percent of federal order producer deliveries went to Class II usage, 7,709 million pounds would have been the Class II utilization, and by subtraction 28,239 million

TABLE XXXVIII

TOTAL ANNUAL SAVINGS, CENTRAL COORDINATION,
AMPI SOUTHERN REGION AND U.S., 1978

	AMPI Southern Region	U.S.
Assembly		
$/cwt	.133	.133
Volume (mil. lbs.)	4574	67,763
Total Savings (mil. dol.)	6.1	90.2
Cross-Haul		
$/cwt	.04	.04
Volume (mil. lbs.)	4574	67,763
Total Savings (mil. dol.)	1.8	27.1
Processing		
$/cwt	.275	.275
Volume (mil. lbs.)	592.8	24,822
Total Savings (mil. dol.)	1.6	69.4
Total Annual Savings (mil. dol.)	9.5	186.7

pounds would have represented the Class III utilization. Class III milk marketed by cooperatives would have been 24,822 million pounds. The assembly and cross-haul benefits of coordination would apply to the total amount of milk marketed by cooperatives, or 67,763 million pounds while the processing benefits would have been realized in the Class III utilization total, or 24,822 million pounds. The savings for the Southern Region under central coordination as determined earlier were $.133 per cwt. for transportation, $.04 per cwt. for cross-hauling, and $.28 per cwt. for processing. Table XXXVIII shows the results of applying these savings figures to the national estimates derived above. The assembly phase realizes the most savings of $90.2 million dollars annually. The processing phase is second with 69.4 million dollars; and cross-hauling shows savings of $27.1 million dollars. Based on the results of this study, the total annual savings that would be realized under a nationally coordinated system is 186.7 million dollars.

CHAPTER V

SUMMARY AND CONCLUSIONS

SUMMARY

Milk is a commodity characterized by perishability, multiple products, geographically dispersed production and locally concentrated consumption. Supply and demand for fluid milk are seasonal in nature, and display opposite patterns where seasonal lows and highs occur. Milk is easily contaminated and is characterized by varying quality. These characteristics of milk present the milk marketing industry with challenges not associated with other commodities.

The marketing environment within which dairy cooperatives function is partly a function of these characteristics. It is characterized by federal market orders and price supports which influence the pricing and accountability for product utilization in marketing operations. Technology, too, plays a major role in shaping the marketing environment. Over the past several decades the number of processing firms has decreased substantially, and remaining firms have increased in size to take advantage of economies of size made available by recent technological advances. Geographical market areas have expanded with technological innovations. Mergers of dairy cooperatives have occurred as cooperatives have strived to cope with the changing market environment, and have attempted to provide services that are in harmony with producer requirements.

As a result of the increasing scope and size, dairy cooperatives have been able to take on an increasingly greater share of the coordination activities in milk marketing. Much of the coordination at the assembly stage was previously carried out by handlers or small cooperatives, as they accepted the responsibility of locating sources of milk. Cooperatives were suited to assuming these duties, as they were able to receive and interpret information and signals more effectively than individual handlers. They were able to buffer short-run surplus and deficit fluid milk supplies throughout a large geographical area and were able to minimize failures to meet demand. Through central management of fluid milk supplies, they were able to obtain efficiencies that were previously not present.

This study has measured some of the efficiencies gained through coordination by a regional cooperative in the Southwestern United States. Specific estimates of cost savings were made and compared for two time periods for a market environment characterized by small local markets, each being served by a small dairy cooperative, and for the total geographical market are coordinated by a large regional cooperative. Areas in which estimates were made were assembly and delivery transportation costs, processing costs of surplus milk, and seasonal and operating reserve levels. The model built to perform these estimates was set up to simulate twenty time periods varying around an average set of supply-demand relationships, and average and extreme values for the estimates were studied.

