MERGERS AND EFFICIENCY IN COOPERATIVE MILK ASSEMBLY AND MANUFACTURING IN THE SOUTHWEST

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PREFACE

This study is concerned with estimating the effects of cooperative mergers on the milk marketing efficiency in the Southwest United States. Specific objectives include determining a market structure that may have existed in the absence of cooperative mergers, and comparing assembly and processing costs under the alternative market structures.

I wish to thank Dr. Leo Blakley, my major adviser, for providing the needed direction and for his patience and assistance in completing this study. Drs. James Plaxico and Paul Hummer are appreciated for serving on my committee and for their constructive comments regarding this study. To Meg Kletke and Elton Li go special thanks for their efforts and excellence in obtaining the necessary computer results. I'd also like to thank Dr. James Osborn and the Department of Agricultural Economics for providing and maintaining financial support during my course of study here. Dr. Ron Shaffer of the University of Wisconsin and Dr. H. Evan Drummond are gratefully acknowledged for their guidance before and early in my graduate program. Debbie Glazner, Judy Ivy, Lori Farris, and Lynita Gillespie are to be commended for their efforts in preparation of the rough draft. Le Ann Snavely is thanked for fine appearance of the final manuscript.

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TABLE OF CONTENTS

LIST OF TABLES

Table		Page

Table | Page

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Milk is a unique agricultural commodity distinguished by its perishability and the wide variety of product forms it can assume. A high degree of coordination is necessary to efficiently integrate the production, assembly, processing and distribution functions to guarantee the product mix marketed is what consumers demand. Coordination is required with respect to space, time, type and quality of product, and quantities.

Technological developments in the dairy industry since World War II made available large potential economies of size in fluid milk processing. Such innovations along with reciprocity of inspection among milk market areas tended to increase the volume and geographic coverage of individual processing firms. Many firms accomplished this through merger activity; while other firms, lacking the financial resources to adopt new technology, saw their ability to compete against larger, more efficient processors erode and ultimately disappear. As a result, the number of fluid milk processors in the United States decreased from 16,000 in 1950 to 3,000 in 1971.

During this period a single milk producers' cooperative typically served fluid handlers in each major city or market area. Due to the large decrease in the number of fluid processors, local cooperatives came to depend on fewer customers, mainly large national or regional proprietary firms with processing and distribution activities in many markets. Thus a cooperative often found itself competing with cooperatives in other milksheds that supplied a common processing firm that operated in many markets. Producer cooperatives retained little market power vis-a-vis the regional or national processing firms. Low returns to producers characterized the period.

In an attempt to offset fluid processors' market power, milk cooperatives formed federations, or marketing agencies-in-common. By doing so, competition between producers' cooperatives was legally eliminated. One primary objective of federations was to increase the market power of member cooperatives through coordination of their marketing activities.

A final organizational change in establishing a countervailing power to the regional and national fluid processors was the creation of large regional cooperatives. To perpetuate and expand the gains due to federation, many of the federations' member cooperatives pursued merger. The number of dairy cooperatives has decreased from 36 to 15 over the period 1964 to 1973 in the south central United States.[1]

With the advent of large regional cooperatives, producers' organizations have taken on a larger role in the coordination of the milk marketing system. Increased coordination does not enhance competition. Coordination in the milk marketing system by cooperatives may have the effect of reducing competition among producers' groups. Although court tests have upheld the antitrust exemption for producers organizing under the Capper-Volstead Act, the Supreme Court has said the act "does not suggest a congressional desire to vest cooperatives with unrestricted power to restrain trade or to achieve monopoly" through predatory and/or monopolistic practices.[2]

Large market shares of the regional cooperatives resulted in the Justice Department initiating antitrust litigation against the three largest cooperatives, alleging monopolistic and predatory conduct. Such litigation focused upon the practices of cooperatives and the effect such practices had on the marketing system. Ignored was the coordination role performed by large regional milk bargaining cooperatives, which may have increased the efficiency of the marketing system.

Cooperatives in the Milk Marketing System

Technological developments in the dairy industry provided early incentives for the formation of large regional cooperatives. Bulk tank farm procurement, improved road networks, one-way paper containers, and in-route refrigeration created large potential economies of size in fluid milk processing and distribution. As a result, the number of fluid processors decreased dramatically with the remaining firms generally enlarging their volume and geographic coverage.

Milk producers' cooperatives operating in a single market competed against each other in serving processing firms that maintained activities in many markets. Unable to match fluid processors market power, the 1950's and early 1960's were characterized by very low returns to dairy farmers and a growing inability of cooperatives to bargain effectively for higher prices.

Another early impetus for cooperative mergers occurred mainly in the Upper Midwest when after World War II there was considerable consolidation of community churning cooperatives. Operational efficiencies due to technology were the prime motivation for the mergers.

Improved trucks and road systems made access to larger geographic regions possible. At the producer level, the practice of separating the cream on the farm and feeding the skim to livestock was abandoned in favor of marketing whole milk. With increased amounts of skim milk being marketed, spray driers were developed to more efficiently process the skim milk into nonfat dry milk. But spray driers were uneconomical at the volumes of most existing cooperative creameries. As a result, many local producer cooperatives merged into larger operations producing both butter and nonfat dry milk.

Within the dairy industry, institutional developments also affected the growth of regional milk marketing cooperatives. The Agricultural Marketing Agreement Act of 1937 set up the legal apparatus for the establishment of milk marketing orders. Such orders were intended to bring about orderly marketing conditions and satisfactory prices for producers.

Because organized producers were necessary to present evidence to effect or amend orders, milk cooperatives played an instrumental role in establishing market orders. And the practice allowing cooperatives to vote on behalf of their members as a block on creation or amendment of orders resulted in further incentive in bringing about large regional cooperatives.

In response to the low returns to dairying in the 1950's, producers and their cooperatives appealed to market order administrators, calling attention to the price improvement objectives of the Agricultural Marketing Agreements Act. Administrators cited primarily supply and demand criteria as means for setting price. This apparent nonresponsiveness to the income problems of dairy farmers by the market order system provided further impetus to the cooperative merge movement.

Most states adopted a uniform milk ordinance recommended by the U. S. Public Health Service providing for reciprocity of inspection. This allowed processors to expand their markets, as well as facilitated the importation of Grade A milk into market areas from alternative producers. The wider acceptance of Grade A ordinances increased the market power of processors relative to producers and contributed to the problem of low producer returns.

A final area where institutions have affected the cooperative merger movement is in the area of antitrust policy and litigation. Agricultural producers were not exempted under the Sherman Antitrust Act, thus producers' organizations formed to restrict competition among themselves were illegal in the early 1900's. The Capper-Volstead Act of 1922 specifically exempted agricultural producers' organizations meeting certain criteria from antitrust legislation. In the case of Maryland-Virginia Milk Producers Association vs. U. S., the Supreme Court upheld the Capper-Volstead exemption, but determined cooperatives are subject to litigation with respect to monopolistic and/or predatory conduct.

The Supreme Court ruled compensatory payments unconstitutional in the case of Lehigh Valley Cooperative Farmers, Inc. et al. vs. United States et al. Compensatory payments were made to a federal order pool of local producers by handlers outside the market shipping milk into that market. The purpose of the payments was to reimburse local producers for the loss of Class I sales. Producers viewed this decision as another setback to achieving equitable returns.

At the proprietary handler level, the Federal Trade Commission, in response to the mid-1950's merger activity of fluid processors, has restricted horizontal combinations. Such actions acknowledged the potential market power fluid processors possessed in the milk marketing system.

Results of the technological and institutional developments in the dairy industry include the increased mobility of bulk milk, greater intermarket movement of packaged milk, and the growth in market power of fluid processors relative to producers and their cooperatives. Cooperatives had appealed to the government in trying to increase producer incomes but received little response. The cooperatives then turned to further self-help by expanding working relationships with other milk cooperatives as an income increasing means.

As a first step, local producers' cooperatives joined together to form federations. The primary purpose of the federations was to increase the coordination between cooperatives to better meet member cooperatives' objectives through collective bargaining, joint action in Federal Order hearings, and political action.

Federation of milk producers' cooperatives proved successful. It enabled joint bargaining with buyers through centralized sales agencies and eliminated duplicate services provided to producers and handlers. In addition, federations coordinated the disposal of surplus fluid milk. With the increased coordination provided by federations, it was also possible to establish standby pool arrangements that provided the means of moving milk from surplus milk production areas to deficit markets. Standby pools were a major development which in some circumstances could increase the market power of cooperatives.

The strength of a federated milk association lies in the retention of the identity of member cooperatives and the loyalty of producers to the member cooperatives. An inherent weakness is organizational tensions resulting from cross-purposes of member cooperatives. For example, larger bargaining cooperatives provided the service of merchandising bulk milk and qualifying cooperative plants not near a major market as pool plants. The more distant operating cooperatives, on the other hand, provided reserve milk supplies and an outlet for surplus fluid grade milk. Thus the two types of cooperatives were not likely to advocate the same policies with respect to the federation.

To eliminate such a weakness, member cooperatives of federations merged into fewer, larger cooperatives in the late 1960's. These consolidations yielded milk cooperatives regional in scope and handling major shares of the milk supplies in some market orders.