Conclusions

Substantial benefits are being realized through central management practices of large regional dairy cooperatives. In the Southwestern United States, specific savings are present in assembly and delivery transportation costs, processing costs and surplus milk. Benefits are also seen in the substantially reduced seasonal and operating reserve requirements under a centrally coordinated market structure.

Cost Savings

The average annual savings in assembly and delivery transportation costs brought about by coordination was $.121 per cwt. for the 1968 situation, or $5,535,000. For the 1978 situation the estimate of savings was $.133 per cwt., or $6,084,000.

Savings in processing costs came about as the configuration of manufacturing facilities was changed by the elimination of economically inefficient plants, the creation of the new plant at El Paso, and increased capacities of remaining plants. Total annual savings in processing costs due to coordination would have been about $.025 per cwt. in 1968. Changes in the manufacturing plant configuration brought about by central coordination under the management of AMPI produced savings of about $.275 per cwt. in 1978, or about $1,630,000. Processing savings on a per hundredweight basis increased tenfold between 1968 and 1978. A conservative estimate of $.04/cwt. from another study was used to estimate cross-haul savings. Including this, total annual savings due to coordination in the Southern region of AMPI would have been about $7,369,000 in 1968 and about $9,543,000 in 1978.

The savings estimated by this study were expanded to apply to all milk handled nationally by cooperatives in 1978. The estimate of transportation savings for the assembly and delivery phases was $90.2

million dollars, the savings due to cross-haul elimination and routing efficiencies would have been about 27.1 million dollars, and the savings in processing costs were 69.4 million dollars. The total savings that would be realized through nationally coordinated milk marketing in 1978 was 186.7 million dollars.

Reserve Levels

Reserve levels are of two types, operating and seasonal. Operating reserves refer to the quantities of milk that must be maintained throughout a week in order that demand be met at peak times during the week. Seasonal reserves refer to the quantity of milk that is produced by the same number of producers throughout a year which is in excess of average demand plus operating reserves. Centrally coordinated management of reserves has the potential of reducing the quantities required for both seasonal and operating reserves.

For this study, central coordination was able to reduce needed operating reserves in the Southern Region by 53 percent in May of 1978 and by 75 percent in October of 1977. Seasonal reserves during the peak production period, May, were reduced by 25 percent through central coordination.

Limitations

This study considered county seats as the smallest locational level in the model. All intra-county movements of milk were consequently ignored. A precise estimate of savings through coordination due to optimization of pickup routes was not included in the model, but a rough estimate of cross-haul savings was included from a Wisconsin study. It was decided that a conservative one-half of the economies obtained for Wisconsin would be used for the Southern Region.

The import structure as implemented in this study could be improved. It was set up with a cost comprised of two parts: a $.10 per cwt. handling charge plus an additional hauling fee equal to 33 percent above the regular transportation cost. The handling charge here is very conservative, and might be more realistic if increased to $.25 per cwt. The way in which imports were brought into the model was from Kansas City, and the precise entry point was at Kansas City for the local cooperative organization, but at Hillsboro, Kansas or Linn, Kansas under central coordination. Distance charges were not 33 percent above normal for the entire length of haul, but only to the entry point. In actuality this charge would apply from Kansas City to the use point for the import. This feature was a minor part of the general model, and as such would probably not have much impact on final results if it were further refined.

Implications

The results of this study imply that given the environment within which dairy cooperatives function as they market producers' milk, the coordination benefits realized by regional coordination are substantial in terms of dollar savings. Benefits as yet unrealized remain to be achieved through coordinating even greater geographical areas by dairy cooperatives, perhaps on a national basis. If dairy cooperatives worked to carry out coordination at the national level, many millions of dollars would be saved each year in marketing costs. The national estimates determined by this study are made leaving the manufacturing plant configuration unchanged. This study showed the increase in savings achieved in the Southern region when AMPI closed some inefficient plants and built a new one. If the process were carried out in such a way as to optimize manufacturing plant locations and capacities at the national level, it is possible that resultant savings could be increased substantially over the 186.7 million dollar estimate of this study.

These implications suggest that the development of large regional cooperatives has reduced the real cost of marketing milk and provided the opportunity for benefiting both consumers and producers. The shares of these benefits accruing to consumers and to producers have not been estimated, but with no supply controls at the producer level, the shares would depend on

1) the elasticities of demand and supply
2) any shift in the supply schedule attributable to coordination, and
3) any divergence of price from the levels indicated by equilibrium of demand and supply in a long-run context.

Further Research

The basic issue of benefits brought to producers and consumers through coordination in milk marketing by regional cooperatives requires further research. There has been little research into the real effects on producers or consumers of milk marketing under a purely competitive structure with its associated uncertainties and instabilities as estimated by this study. Social equity benefits to producers and consumers brought about by regional cooperatives would require additional research involving three steps.

First, the costs or benefits, both real and social, to producers and consumers should be estimated under a purely competitive market structure. This would include examining pickup of raw milk at the producer level, the assembly and delivery to handlers, and the processing of surplus. Absolute costs of transportation, storage and processing of surplus milk should be studied under an atomistic buyer and seller structure, as specified under pure competition. Social concerns and related measurement in areas such as price stability, quality of product, equity of returns to individual producers, and demand satisfaction in terms of time, place and form utility would necessarily be a part of a comprehensive study on the relationship of pure competition to milk marketing.

Second, the same set of absolute and social costs should be estimated under a regionally coordinated market structure. Additional benefits stemming from services provided by regional cooperatives should be delineated, measured and included in the analysis. These should be compared with estimates associated with the purely competitive norm.

Third, both sets of costs should be expanded to relate nationally and resultant figures compared. In this manner the actual effects of a purely competitive market structure on producers and consumers could be assessed.

Specific areas for further research include savings to be realized at the farm pickup stage. More accurate estimates of savings that can be achieved at that level through efficient routing schedules and cross-haul elimination are needed. These savings may vary in different areas of the country, so regional estimates are needed.

Much work also remains to be done toward quantifying costs of all the services provided by large regional cooperatives. These services need to be defined, and precise benefits discussed in terms of what they are and to whom they accrue. Actual costs must be estimated for each individual service, and the portion of these costs borne by cooperatives should be estimated. Also important is what portion of these costs is reflected in the price of milk paid by handlers.

A SELECTED BIBLIOGRAPHY

(1) Agrawal, R. C. and Earl O. Heady. Operations Research Methods for Agricultural Decisions. Ames, Iowa: The Iowa State University Press, 1972.

(2) Arnold, Richard A. Special Unpublished Tabulations. Tulsa, Oklahoma: Federal Milk Market Administrator, USDA, April, 1980.

(3) Bartlett, M. S. "Some Examples of Statistical Methods of Research in Agriculture and Applied Biology". Journal of the Royal Statistical Society, (Supplement) 4, 2 (1937), pp. 137-170.

(4) Blakley, Leo V. "Theoretical Considerations of Intermarket Price Alignment for Milk". Stillwater, Oklahoma: Agricultural Economics Paper No. 6514, June, 1965.

(5) Boehm, William T. and M. C. Conner. "Technically Efficient Movement Patterns and Manufacturing Plant Locations Under Regionally Coordinated Milk Assembly". American Journal of Agricultural Economics, 59, 3 (1977), pp. 520-524.

(6) Box, G. E. P. and S. L. Gould. "Permutation Theory in the Derivation of Robust Criteria and the Study of Departures from Assumption". Journal of the Royal Statistical Society, Series B, 17, 1 (1955), pp. 1-29.

(7) Bressler, Raymond G., Jr. and Richard A. King. Markets, Prices and Interregional Trade. Raleigh, N.C.: Norman-Weathers Printing Co., 1978.