In order to secure increased market power, cooperatives assumed a vastly expanded role in the coordination of the milk marketing system, especially at the first handler level. In years past, each milk processing firm used its own resources to develop a dependable supply of milk for plant needs. But over time, cooperatives assumed the responsibility for raw product assembly for three basic reasons. First, improved roads and trucks, on-farm bulk tanks, and bulk hauling meant many apparent economies of size could be achieved to decrease hauling costs paid by producers. Cooperatives performing procurement and coordinating functions more efficiently grew in size and importance. Second, cooperatives were the only type of firm in the fluid milk market willing to market all milk of its members at all times and take on new producers. Third, classified pricing and market wide pooling eliminated differentiation of producers selling to individual plants. In view of the foregoing, regional cooperatives could provide procurement services more economically than several firms, reducing plant resources used for assembly.

Cooperatives also undertook increased responsibility for marketing their members milk. An important role in milk marketing is the allocation function. Cooperatives coordinate supplies to meet the quality and quantity specifications of fluid handlers on a daily and long-run basis. Only those quantities needed for Class I and Class II uses are delivered to handlers, with the surplus diverted to cooperative-owned facilities for manufacturing. Actual milk movements are such that the total transportation cost for all classes of milk is minimized. Cooperatives also established the standby pool. Standby pool arrangements between cooperatives provide a mechanism to move supplies to deficit areas when and where needed. This coordinating function eliminates the need for proprietary handlers to develop alternative sources of supply whose milk is only needed on occasion.

The overall effect of increased coordination is a stronger horizontal marketing base at the producer and first handler level and forward vertical integration by cooperatives. Regional milk cooperatives have more control of the milk marketing system than their predecessors had.

At the producer level, increased coordination resulted in increased incomes for members of cooperatives. Nonmembers also benefited from services provided by cooperatives. Cooperative surplus milk management, full supply arrangements and demand stimulation benefits the market as a whole, yet nonmembers of cooperatives did not pay for such services. Since handlers usually pay over-order premiums to nonmembers, they also received increased incomes. Reduced market access and increased marketing costs are adverse effects on nonmember producers.

With respect to the agribusiness sector, some marketing functions have shifted to cooperatives from proprietary firms. This is especially true with respect to manufactured dairy products. In 1957, cooperatives manufactured 58 percent of the total butter production in the United States, 57 percent of the dry powder and 18 percent of the cheese. Comparable figures for 1973 are 66 percent, 85 percent, and 35 percent for butter, dry powder and cheese, respectively.[3]

Retail prices of milk and dairy products are higher because of the market order system and cooperative bargaining. But this fact must be weighed against improvements in the stability and efficiency of the milk marketing system.

The Problem

Large regional milk marketing cooperatives emerged in the late 1960's as a final step in the establishment of a countervailing power to regional and national fluid processors. These cooperatives controlled large shares of the supply in many market areas. In 1971, the Justice Department initiated litigation against Associated Milk Producers, Incorporated (AMPI), alleging predatory and exclusionary conduct in violation of antitrust laws.

In connection with the suit against AMPI, Philip Eisenstat, Robert T. Masson, and David Roddy prepared a report for the Justice Department, An Economic Analysis of the Associated Milk Producers, Inc. Monopoly. With respect to performance, the report considers only AMPI's Class I premiums and producer payout efficiency. The authors cited measurement difficulties for not exploring further performance aspects. Doing so ignores possible technical and organizational efficiencies accruing to the milk marketing system due to increased coordination by cooperatives. Cook, Blakley, and Berry in a review of Eisenstat et. al. maintain other performance aspects could have been measured. These include the elimination of excess capacity within the dairy industry.[4]

By reshuffling milk routes to avoid overlapping and phasing out smaller, inefficient manufacturing facilities, AMPI has tried to attain economies of size in performing the coordination function at the first-handler level. However, there has been little inquiry into the influence of cooperative mergers on the efficiency of the milk marketing system.

Because of increased attention focused on large producer cooperatives by the government, consumers' groups, and the media, some knowledge of technical efficiencies in the marketing system due to mergers of producers' groups is desired. This knowledge would be important in the cooperative bargaining process, and in determining government policy concerning large regional milk cooperatives.

Objectives and Procedures

The overall objective of this study is to determine the effects of milk cooperative mergers on the capacity, efficiency, and location of hard-product processing facilities for reserve and Class III milk and on the cost of assembling all classes of milk. Specific objectives include:

1. To estimate the number, size, and location of cooperative firms that would exist in selected years 1968-78 in absence of cooperative mergers that led to the creation of AMPI.

2. To estimate changes in assembly and transportation costs for all classes of milk under market structures with and without cooperative mergers.

3. To estimate changes in manufacturing costs for Class III milk supplies under market structures with and without cooperative mergers.

Chapter II discusses theoretical considerations relating to the long-run average cost curve. It also treats the development of the specific long-run average curves for cheese and butter-powder processing used in this study. Chapter III describes the market structures with and without cooperative mergers and the procedures used to determine those structures. A description of the transportation algorithm used to estimate assembly costs is contained in Chapter IV. Chapter V includes the results and analysis of estimating assembly and processing costs under the alternative market structures. Finally, Chapter VI contains the summary and conclusions and some comments on the limitations of the study.

FOOTNOTES

[1]George C. Tucker, William J. Monroe, and James B. Roof, Marketing Operations of Dairy Cooperatives, U. S. Department of Agriculture; Farmer Cooperative Service Research Report 38 (Washington, 1977).

[2]Maryland and Virginia Milk Producers Association, Inc. vs. United States 362, U. S. 458, 1960.

[3]Tucker, et. al., pp. 35-38.

[4]Hugh L. Cook, Leo Blakley, and Calvin Berry, Review of Eisenstat, Philip, Robert T. Masson and David Roddy, "An Economic Analysis of the Associated Milk Producers, Inc. Monopoly," College of Agricultural and Life Sciences Research Bulletin R2790 (University of Wisconsin-Madison, 1976), p. 6.

CHAPTER II

PROCESSING COST THEORY AND ESTIMATES

In order to assess the effects of cooperative mergers on marketing efficiency, estimates of total and average processing costs of cheese and butter-powder under alternative market structures are needed. In this chapter the principles of marginal analysis provide the basis for examining the economic and technical relationships within the firm. Specifically, this study examines the nature of the variation between output and long-run average cost. According to Watson,

> It is not much of an exaggeration to say that a good part of the economic foundation of the antitrust laws depends on the shape of the long-run curve of a firm. The antitrust laws attempt to maintain competition. Among other things, competition means the existence of many firms in an industry rather than one or a few. If long-run cost curves would decline and keep on declining indefinitely, then costs would be at a minimum if only one firm produced each commodity. If this were so, the policy of maintaining competition would be condemned on the ground that it would keep costs up; it would result in economic inefficiency.[1]

After a discussion of cost theory and estimation of long-run average cost curves, the specific long-run average cost curves and equations for butter-powder and cheese manufacturing for this study are developed.

Plant Costs

The physical conditions of production, the prices paid for resources and the economically efficient (or inefficient) conduct of an entrepeneur jointly determine the cost of production. The basic technical relationships of the firm are expressed in the production function, which is represented by equation (2.1).

$$Y = f\ (X_1, \ldots, X_k \ / \ X_{k+1}, \ldots, X_n) \tag{2.1}$$

Equation (2.1) is assumed to be a single-valued function: the value for Y is the maximum rate of output technologically feasible with the specified levels of the inputs $X_1, X_2, \ldots, X_n$.

It is also assumed possible to continuously vary at least some of the inputs over nonnegative values, and Y is a continuous function with continuous first- and second-order partial derivatives with respect to the variable inputs $X_1, \ldots, X_k$.[2] According to Johnston, "this emphasizes the possibility of continuous substitutions of one input service for another input . . . without causing sharp jumps in output."[3]

A final assumption of the production function is the nature of the joint variation of Y with the inputs $X_1, X_2, \ldots, X_n$. Consider a short-run set of conditions where the inputs $X_1, \ldots, X_k$ are continuously variable and the inputs $X_{k+1}, \ldots, X_n$ are fixed in their values. Cost curves and equations derived under such a restriction portray the best results obtained under the set of conditions defining the short-run. In the short-run, output can be changed only by increasing or decreasing the input rates of $X_1, \ldots, X_k$. One can also view a long-run set of conditions where the concern is with how cost varies with output when all inputs $X_1, \ldots, X_n$ are variable. The long-run is a planning horizon and consists of all possible short-run situations.[4] Ferguson distinquishes between the short-run and the long-run by stating "an economic agent operates in the short-run and plans in the long-run."[5]

Equation (2.2) gives the total cost of production for a firm operating in the short-run.

$$TC = b + \sum_{i=1}^{k} P_i X_i \qquad (2.2)$$

P_i is the price of the i^{th} variable input and b is the cost of fixed inputs which cannot be varied in the short-run. Since a cost function expresses the minimum cost of producing a given output, solving Equation (2.3), a constrained cost minimization equation, yields the firms cost function based on the specified production function and given input prices.

$$Z = b + \sum_{i=1}^{k} P_i X_i - \lambda(Y_o - f(X_1, \ldots, X_k / X_{k+1} \ldots X_n)) \qquad (2.3)$$

Y_o represents an arbitrary level of production and λ is a LaGrangian multiplier.

First-order conditions for the minimization of Z require that partial derivations of Z with respect to X_i equal zero. Solving these equations provides the optimal levels of the variable inputs. When the cost of producting Y_o is minimized, the first-order conditions require the ratio of the marginal products of X_i (the marginal rate of technical substitution) to be equal to the ratio of the input prices. Further, if we consider any production function for which the first- and second-order conditions are satisfied and assume two variable inputs, then

$$\frac{MPP_1}{MPP_2} = \frac{P_1}{P_2} = \frac{X_2}{X_1} \tag{2.4}$$

Thus,

$$P_1 X_1 - P_2 X_2 = 0 \tag{2.5}$$

Equation (2.5) can be stated in the form of an implicit function and in general terms as

$$g (X_1, X_2, \ldots, X_k) = 0 \tag{2.6}$$

Equation (2.6) represents the expansion path, and is a function of the variable inputs for which the first- and second-order conditions for constrained maxima and minima are fulfilled. The expansion path is a locus of points where isoquants and isocost lines are tangent. Since an isoquant represents the maximum output for any given level of the inputs, the expansion path represents the least cost combination of inputs for every output, given fixed input prices.

Short-Run Costs

The short-run cost function can be derived from the equations for the production function (2.1), cost equation (2.2), and the expansion path (2.7). Reducing this system of equations to one equation, cost can be stated explicitly as a function of the level of output and the cost of the fixed inputs.

$$C = C(Y) + b \tag{2.7}$$

Equation (2.7) specifies the minimum total cost of producing any level of output given the constraints of fixed factors, the implied production function, and the input prices.

Cost functions important in firms' pricing and output decisions are derived from Equation (2.7). The relevant functions include total variable cost (TVC), total fixed cost (TFC), average variable cost (AVC), average fixed cost (AFC), and marginal cost (MC).

$$TVC = C(Y) \tag{2.8a}$$

$$TFC = b \tag{2.8b}$$

$$AVC = \frac{C(Y)}{Y} \tag{2.8c}$$

$$AFC = \frac{b}{Y} \tag{2.8d}$$

$$MC = \frac{dC(Y)}{dY} \tag{2.8e}$$

The law of diminishing physical returns states as the amount of a variable input is increased by equal increments per unit time, with the other input levels held constant, points are reached beyond which average physical product and marginal physical product decline.[6] That is, the total product increase becomes smaller and smaller with each additional equal increment of the variable input. If one assumes the law of diminishing physical returns holds for each of the variable inputs after some input level, then the cost functions assume the shapes portrayed in Figure 1 and 2.

Under conditions where the law of diminishing physical returns holds, total cost is a function of output plus the cost of fixed inputs. Total fixed cost is constant in the short-run and is depicted as a horizontal line at some positive level in Figure 1. Total variable cost, strictly a function of output, increases at a decreasing

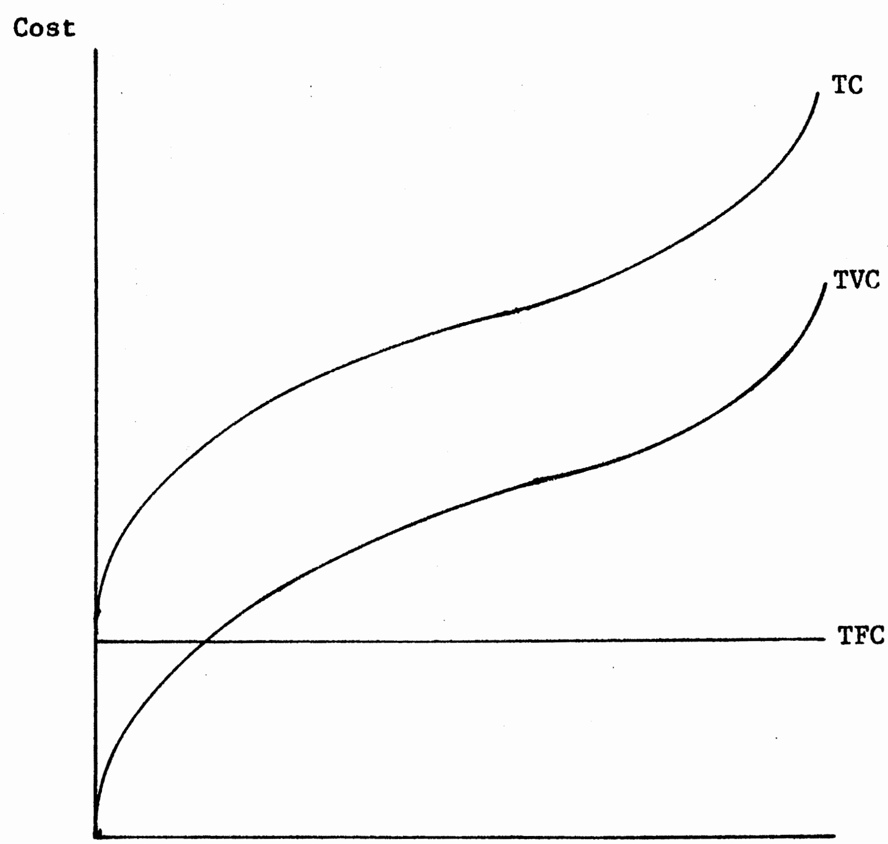

Figure 1. Theoretical Total Cost Curves

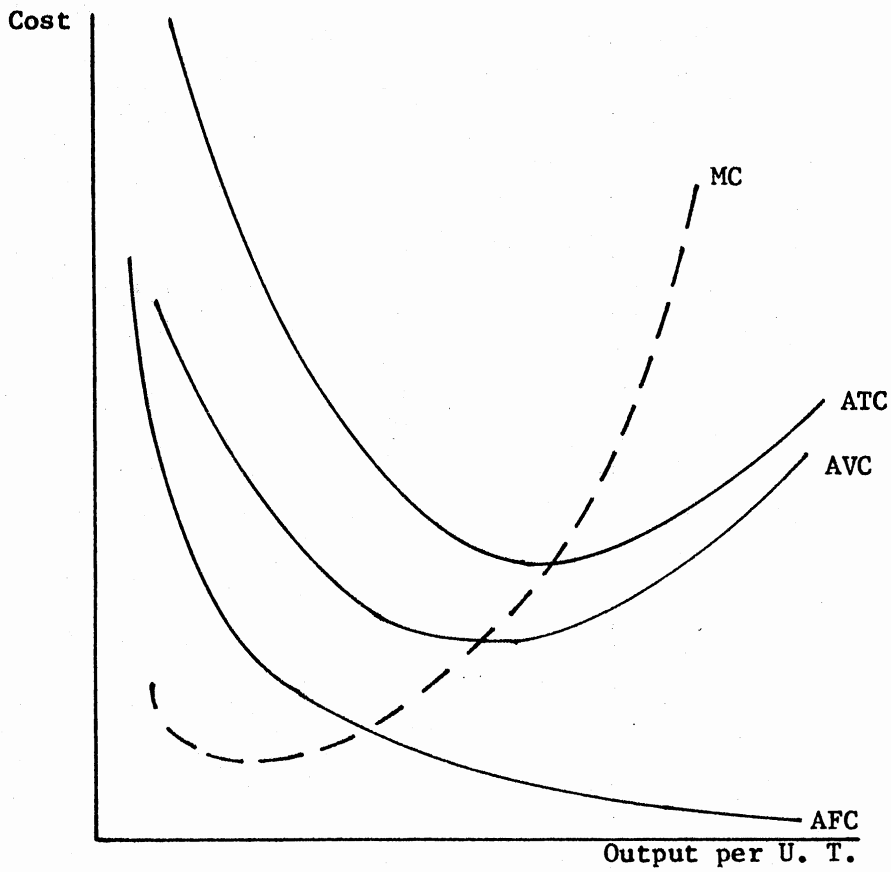

Figure 2. Theoretical Short-Run Cost Curves

rate at first, then increases at an increasing rate.

The nature of the total cost function and curve and the inverse relationships between average variable cost and average physical product (APP) and between marginal cost and marginal physical product (MPP) explain the U-shape of the average variable and marginal curves.[7] Assuming the law of diminishing physical returns holds, average physical product rises to some maximum and decreases; average variable cost decreases to some minimum and then increases. Marginal physical product increases, reaches a maximum and then decreases, intersecting the average physical product curve at its maximum, and then decreases at a rate faster than the average physical product curve. The marginal cost curve, then, decreases until it reaches a minimum, and then increases at a rate faster than the average variable cost curve, intersecting the average variable cost curve at its minimum point.

The average fixed cost curve is a rectangular hyperbola, declining monotonically due to the fact fixed cost is spread over a larger number of units as output increases. The average total cost curve is a vertical summation of the average variable and average fixed cost curves.