(8) Buccola, Steven T. and M. C. Conner. Potential Efficiences Through Coordination of Milk Assembly and Milk Manufacturing Plant Location in the Northeastern United States. Blacksburg, Virginia: Virginia Polytechnic Institute and State University Research Division Bulletin No. 149, July 1979.

(9) Christensen, Rondo A., Douglas E. Petterson, and Allan H. Swainston. The Function and Cost of Market Milk Reserves and Balancing Supply with Demand. Logan, Utah: Economics Research Institute Study Paper No. 79-8, September 1979.

(10) Cook, Hugh L., Leo Blakley, and Calvin Berry. Review of Eisenstat, Philip, Robert T. Masson and David Roddy "An Analysis of the Associated Milk Producers, Inc. Monopoly". Madison, Wisconsin: University of Wisconsin-Madison College of Agriculture and Life Sciences Research Division Bulletin R2790, 1976.

(11) Cook, Hugh, L., Leo Blakley, Robert Jacobson, Ronald Knutson, Robert Milligan, and Robert Strain. The Dairy Subsectors of American Agriculture: Organization and Vertical Coordination. Madison, Wisconsin: North Central Regional Research Publication 257, 1978.

(12) Deason, Charles. Unpublished Study. San Antonio, Texas, 1979.

(13) Dunham, Chapman E. Special Unpublished Tabulations. Dallas, Texas: Federal Milk Market Administrator, USDA, April, 1980.

(14) Eisenstat, Phillip, Robert T. Masson and David Roddy. An Economic Analysis of the Associated Milk Producers Inc. Monopoly. Washington, D. C.: U. S. Department of Justice, 1971.

(15) Ferguson, C. E. and J. P. Gould. Microeconomic Theory. 4th Edition. Homewood, Illinois: Richard D. Irwin, Inc., 1975.

(16) Fisher, R. A. Statistical Methods for Research Workers. 4th Edition. New York: Hafner Publishing Company, 1973.

(17) Goodnight, James H., Anthony J. Barr, and John P. Sall. SAS User's Guide. 1979 Edition. Raleigh, N.C.: Sas Institute, Inc., 1979.

(18) Hillier, Frederick S. and Gerald J. Lieberman. Operations Research. 3rd Edition. San Francisco: Holden-Day, Inc., 1980.

(19) Lamb, Leslie F. Potential Savings In Farm To Plant Milk Assembly. Wisconsin: Wisconsin Department of Agriculture, Trade and Consumer Protection Bulletin No. EU-180, July 1980.

(20) Lasley, Floyd A. Coordinating Fluid Milk Supplies in the Oklahoma Metropolitan Milk Market. Washington, D. C.: U.S. Department of Agriculture Marketing Research Report No. 686, November 1964.

(21) Lasley, Floyd A. Coordinating Fluid Milk Supplies in the Pittsburgh Market. Washington, D. C.: U. S. Department of Agriculture Marketing Research Report No. 746, November 1964.

(22) Leftwich, Richard H. The Price System and Resource Allocation. 5th Edition. Hinsdale, Illinois: The Dryden Press, 1973.

(23) MacAvoy, Paul W., (Ed.). Federal Milk Marketing Orders and Price Supports. Washington, D. C.: American Enterprise Institute for Public Policy Research, 1977.

(24) Manchester, Alden Coe. Market Structure, Institutions and Performance in the Fluid Milk Industry. Washington, D. C.: U. S. Department of Agriculture Economic Research Service Bulletin No. 248, 1974.

(25) Manchester, Alden Coe. "The Structure of the Fluid Milk Market, Two Decades of Change." Washington, D. C.: ERS-USDA Agricultural Economics Report No. 137, 1968.

(26) Mueller, Willard F., Larry G. Hamm, and Hugh L. Cook. Public Policy Toward Mergers in the Dairy Processing Industry. Madison, Wisconsin: North Central Regional Research Publication 23 (NC Project 117 Monograph 3), December 1976.