Long-Run Costs

In the long-run, a firm can vary all inputs and the level of their usage. There are no fixed factors, and hence, no fixed cost. A firm expands its size by building a newer and/or larger plant. Associated with each possible plant size are certain fixed inputs, b, which vary directly with plant size. The short-run problem is one of optimum utilization of a fixed plant, in contrast to the long-run issue of determining the optimum size plant.

The long-run cost function gives the minimum cost of producing a given output when the firm can vary the size of the plant. This function, in turn, is derived from the long-run production function, long-run cost equation, and long-run expansion path, given by Equations (2.9), (2.10), and (2.11) respectively.

$$Y = f(X_1, \ldots, X_k, b) \tag{2.9}$$

$$TC = Y(b) + \sum_{i=1}^{n} P_i X_i \tag{2.10}$$

$$g(X_1, \ldots X_k, b) = 0 \tag{2.11}$$

Fixed cost is an increasing function of plant size: $Y'(b) > 0$. From Equations (2.9), (2.10), and (2.11), one can eliminate the variable inputs X_i from the relation such that long-run total cost may be expressed as a function of output level and plant size:

$$C = P(Y, b) + b \tag{2.12}$$

By varying b, a whole family of short-run total cost curves are obtained. Equation (2.12) can be written as an implicit function of C and Y.

$$C - P(Y, b) - b = G(Y, X_i, b) = 0 \tag{2.13}$$

The envelope of the family of curves obtained by varying b is itself a curve that is tangent to each of the short-run total cost curves.

To derive the long-run total cost function, set the partial derivative of (2.13) with respect to b equal to zero:

$$G_b(Y, X_i, b) = 0 \tag{2.14}$$

By eliminating b from (2.12) and (2.13), solving (2.14) for b, and substituting b into (2.10), one obtains the long-run cost equation.[8]

$$C = C(Y)$$

From (2.15), long-run average and marginal cost can be derived. The long-run average cost curve is the envelope to the short-run average cost curves. Kells states:

> If f(X,Y,C) = 0 represents a one parameter family of curves and E is a curve which contacts tangentially (has a common tangent with) every curve of the family f=0, and contacts tangentially one or more curves of f=0 at each of its points, then E is an envelope of f.[9]

The long-run average cost curve, like the short-run curve, is generally considered to be U-shaped, although for different reasons. With respect to the short-run average cost curve, diminishing physical returns explain the U-shape. But in the long-run, with no fixed factors of production, the law of diminishing physical returns does not hold, and thus inapplicable. A decrease in the long-run average cost curve implies larger sizes of plants are more efficient as output increases. Conversely, an increase in the long-run average cost curve suggests larger size plants are less efficient as output is expanded.

The two broad forces of specialization and division of labor and technological factors enable firms to reduce unit costs, and are referred to as economies of size. Larger size plants along with an increased work force allow more possibilities for each worker to specialize in one job, gain proficiency, and eliminate time consuming interchanges of location and equipment.[10]

Technological factors contribute to economies of size in two manners. First, expansion of plant size and output permit mass-production techniques to be used which reduce the production cost per unit. Second, purchasing and installing larger and more productive machinery costs proportionately less than a small machine.[11]

If long-run average cost increases directly with output, then diseconomies of size exist. Economists suggest the problems of coordination and management impose rising costs as plant size increases. Put another way, the ability of a firm manager to coordinate and control is an indivisible factor of production which may be cultivated subject only to diminishing returns.[12]

The cost functions discussed so far are theoretical and may not agree with empirically derived cost functions. P. W. S. Andrews sets forth an alternative hypothesis. He concludes:

> In general, average direct costs per unit of product will be expected to remain constant over large ranges of output, so long as the business continues to employ the same methods of production, and the total of such costs will vary proportionately with total output.[13]

In such a case, total variable cost is a linear function of output. Thus, average variable cost equals marginal cost. The average total cost curve takes the form of monotonically declining rectangular hyperbola as shown in Figure 3. Johnston suggests this type of average total cost curve is the most plausible considering the empirical evidence.[14]

With respect to dairy processing costs, Hanlon and Koller state:

> Total variable costs for a butter-nonfat dry milk plant are linear with respect to volume. This indicates that, as volume changes by successive equal increments, the change in cost always is the same.[15]

Earlier studies indicate this is true in actual plant operations.

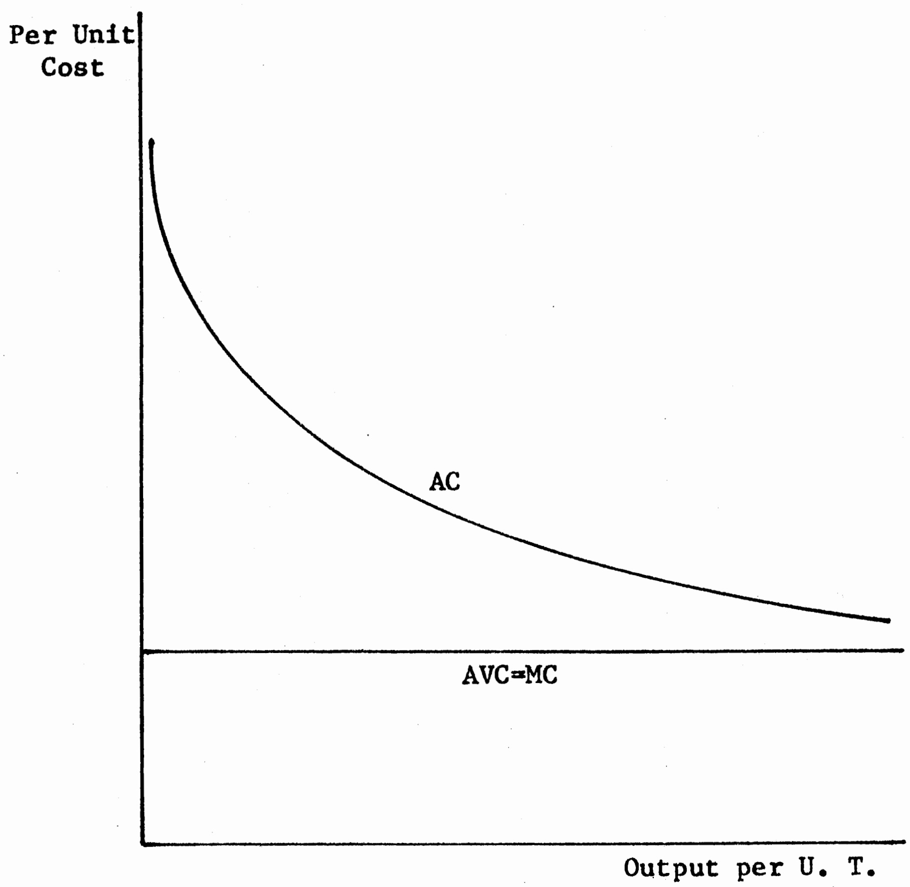

Figure 3. Theoretical Average and Marginal Cost Curves

The processing costs used in this study were derived from synthetic cost estimates in earlier studies which essentially assume variable costs are a linear function of output, which is closer to the cost-output relationships illustrated in Figure 3 than to those in Figure 2.

Estimating Long-Run Average Cost Curves

When estimating long-run average curves, economists have generally employed two methods, the statistical method and the synthetic method, also referred to as the economic-engineering or building block approach. The statistical method applies regression techniques to firms' actual cost and volume data to determine the long-run average cost, or planning curve. A long-run average cost curve derived in this manner represents an average relationship between cost and volume, not the least cost for producing a given output as the theoretical planning curve depicts. Moreover, a statistically derived planning curve combines and confuses cost changes due to better plant utilization and cost changes due to changes in plant size. The curve lies above the theoretical planning curve, and understates the savings as capacity is better utilized and overstates savings from increases in size when plants operate at capacity.[16] Finally, the sample used to generate the long-run average cost curve may be inconsistent with actual operating conditions due to changing technology and/or changing factor prices.

The synthetic method involves determination of the physical input-output relations for each of the various processing operations. These relationships are then cast from physical terms into cost terms.

Each discrete act of production is analyzed separately and the optimum technique for each process selected. The final step entails aggregating the individual process cost functions into total short-run cost functions for plants of varying sizes.[17] The synthetic method of estimating long-run average cost curves develops least cost plant organizations. According to Knudston, the economic-engineering approach yields a long-run average cost curve that "bears logical consistency to the theoretical formulation of the planning curve."[18] Furthermore, the synthetic method can be applied to industries where data are not adequate to apply regression techniques, or where changes in technology and/or input prices render firms' historical records useless.[19]

There remain some unsolved problems with the synthetic approach.[20] Like the statistical method, the problem remains of arbitrarily allocating many joint and overhead costs. Unlike the statistical approach, estimates from synthetic studies are removed from standard measures of statistical reliability; estimates can be checked only by comparing results with alternative sources of information. Synthetic studies have also failed to uncover any diseconomies of size, aside from the zig-zags in cost curves resulting from incomplete divisibilities of men and equipment. Finally, the synthetic technique speaks little of external economies of size associated with the size of the industry. Black states:

> The synthetic method has not yet been used to shed light on the question of the proper place of the gigantic multi-plant processing and retailing firms that have become characteristic of agricultural marketing. From the point of view of public policy, this issue is as important as any in the whole field of marketing efficiency. Are these firms dominant because of their inherent efficiency in physical operations, or because of the competitive advantages they are able to develop from their monopoly power?[21]

But in general, the synthetic method provides the most accurate determination of the long-run average cost curve.