(27) Ostle, Bernard. Statistics In Research. Ames, Iowa: The Iowa State University Press, 1963.

(28) Parker, Russell C. Economic Report on the Diary Industry. U. S. Federal Trade Commission Staff Report, March 19, 1973.

(29) Shapiro, S. S. and M. B. Wilk. "An Analysis of Variance Test for Normality (Complete Samples)." Biometrika, 52 (1965), pp. 591-611.

(30) Smith, Blair J., Homer B. Metzger, and Floyd A. Lasley. Fluid Milk Reserves and Production -Consumption Balances in Northeastern United States. University Park: Pennsylvania Agricultural Experiment Station Bulletin 819, May 1978.

(31) Snedecor, G. W. Analysis of Variance and Covariance. Ames, Iowa: Collegiate Press, Inc., 1934.

(32) Snedecor, G. S. Statistical Methods. Ames, Iowa: Collegiate Press, 1946.

(33) Snedecor, G. W. Statistical Methods. Sixth Edition. Ames, Iowa: The Iowa State University Press, 1967.

(34) Stellmachér, Michael J. "Mergers and Efficiency in Cooperative Milk Assembly and Manufacturing in the Southwest". (M. S. Thesis, Oklahoma State University, 1979).

(35) Stellmacher, Michael J. and Leo V. Blakley. Efficiencies in Milk Assembly and Manufacturing Through Cooperative Mergers in the Southwest. Stillwater, Oklahoma: Oklahoma Agricultural Experiment Station Bulletin B-756, March 1981.

(36) Stellmacher, Michael J. and Leo V. Blakley. Processing Cost Estimates for the Study of Efficiencies in Milk Assembly and in Manufacturing through Co-operative Mergers in the Southwest. Stillwater, Oklahoma: Ag. Econ. Dept. Paper 8107, Oklahoma Agricultural Experiment Station, January, 1981.

(37) Tucker, George, C., William J. Monroe, and James B. Roof. Marketing Operations of Dairy Cooperatives. Washington, D. C.: U. S. Department of Agriculture, Farmer Cooperative Service Research Report 38, June, 1977.

(38) U. S. Department of Agriculture. Federal Milk Order Market Statistics: Annual Summary for 1969. Washington, D. C.: U. S. Government Printing Office, June, 1980.

(39) U. S. Department of Agriculture. Federal Milk Order Market Statistics: Annual Summary for 1979. Washington, D. C.: U. S. Government Printing Office, June, 1980.

(40) U. S. Department of Agriculture. Sources of Milk for Federal Order Markets in 1967. Washington, D. C.: U. S. Government Printing Office, May, 1975.

(41) U. S. Department of Commerce. Counties and County Equivalents of the United States Federal General Data Standard Representations and Codes. Washington, D. C.: FIPS Publication 6-2, June, 1970.

TABLE XXXIX

SELECTED STATISTICS FOR TESTING DISTRIBUTION OF DAILY SALES BY AMPI SOUTHERN REGION, TUESDAYS, OCTOBER 1977 AND MAY 1978

	Firm Size Code							
	1	2	3	4	5	6	7	8
			All Markets, October, 1977					
N	5	6	42	57	79	72	47	16
D	-	-	-	.207	.074	.071	-	-
W	.728	.688	.697	-	-	-	.961	.930
Probability	.03	.01	.01	.01	.15	.15	.25*	.31*
			All Markets, May, 1978					
N	85	9	17	66	105	89	60	20
D	-	-	-	.165	.130	.079	.159	-
W	.518	.728	.539	-	-	-	-	.949
Probability	.01	.01	.01	.01	.15	.15	.01	.40*

*Rejected at the .15 level
N is the number of observations; D is the Kolmogorov-Smirnov D-Statistic; W is the Shapiro-Wilk W-Statistic

TABLE XL

SELECTED STATISTICS FOR TESTING DISTRIBUTION
OF DAILY SALES BY AMPI SOUTHERN REGION,
WEDNESDAYS, OCTOBER 1977 AND MAY 1978

	Firm Size Code							
	1	2	3	4	5	6	7	8
	All Markets, October, 1977							
N	4	7	35	52	75	68	42	16
D	-	-	-	.286	.120	.131	-	-
W	.834	.828	.526	-	-	-	.978	.873
Probability	.22*	.09	.01	.01	.01	.01	.67*	.03
	All Markets, May, 1978							
N	2	14	20	57	86	81	52	20
D	-	-	-	.201	.152	.084	.083	-
W	1	.798	.757	-	-	-	-	.914
Probability	1*	.01	.01	.01	.01	.13	.15	.08

*Rejected at the .15 level
N is the number of observations; D is the Kolmogorov-Smirnov D-Statistic; W is the Shapiro-Wilk W-Statistic

TABLE XLI

SELECTED STATISTICS FOR TESTING DISTRIBUTION OF DAILY SALES BY AMPI SOUTHERN REGION, THURSDAYS, OCTOBER 1977 AND MAY 1978

	Firm Size Code							
	1	2	3	4	5	6	7	8
	All Markets, October, 1977							
N	8	6	38	52	84	72	44	16
D	-	-	-	.233	.085	.099	-	-
W	.886	.845	.523	-	-	-	.943	.935
Probability	.27*	.17*	.01	.01	.14	.08	.05	.36*
	All Markets, May, 1978							
N	7	9	18	50	86	69	48	16
D	-	-	-	-	.166	.067	-	-
W	.931	.891	.913	.958	-	-	.951	.870
Probability	.53*	.27*	.10	.16*	.01	.15	.08	.03

*Rejected at the .15 level
N is the number of observations; D is the Kolmogorov-Smirnov D-Statistic; W is the Shapiro-Wilk W-Statistic

TABLE XLII

SELECTED STATISTICS FOR TESTING DISTRIBUTION OF DAILY SALES BY AMPI SOUTHERN REGION, FRIDAYS, OCTOBER 1977 AND MAY 1978

	Firm Size Code							
	1	2	3	4	5	6	7	8
				All Markets, October, 1977				
N	5	6	27	54	87	69	44	16
D	-	-	-	.161	.116	.137	-	-
W	.934	.783	.847	-	-	-	.980	.873
Probability	.55*	.05	.01	.01	.01	.01	.74*	.03
				All Markets, May, 1978				
N	6	9	4	43	84	67	47	16
D	-	-	-	-	.098	.072	-	-
W	.787	.823	.932	.932	-	-	.877	.876
Probability	.05	.05	.02	.02	.02	.15	.01	.04

*Rejected at the .15 level

N is the number of observations; D is the Kolmogorov-Smirnov D-Statistic; W is the Shapiro-Wilk W-Statistic

TABLE XLIII

SELECTED STATISTICS FOR TESTING DISTRIBUTION OF DAILY SALES BY AMPI SOUTHERN REGION, SATURDAYS, OCTOBER 1977 AND MAY 1978

	Firm Size Code							
	1	2	3	4	5	6	7	8
				All Markets, October, 1977				
N	1	4	32	65	91	66	51	20
D	-	-	-	.250	.113	.098	.129	-
W	-	.908	.863	-	-	-	-	.943
Probability	-	.43*	.01	.01	.01	.12	.03	.34*
				All Markets, May, 1978				
N	1	8	11	36	70	56	41	16
D	-	-	-	-	.160	.076	-	-
W	-	.749	.602	.973	-	-	.938	.969
Probability	-	.01	.01	.60*	.01	.15	.04	.78*

*Rejected at the .15 level

N is the number of observations; D is the Kolmogorov-Smirnov D-Statistic; W is the Shapiro-Wilk W-Statistic