Long-Run Average Cost Curve for Butter-Powder Manufacturing

Basic data for estimating a long-run average cost curve for butter-powder manufacturing under AMPI Southern Region conditions come from a University of Minnesota study.[22] In that study, the authors set forth processing costs at varying whole milk equivalent volumes for six synthesized model butter-powder plants.

AMPI butter-powder plants, as well as cheese plants, process milk not needed for Class I and Class II purposes. Demand for Class I and Class II milk is seasonal as is the production of whole milk. Thus the amount of milk available to AMPI plants varies considerably over the year, peaking in May and June when milk production is flush and the demand for school milk declines, and troughing in October when production is slack and school milk demand increases.

Because of the wide variance in the supply of whole milk available to AMPI Southern Region plants, this study considers an alternative concept of capacity: effective capacity. Effective capacity equals some portion of a plant's rated capacity and measures how much milk could be processed annually in an AMPI Southern Region plant given the variability of Class III milk supplies. To compute effective capacity, a plant's rated capacity is multiplied by an index of Class III milk available to AMPI plants.

To obtain a seasonal index of Class III milk available to AMPI Southern Region plants, needed data include measures of producer deliveries (production), and Class I and Class II utilization levels. AMPI Southern Region data of average daily AMPI deliveries to handlers by month for the years 1971-1975 serve as a measure of production. Five-year averages for each month were used as estimates of the average daily supply of AMPI milk for use in all classes. The daily average ranges from a low of 11.48 million pounds in November to a high of 13.38 million pounds in May (Table I).

Average daily sales of whole and skim milk in AMPI Southern Region Federal Order marketing areas for each month in the years 1971-1975 are employed to estimate Class I use in the AMPI Southern Region. Average daily sales of whole and skim milk were lowest in June, averaging 8.80 million pounds, and highest in October with average daily sales of 9.94 million pounds (Table I).

Monthly data from AMPI's Arkansas Division for January 1977 to May 1978 provide estimates of Class II utilization. The Arkansas Division contains no plants that process Class III milk into butter, powder, or cheese. Thus, all milk delivered to handlers in the division not used for Class I purposes probably goes into Class II use, primarily for manufacturing cottage cheese. To find the percent overrun of Class I milk, or the amount available for Class II use, total AMPI monthly sales to Arkansas handlers are divided by Class I utilization levels for the seventeen months from January 1977 to May 1978. The average monthly overrun equals 10.4 percent, and ranged from 7.8 percent to 11.8 percent over the period. This study assumes a Class II usage of 10 percent of Class I levels (Table I).

Class III supply with respect to AMPI Southern Region manufacturing plants is the residual after Class I and Class II needs are met.

TABLE I

AVERAGE DAILY PRODUCER DELIVERIES, SALES OF WHOLE MILK AND SKIM MILK, CLASS II UTILIZATION, AND CLASS III SUPPLY OF WHOLE MILK AVAILABLE TO AMPI MANUFACTURING PLANTS, AMPI SOUTHERN REGION, 1971-75

Month	Producers' Deliveries*	Whole and Skim Sales*	Class II Utilization*	Class III Supply **
		-Millions of Pounds-		
January	11.786	9.735	.973	1.078
February	12.130	9.691	.969	1.470
March	12.781	9.593	.959	2.229
April	13.298	9.479	.948	2.870
May	13.371	9.415	.941	3.015
June	12.904	8.794	.879	3.231
July	12.548	8.911	.891	2.746
August	12.216	9.328	.933	1.955
September	11.847	9.873	.987	.987
October	11.614	9.944	.994	.676
November	11.479	9.812	.981	.686
December	11.528	9.474	.947	1.107
Total Annual	147.502	114.049	11.402	22.050

*Based on data furnished by Associated Milk Producers, Inc., San Antonio, Texas

**Class III Supply = Producers' Deliveries - Whole and Skim Milk Sales - Class II Utilization.

Estimated monthly Class III supply, then, equals average daily producer deliveries net of daily average Class I and Class II utilizations. On a monthly basis, daily average Class III supply peaks in June, averaging 3.23 million pounds, and is lowest in October, which has a daily average surplus of .68 million pounds (Table I).

In computing a seasonal index of Class III milk availability, June is assigned an index value of 100. By dividing each month's Class III supply by June's Class III supply, each month's index of Class III milk is obtained. The monthly indexes were then summed and divided by twelve to get an average of the monthly indexes. This seasonal index equals 56.87. This means over the entire year the amount of milk available to AMPI Southern Region manufacturing plants averaged 56.87 percent of the peak month's Class III supply. The monthly indexes are listed in Table II.

By assuming AMPI processing plants operated at 100 percent of capacity during June, the peak month for Class III supplies, a plant's effective capacity can be estimated. To obtain effective capacity, a plant's rated annual capacity is multiplied by .5687, the seasonal index of Class III supplies. For example, one of the synthesized model butter-powder plants in the Minnesota study has a rated annual capacity of 623 million pounds of whole milk. Effective capacity for the AMPI region then would equal 623 million pounds times .5687, or 354 million pounds of whole milk per year. Because of variability in Class III milk supplies in the Southwestern United States, such a model plant could expect to process no more than 354 million pounds of whole milk in a year.

From a plot of the short-run average cost curves for butter-powder

TABLE II

INDEX OF CLASS III MILK AVAILABLE TO AMPI
SOUTHERN REGION MANUFACTURING PLANTS
BY MONTH, JUNE = 100

Month	Seasonal Index*
January	33.3
February	45.5
March	69.0
April	88.8
May	93.3
June	100.0
July	85.0
August	60.5
September	30.6
October	20.9
November	21.2
December	34.3
Average index = 56.9	

*Computed from data in Table I

plants in the Minnesota study, a long-run average cost curve can be drawn by connecting the minimum cost points of each short-run cost curve. This planning curve reflects optimum milk supply conditions in Minnesota. To adjust the curve to represent the more variable supply conditions of the AMPI Southern Region, cost estimates are needed for each of the six synthesized plants in the Minnesota study at the effective capacities defined for this study.

The Minnesota study gives no cost estimates for four of the model plants at their effective capacities, making it necessary to extrapolate cost estimates. For example, model plant VI has a rated annual capacity of 623 million pounds, and effective capacity of 354 million pounds. But the lowest volume for which a cost estimate is given for model plant VI is 450 million pounds.

To extend the cost estimates to the effective capacities of the six synthesized plants, simple regression techniques are employed. Each model plant has five to ten cost-volume observations, and overall there are 36 volume points ranging from 40 to 623 million pounds of whole milk annually. A regression of volume on cost for each of the six sets of observations is then fitted. Because of the parabolic nature of the theoretical short-run average cost curves, the regressions assumed the following functional form:

$$Y = a + bx + cx^2 + u \qquad (2.16)$$

Y, the dependent variable, is cost per hundredweight of whole milk processed, in dollars; x equals volume processed annually in millions of pounds; and u is a disturbance term. The regression results are shown in Table III.

TABLE III

REGRESSION ESTIMATES OF SHORT-RUN AVERAGE COST FUNCTIONS FOR SIX MODEL BUTTER-POWDER PLANTS

Plant	a	b	c	R^2	Equation Variance
I	1.3731 (30.18)	-.0214 (-13.38)	.0001 (9.03)	.9991	.00002
II	.9301 (31.92)	-.0075 (-13.62)	.00002 (9.21)	.9978	.00002
III	.6841 (45.04)	-.0031 (-18.53)	.000006 (12.50)	.9996	.0000009
IV	.5752 (24.86)	-.0017 (-9.66)	.000002 (6.37)	.9991	.0000008
V	.4960 (46.60)	-.0010 (-17.31)	.0000009 (11.35)	.9992	.0000005
VI	.4367 (28.67)	-.0006 (-10.44)	.0000004 (7.01)	.9988	.0000002

As an example of extrapolation of the cost estimates, consider model plant VI. The regression was fitted using ten observations, with the volume points ranging from 450 million pounds to 623 million pounds of whole milk annually. From the regression results, cost estimates for the remaining 26 volume points are generated. For plant VI, effective capacity equals 354 million pounds. The regression results give a cost estimate of \$ .274 per cwt. at 350 million pounds, and \$ .267 per cwt. of whole milk processed at 370 million pounds. Interpolating, an estimate of \$ .272 per cwt. is obtained for a volume of 354 million pounds. In a similar manner, cost estimates for the other estimates at each plants' effective capacity completes the derivation of a long-run average cost curve for AMPI Southern Region butter-powder plants.

Given the cost estimates at the effective capacities of the model butter-powder plants, regressing cost on volume provides an equation for the planning curve. The functional form assumed is a rectangular hyperbola because no diseconomies of size exist in the data. The long-run average cost function is as follows:

$$Y = a + b \left(\frac{1}{X}\right) + u \qquad (2.17)$$

Y is the dependent variable, cost per hundredweight in dollars; X equals volume in million of pounds; and u is the disturbance term. The estimated cost function is given by (2.18) (standard error of the coefficient in parentheses).

$$Y = \underset{(.0028)}{.2214} + \underset{(.2531)}{19.7979} \left(\frac{1}{X}\right) \qquad (2.18)$$

The equation has an R^2 of .9993, and the equation variance equals 0.0000171. It is assumed manufacturing costs have increased at about the same percentage as the increase in the make allowance. Therefore, the Minnesota study, published in 1972, probably reflects circa 1971 cost conditions; thus the planning curve derived represents 1971 cost conditions as well. To adjust the curve to 1978 cost conditions, the curve is indexed on the basis of the manufacturing grade milk processing and marketing margin used for calculation of Commodity Credit Corporation purchase prices of butter and nonfat dry milk. This margin, also referred to as the make allowance, supposedly reflects the processing and marketing costs of one hundred pounds of whole milk into butter and nonfat dry milk. Dividing the 1978 value of the make allowance, \$1.12, by the 1971 value, \$0.67, yields a quotient of 1.67. This translates as 1978 costs being 1.67 times greater than 1971 costs of manufacturing and marketing butter and powder. Multiplying all cost estimates on the long-run average cost curve previously derived for AMPI Southern Region conditions provides a new curve that also represents 1978 cost conditions (Table IV).

Figure 5 portrays the long-run average cost curve for butter-powder used in this study. It is drawn to represent AMPI Southern Region supply conditions and 1978 cost conditions. From an inspection of the curve, one sees most of the economies of size are exhausted at a volume of 200 million pounds of whole milk. A volume of about seven million pounds has associated with it a cost estimate of greater than \$5.00 per cwt. In contrast, at 200 million pounds, it costs about \$ .53 per cwt. This, in turn, compares with an estimate of \$0.44 per cwt. at a volume of 354 million pounds of whole milk processed annually.

TABLE IV

RATED CAPACITY, EFFECTIVE CAPACITY, AND PER UNIT PROCESSING COST AT EFFECTIVE CAPACITY UNDER 1971 AND 1978 COST CONDITIONS

Plant	Rated Capacity	Effective Capacity	Cost, 1971	Cost, 1978
	(million lbs.)	(million lbs.)	($/cwt.)	($/cwt.)
I	78.0	44.4	.665	1.112
II	156.0	88.7	.447	.747
III	233.0	132.5	.374	.625
IV	311.0	176.9	.337	.563
V	467.0	265.6	.294	.491
VI	623.0	354.3	.272	.455

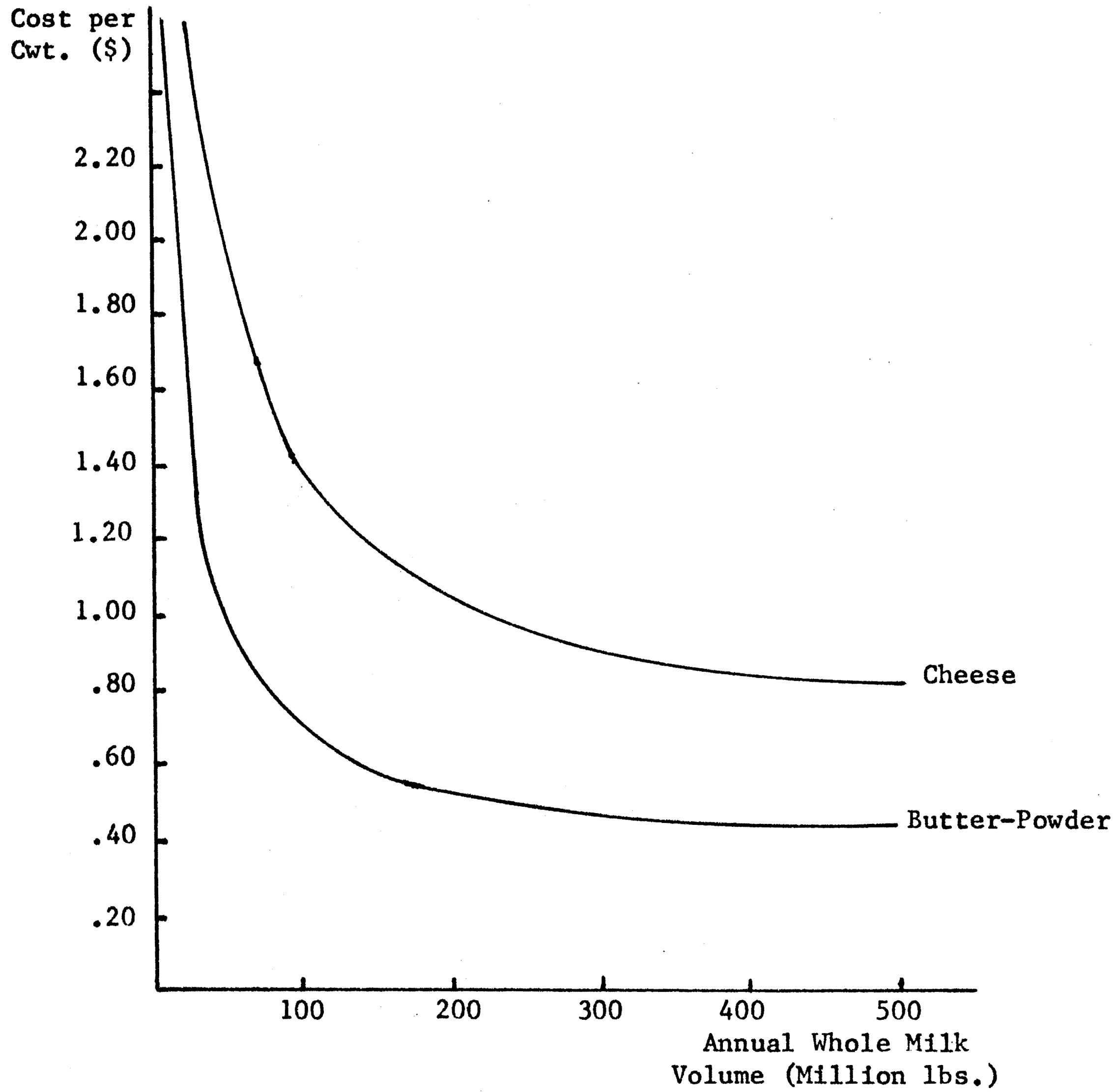

Figure 4. Long-Run Average Cost Curves for Butter-Powder and Cheese Manufacturing, AMPI Southern Region

Per unit processing costs thus decrease rapidly as volume expands up to 100 million pounds, and decline at a much slower rate after that.

Long-Run Average Cost Curve for Cheese Manufacturing

A study of the dairy processing industry in Southeastern United States by Boehm and Conner provides per unit manufacturing cost estimates for three synthesized cheese plants with annual whole milk capacities of 154.7 million pounds, 182.2 million pounds, and 309.4 million pounds.[23,24] Each plant has associated with it a cost estimate at minimum, average, and maximum operating levels (Table V). The minimum operating level reflects a five-day work week with one shift; the average level represents a six-day, two-shift setup; and the maximum level stands for a seven-day, three-shift operating scheme.

Over the range of volume from 75 million pounds to 160 million pounds of whole milk per year, the maximum difference between the short-run average cost curves for the three plants at any given volume is seven cents per hundredweight. Thus, processing costs between the three different plant sizes differ to a small enough extent that a long-run average cost curve can be fitted to the Boehm and Conner data.

Supply conditions in Southeastern United States for Class III milk are similar to those faced in the AMPI Southern Region. Therefore, the cost estimates from the Boehm and Conner study do not have to be adjusted for supply conditions, as is necessary in deriving a butter planning curve.

To extend the cheese curve to a volume of 500 million pounds annually, two additional cost volume points are added from a study by

TABLE V

CHEESE MANUFACTURING COSTS FOR THREE SYNTHESIZED MODEL CHEESE PLANTS

Plant Size	Operating Level	Annual Volume	Cost
		(million lbs.)	($/cwt.)
	Minimum	39.0	1.75
Small	Average	78.0	1.25
	Maximum	154.7	.95
	Minimum	52.0	1.60
Medium	Average	93.6	1.13
	Maximum	182.2	.87
	Minimum	78.0	1.21
Large	Average	156.0	.88
	Maximum	309.4	.69

SOURCE: William T. Boehn and M. C. Conner, Technically Efficient Milk Assembly and Hard Product Processing for the Southeastern Dairy Industry, Virginia Polytechnic Institute and State University Research Division Bulletin 122 (Blacksburg, 1976).

Lilwall and Hammond.[25] That study uses economic-engineering techniques to derive cost-volume estimates for peak daily volumes given different technologies and work period organizations.

Because Lilwall and Hammond publish cost estimates for peak daily volumes, and because the cost conditions differ from those associated with the Boehm and Conner study, estimates are adjusted to fit with those of Boehm and Conner. Lilwall and Hammond provide cost estimates for peak daily volumes of 0.8 million pounds, 1.0 million pounds, and 1.2 million pounds. These volumes correspond to annual volumes of 288 million pounds, 364 million pounds, and 436.8 million pounds, respectively. In comparison, the largest plant in the Boehm and Conner study has annual volume of 309.4 million pounds, or a peak daily volume of 0.85 million pounds. Thus, it is desirable to find a processing cost estimate that corresponds to 0.85 million pounds in the Lilwall and Hammond Study.