TABLE XLIV

SELECTED STATISTICS FOR TESTING DISTRIBUTION OF DAILY SALES BY AMPI SOUTHERN REGION, SUNDAYS, OCTOBER 1977 AND MAY 1978

	Firm Size Code							
	1	2	3	4	5	6	7	8
				All Markets, October, 1977				
N	11	4	32	68	83	76	50	20
D	-	-	-	.249	.145	.155	-	-
W	.567	.717	.505	-	-	-	.954	.909
Probability	.01	.03	.01	.01	.01	.01	.10	.06
				All Markets, May, 1978				
N	5	5	12	37	65	62	40	16
D	-	-	-	-	.194	.090	-	-
W	.687	.687	.568	.930	-	-	.939	.901
Probability	.01	.01	.01	.04	.01	.15	.05	.09

*Rejected at the .15 level
N is the number of observations; D is the Kolmogorov-Smirnov D-Statistic; W is the Shapiro-Wilk W-Statistic

TABLE XLV

SELECTED STATISTICS FOR TESTING DISTRIBUTION OF DAILY SALES BY AMPI SOUTHERN REGION, POOLED BY FIRM SIZE OR MONTH, MONDAYS, OCTOBER 1977 AND MAY 1978

Size	N	D	W	Probability
1	15	-	.413	.01
2	21	-	.620	.01
3	64	.377	-	.01
4	135	.180	-	.01
5	212	.148	-	.01
6	178	.077	-	.01
7	117	.065	-	.15
8	40	-	.941	.05
October	411	.145	-	.01
May	378	.137	-	.01
Total	789	.132	-	.01

*Rejected at the .15 level
N is the number of observations; D is the Kolmogorov-Smirnov D-Statistic; W is the Shapiro-Wilk W-Statistic

TABLE XLVI

SELECTED STATISTICS FOR TESTING DISTRIBUTION OF DAILY SALES BY AMPI SOUTHERN REGION, POOLED BY FIRM SIZE OR MONTH, TUESDAYS, OCTOBER 1977 AND MAY 1978

Size	N	D	W	Probability
1	13	-	.443	.01
2	15	-	.755	.01
3	59	.256	-	.01
4	123	.189	-	.01
5	184	.100	-	.01
6	161	.050	-	.15
7	107	.134	-	.01
8	36	-	.977	.70*
October	324	.165	-	.01
May	383	.153	-	.01
Total	707	.158	-	.01

*Rejected at the .15 level

N is the number of observations; D is the Kolmogorov-Smirnov D-Statistic; W is the Shapiro-Wilk W-Statistic

TABLE XLVII

SELECTED STATISTICS FOR TESTING DISTRIBUTION OF DAILY SALES BY AMPI SOUTHERN REGION, POOLED BY FIRM SIZE OR MONTH, WEDNESDAYS, OCTOBER 1977 AND MAY 1978

Size	N	D	W	Probability
1	6	-	.835	.14
2	21	-	.801	.01
3	55	.365	-	.01
4	109	.240	-	.01
5	161	.114	-	.01
6	155	.096	-	.01
7	94	.067	-	.15
8	36	-	.969	.49*
October	300	.168	-	.01
May	347	.138	-	.01
Total	647	.152	-	.01

*Rejected at the .15 level

N is the number of observations; D is the Kolmogorov-Smirnov D-Statistic; W is the Shapiro-Wilk W-Statistic

TABLE XLVIII

SELECTED STATISTICS FOR TESTING DISTRIBUTION OF DAILY SALES BY AMPI SOUTHERN REGION, POOLED BY FIRM SIZE OR MONTH, THURSDAYS, OCTOBER 1977 AND MAY 1978

Size	N	D	W	Probability
1	15	-	.930	.34*
2	15	-	.862	.03
3	56	.358	-	.01
4	102	.202	-	.01
5	170	.106	-	.01
6	141	.055	-	.15
7	927	.065	-	.15
8	32	-	.961	.40*
October	320	.155	-	.01
May	309	.135	-	.01
Total	629	.136	-	.01

*Rejected at the .15 level
N is the number of observations; D is the Kolmogorov-Smirnov D-Statistic; W is the Shapiro-Wilk W-Statistic

TABLE XLIX

SELECTED STATISTICS FOR TESTING DISTRIBUTION OF DAILY SALES BY AMPI SOUTHERN REGION, POOLED BY FIRM SIZE OR MONTH, FRIDAYS, OCTOBER 1977 AND MAY 1978

Size	N	D	W	Probability
1	11	-	.653	.01
2	15	-	.665	.01
3	31	-	.836	.01
4	97	.168	-	.01
5	171	.100	-	.01
6	136	.101	-	.01
7	91	.130	-	.01
8	32	-	.951	.25*
October	308	.171	-	.01
May	282	.137	-	.01
Total	590	.148	-	.01

*Rejected at the .15 level

N is the number of observations; D is the Kolmogorov-Smirnov D-Statistic; W is the Shapiro-Wilk W-Statistic

TABLE L

SELECTED STATISTICS FOR TESTING DISTRIBUTION OF DAILY SALES BY AMPI SOUTHERN REGION, POOLED BY FIRM SIZE OR MONTH, SATURDAYS, OCTOBER 1977 AND MAY 1978

Size	N	D	W	Probability
1	2	-	1.0	1.0*
2	12	-	.806	.01
3	43	-	.779	.01
4	101	.224	-	.01
5	161	.101	-	.01
6	122	.034	-	.15
7	92	.103	-	.02
8	36	-	.952	.22*
October	330	.165	-	.01
May	245	.180	-	.01
Total	575	.160	-	.01

*Rejected at the .15 level

N is the number of observations; D is the Kolmogorov-Smirnov D-Statistic; W is the Shapiro-Wilk W-Statistic

TABLE LI

SELECTED STATISTICS FOR TESTING DISTRIBUTION OF DAILY SALES BY AMPI SOUTHERN REGION, POOLED BY FIRM SIZE OR MONTH, SUNDAYS, OCTOBER 1977 AND MAY 1978

Size	N	D	W	Probability
1	16	-	.620	.01
2	9	-	.639	.01
3	44	-	.477	.01
4	105	.241	-	.01
5	148	.161	-	.01
6	138	.099	-	.01
7	907	.073	-	.15
8	36	-	.943	.09
October	344	.152	-	.01
May	248	.150	-	.01
Total	592	.143	-	.01

*Rejected at the .15 level
N is the number of observations; D is the Kolmogorov-Smirnov D-Statistic; W is the Shapiro-Wilk W-Statistic

2

VITA

Marilyn Graves Kletke

Candidate for the Degree of

Doctor of Philosophy

Thesis: EFFICIENCIES IN COORDINATION OF FLUID MILK SUPPLIES THROUGH COOPERATIVE MERGERS IN THE SOUTHWEST

Major Field: Agricultural Economics

Biographical:

Personal Data: Born in Los Alamos, New Mexico, September 19, 1945, the daughter of Dr. and Mrs. Alvin C. Graves.

Education: Graduated from Los Alamos High School, Los Alamos, New Mexico, in May, 1962; received the Bachelor of Arts degree in Mathematics from Colorado College, Colorado Springs, Colorado, in May, 1966; received the Master of Science degree in Computer Science from Iowa State University, Ames, Iowa, in May, 1970; completed requirements for the Doctor of Philosophy degree at Oklahoma State University in December, 1981.

Professional Experience: Mathematics Teacher, Collins Public School, Collins, Iowa, September, 1966 through May, 1967; Graduate Research and Teaching Assistant, Department of Computer Science, Iowa State University, June, 1967 through May, 1970; Instructor, Department of Agricultural Economics, Oklahoma State University, January, 1971 through January, 1981; Graduate Research Assistant, Department of Agricultural Economics, Oklahoma State University, March, 1981 through August, 1981.