The cost estimates associated with peak daily volumes of 0.8 million pounds, 1.0 million pounds, and 1.2 million pounds are $ .414 per cwt., and $ .409 per cwt., $ .404 per cwt. respectively.[26] Per unit manufacturing costs decline linearly over the range 0.8 million pounds to 1.2 million pounds. Interpolating for 0.85 million pounds daily yields an estimate of $ .41275 per cwt. This value is equivalent to the Boehm and Conner estimate of $ .690 per cwt. at .85 million pounds of whole milk daily or 309.4 million pounds annually.

To find the Boehm and Conner estimates equivalent to the Lilwall and Hammond cost estimates at 1.0 million pounds and 1.2 million pounds daily, the Lilwall and Hammond cost estimates are divided by

$ .41275 per cwt. to derive an index of per unit cost at volumes of 1.0 million pounds and 1.2 million pounds with respect to the cost at 0.85 million pounds. For example, at 1.0 million pounds daily (364.0 million pounds annually), $ .409 per cwt. ÷ $ .41275 per cwt. = .9909. This means the per unit processing cost at 1.0 million pounds is 0.9909 of the unit processing cost at 0.85 million pounds. To convert this estimate to correspond with the Boehm and Conner observations, 0.9909 is multiplied by $ .690 per cwt., the Boehm and Conner estimate at 0.85 million pounds. Doing this yields an estimate of $ .6837 per cwt. of whole milk processed at an annual volume of 364.0 million pounds. Following the same procedure gives an estimate of $ .6754 per cwt. at 1.2 million pounds of whole milk daily, or 436.8 million pounds annually. Thus, this study uses eleven observations to derive a long-run average cost curve, nine from the Boehm and Conner study and two adapted from the Lilwall and Hammond study.

Several functional forms are considered in fitting the data to a long-run average cost curve. A parabolic cost function is rejected because it reaches a minimum per unit cost at 330 million pounds, and then rises rapidly (Table VI). This is contrary to the accepted empirical form of the long-run average cost curve.

A rectangular hyperbola cost function fit to the data closely resembles the shape of an empirical planning curve. But it overstates the cost estimates at the lowest and highest volumes (Table VI).

A final functional form proposed is a fifth-degree polynomial. Over the range covered by the nine original Boehm and Conner observations (39.0 million pounds annually to 309.4 million pounds), an almost perfect fit of the data is assured. At volumes greater than

TABLE VI

OBSERVED AND PREDICTED CHEESE MANUFACTURING COST ESTIMATES
FROM VARIOUS FUNCTIONS AT DIFFERENT WHOLE MILK VOLUMES

	Observed Cost	Parabolic Function Cost	Rectangular Hyperbola Cost	Fifth-Degree Polynomial Cost	Combined Function Cost*
(million lbs.)	($/cwt.)	($/cwt.)	($/cwt.)	($/cwt.)	($/cwt.)
39.0	1.750	1.591	1.838	1.775	1.775
52.0	1.600	1.501	1.524	1.551	1.551
78.0	1.250	1.335	1.210	1.244	1.244
93.6	1.130	1.243	1.106	1.130	1.130
154.7	.950	.941	.899	.914	.914
156.0	.880	.936	.897	.910	.910
182.0	.870	.837	.852	.869	.869
309.4	.690	.595	.741	.693	.693
325.0	- -	.594	.734	.683	.686
350.0	- -	.604	.723	.679	.676
364.0	.684	.616	.717	.682	.671
400.0	- -	.671	.705	.696	.659
436.8	.675	.760	.695	.676	.650
450.0	- -	.801	.692	.644	.647
500.0	- -	.993	.681	.253	.637

*Cost is estimated using a fifth-degree polynomial function for volumes less than or equal to 309.4 million pounds. At volumes greater than 309.4 million pounds, a rectangular hyperbola cost function yields estimates which are indexed to be compatible with the fifth-degree polynomial estimates.

309.4 million pounds, though the predicted cost curve exhibits a series of wiggles. For example, the fifth-degree polynomial cost function predicts a cost of $ .679 per cwt. at 350 million pounds. Predicted cost increases at a volume of 364.0 million pounds to $ .682 per cwt., and increases further to a value of $ .696 per cwt. at 400 million pounds. Predicted cost decreases to $ .644 per cwt. at 450 million pounds, and then falls to an unrealistic estimate of $ .253 per cwt. at 500 million pounds. Predicted cost estimates at volumes less than 39.0 million pounds exhibit no such variations in cost as did estimates at volumes greater than 309.4 million pounds. This leads to the conclusion the fifth-degree polynomial cost function is valid only up to volumes of 309.4 million pounds of whole milk per year. The fitted regressions for the cost functions are reported in Table VII.

To maintain the fit generated by the fifth-degree polynomial function up to a volume of 309.4 million pounds, and yet extend the planning curve to a volume of 500 million pounds, it is assumed the long-run average cost curve for cheese manufacturing takes the form of a rectangular hyperbola for volumes greater than 309.4 million pounds. The previous cost estimates from the rectangular hyperbola cost function are indexed to make them compatible with the fifth-degree polynomial estimates at volumes less than 309.4 million pounds.

To index the estimates, each rectangular hyperbola cost estimate at volumes greater than 309.4 million pounds is divided by $ .741 per cwt., the estimate associated with 309.4 million pounds from the rectangular hyperbola cost function. The resulting value is then multiplied by $ .693 per cwt., the fifth-degree polynomial estimate at 309.4 million pounds. Doing so puts each estimate obtained from

TABLE VII

ESTIMATED COST EQUATIONS FOR PARABOLA, RECTANGULAR HYPERBOLA, AND FIFTH-DEGREE POLYNOMIAL

Function	Coefficients	R^2	Equation Variance
Parabola	$Y = 1.886 - 8.112\ (10^{-3})X + 1.274\ (10^{-5})X^2$	.929	.0119
Rectangular Hyperbola	$Y = 0.583 + 48.930(\frac{1}{X})$	.983	.0025
Fifth-Degree Polynomial	$Y = 2.861 - 3.784\ (10^{-2})X + 2.996\ (10^{-4})X^2 - 1.199\ (10^{-6})X^3 + 2.318\ (10^{-9})X^4 - 1.713\ (10^{-12})X^5$	.995	.0359

Y = Cost per hundredweight, dollars
X = Annual volume of whole milk processed, millions of pounds

the rectangular hyperbola cost function on a comparable basis as those predicted from the fifth-degree polynomial cost function. For example, using the predicted cost from the rectangular hyperbola function at 325 million pounds is $ .732 per cwt. Dividing $ .732 per cwt. by $ .741 per cwt. yields a quotient of .9879. Multiplying .9879 by $ .693 per cwt. produces an indexed estimate of $ .685 per cwt. at 325 million pounds. Table VI lists the estimated per unit processing costs for cheese using the various functions.

At volumes less than 309.4 million pounds of whole milk, substituting the volume into the fifth-degree polynomial cost function will yield a plant's per unit cheese manufacturing cost. To compute a plant's cost at volumes greater than 309.4 million pounds, substitute volume into the rectangular hyperbola cost function. Then divide that estimate by $ .741 per cwt. The resulting value is then multiplied by $ .693 per cwt. to obtain that plant's estimated processing cost per hundredweight.

A final step in deriving a long-run average cost curve for cheese manufacturing involves indexing the curve to represent 1978 cost conditions. (The Boehm and Conner study is assumed to represent 1975 cost conditions.) This is done in a similar manner to that used to make the butter-powder planning curve reflective of 1978 cost conditions. The 1978 make allowance for manufacturing and marketing cheese from whole milk, $1.27 per cwt., is divided by the 1975 weighted average make allowance, $ .995 per cwt.[27] This yields a factor of 1.276 by which all points on the planning curve heretofore derived are multiplied by. Cost estimates then are representative of 1978 cost conditions.

The final functional form of the cheese manufacturing long-run average cost curve, shown in Figure 5, is a fifth-degree polynomial up to a volume of 309.4 million pounds of whole milk annually. At volumes greater than 309.4 million pounds, the curve takes the form of a rectangular hyperbola, decreasing at a decreasing rate but never reaching a minimum. The curve, which reflects 1978 cost conditions, has a cost estimate of about $3.60 per cwt. at 2.0 million pounds. At 182.0 million pounds, cost equals $1.109 per cwt. At this point, most economies are exhausted. Cost declines only about seven cents per hundredweight from a volume of 309.4 million pounds to 500 million pounds.

FOOTNOTES

[1]Donald W. Watson, Price Theory and Its Uses (Boston, 1968), p. 203.

[2]J. Johnston, Statistical Cost Analysis (New York, 1960), p. 4.

[3]Ibid., p. 5.

[4]C. E. Ferguson, Microeconomic Theory (Homewood, Ill., 1972), p. 221.

[5]Ibid., p. 222.

[6]Richard H. Leftwich, The Price System and Resource Allocation (5th ed., Hinsdale, 1973), p. 144.

[7]Assume one variable input X, and its price P. Then, $TVC = PX$, and $AVC = \frac{PX}{Y} = P\left(\frac{X}{Y}\right)$. Since $\frac{X}{Y} = \frac{1}{MPP}$, $AVC = \frac{P}{APP}$, and hence, average variable cost and average physical product are inversely related. Likewise, marginal physical product and marginal cost are also inversely related.

[8]James M. Henderson and Richard E. Quandt, Microeconomic Theory (New York, 1971), pp. 75-77.

[9]Lyman M. Kells, Elementary Differential Equation (New York, 1965), p. 107.

[10]Ferguson, p. 235.

[11]Ibid.

[12]Johnston, p. 23.

[13]P. W. S. Andrews, quoted in Johnston, p. 13.

[14]Johnston, p. 13.

[15]J. William Hanlon and E. Fred Koller, Processing Costs in Butter-Nonfat Dry Milk Plants, University of Minnesota Agricultural Experiment Station, Bulletin 491, 1969, p. 6.

[16]R. G. Bressler, Jr., "Research Determination of Economies of Scale," Journal of Farm Economics, 27 (1945), pp. 528-529.

[17]Arvid C. Knudtson, "Estimating Economies of Scale," Journal of Farm Economics, 40 (1958), pp. 750-751.

[18]Ibid., p. 751.

[19]Guy Black, "Synthetic Method of Cost Analysis in Agricultural Marketing Firms," Journal of Farm Economics, 37 (1955), p. 275.

[20]Ibid., pp. 277-278.

[21]Ibid., p. 277.

[22]G. M. Nolte and E. Fred Koller, Milk Assembly and Processing Costs in the Butter-Dry Milk Industry, University of Minnesota Agricultural Experiment Station Bulletin 507 (1972), pp. 9-10.

[23]William T. Boehm and M. C. Conner, Technically Efficient Milk Assembly and Hard Product Processing for the Southeastern Dairy Industry, Virginia Polytechnic Institute and State University Research Division, Bulletin 122 (Blacksburg, 1976), p. 19.

[24]Boehm and Conner present volume in weekly terms. To convert volume to an annual basis, each weekly volume is multiplied by 52.

[25]Nicholas B. Lilwall and Jerome W. Hammond, Cheddar Cheese Manufacturing Costs, University of Minnesota Agricultural Experiment Station Bulletin 501 (1970), p. 25.

[26]Ibid.

[27]The Commodity Credit Corporation operates on a marketing year from April 1 to March 31 in setting make allowances. In 1975, the make allowance was increased from $ .92 per cwt. to $1.07 per cwt. on October 2. The weighted average, then, equals ($.92) (.5) + ($1.07) (.5) = $.995.

CHAPTER III

PLANT NUMBERS, LOCATIONS, AND VOLUMES UNDER ALTERNATIVE MARKET STRUCTURES

With the creation of Associated Milk Producers, Incorporated (AMPI), many of the processing plants acquired through merger were shut down to achieve economies of size in the total operation of surplus milk handling.[1] In the absence of AMPI, many of those plants closed might be in operation today. Thus to compare assembly and processing costs under a with merger and without merger situation, one needs to know the number, locations and volumes under the alternative market structure.

Actual AMPI Plant Configuration

Milk Producers, Incorporated (MPI) of San Antonio, Texas merged with 11 northern states cooperatives to form AMPI in 1969. Prior to that MPI was created by consolidation of many cooperatives in the Southwestern United States, primarily in Texas, Oklahoma, and Kansas.

The series of mergers establishing the AMPI Southern Region involved 16 processing plants to handle surplus milk (Table VIII). In 1968, MPI operated 13 plants in the Southwest. By 1978, the cooperative had trimmed the number of operating plants to six. Supposedly, merger allowed AMPI to eliminate excess capacity by closing down smaller, inefficient plants. Also, a large regional cooperative

TABLE VIII

MPI AND AMPI SOUTHERN REGION PROCESSING PLANT LOCATIONS IN SELECTED YEARS

Pre-1968	1968	1971	1978
	Kansas		
Hillsboro	Hillsboro	Hillsboro	Hillsboro
Arkansas City	Arkansas City	Linn	
	Oklahoma		
Tulsa	Tulsa	Tulsa	Tulsa
Enid	Enid	Oklahoma City	Oklahoma City
Oklahoma City	Oklahoma City		
Mangum	Mangum		
	Texas		
Wichita Falls	Sulphur Springs	Muenster	Muenster
Sulphur Springs	Muenster	Sulphur Springs	Sulphur Springs
Muenster	Fort Worth	Rusk	El Paso
Fort Worth	Round Rock	San Antonio	
Jacksonville	La Grange		
Ballinger	Rusk		
Round Rock	San Antonio		
La Grange			
Rusk			
San Antonio			

SOURCE: Data furnished by Associated Milk Producers, Inc. San Antonio, Texas like AMPI had the financial capability to introduce new equipment and technology for specialized, high butter-powder and cheese production, often in dual-purpose plants. That contrasts with the premerger situation where many plants possessed equipment for manufacturing more than one product but at low volumes and, for cheese, with high labor requirements. The effect of such actions theoretically leads to economies of size with respect to assembly and processing costs of surplus milk and to flexibility in product mix in response to tilts in prices favoring cheese production relative to butter-powder production or vice versa.

Assumed Pre-Merger Market Structure

The first step in determining the number and location of manufacturing plants that would be operative without the series of mergers is to specify a premerger configuration of butter-powder and cheese plants in what is now the AMPI Southern Region.[2] For butter-powder, ten plants are assumed to operate in 1968. Six actually manufactured butter and powder in 1968: Arkansas City, Kansas; Hillsboro, Kansas; Tulsa, Oklahoma; Oklahoma City, Oklahoma; Enid, Oklahoma; and Muenster, Texas. The Sulphur Springs, Texas plant produced only nonfat dry milk, but for this study is assumed to be a joint butter-powder plant. Three plants closed down prior to 1968. This study includes them in the premerger market structure on the assumption some of the older, smaller plants would have operated in 1968 in the absence of the formation of MPI. The Jacksonville and Wichita Falls plants are designated as butter-powder plants given the fact most of the smaller cooperative-owned dairy processing plants in Southwest United States produced butter and/or powder. The La Grange plant, last used during the flush season of 1968, actually possessed a batch churn and printing equipment.

Six cheese manufacturing facilities are assumed to operate during 1968. Four plants in reality produced cheese in 1968: Linn, Kansas; Mangum, Oklahoma; Fort Worth, Texas; and San Antonio, Texas. Two plants, at Ballinger and Round Rock, both in Texas, are also included on the assumption some of the older, smaller plants were operative in 1968 as part of the premerger configuration. In fact, MPI closed the Ballinger plant in October, 1968, and also shut down the Round Rock facility prior to 1968. Both plants had cheese manufacturing equipment.

Estimating the Number of Plants

Data to predict the number of butter-powder and cheese plants that would exist without the creation of AMPI came from the July 1974 Dairy Situation.[3] That publication presents the number of butter and cheese plants operating in various production-size catagories for the years 1957, 1963, and 1972 in the United States.

The distribution of butter plants is divided into ten size groups based on the plants' annual output. The smallest production-size category includes plants producing less than 100,000 pounds of butter per year, while the largest size category encompasses plants manufacturing greater than 4.0 million pounds annually. This study combines the five smallest size groupings, covering volumes up to 1.0 million pounds, into one production-size group to more realistically predict the size distributions of the plants considered in this study. For the same reason, the two next-to-largest size categories are consolidated into one category; volumes range from 2.0 million to 4.0 million pounds. Thus, this study utilizes only five categories of butter plants (Table IX).

For American Cheese, nine size categories of plants are set forth. The smallest size grouping covers plants with cheese production of less than 50,000 pounds per year, and the largest category includes plants with annual volumes in excess of 2.0 million pounds of cheese per year. For the same reasons stated above, the four smallest size categories are aggregated into one with volumes ranging up to 500,000 pounds annually (Table IX).

This study assumes some plants not operative in 1968 did actually process milk into hard products that year. These include the Wichita Falls, Jacksonville, and La Grange butter-powder plants. To place them in a production-size group, it is assumed their production equals 500,000 pounds per year, the mid-point of the smallest size category.

The Sulphur Springs facility produced only powder in 1968. It's nonfat dry milk output, 9.98 million pounds, is multiplied by 8.13 pounds of whole milk per pound of powder, to obtain a whole milk equivalent of 81.16 million pounds. That value is divided by 22.22 pounds of whole milk per pound of butter to yield a value of 3.652 million pounds of butter; that is the assumed butter output of the Sulphur Springs plant in 1968.

Table X lists each plant's 1968 output and associated production-size group.

Two plants that produced no cheese during 1968, Round Rock and Ballinger, are assumed to manufacture 250,000 pounds of cheese, which

TABLE IX

NUMBER OF PLANTS MANUFACTURING BUTTER AND CHEESE IN THE UNITED STATES, 1957, 1963, and 1972

Output Per Plant	1957	1963	1972
(Thousand lbs. of products)	(number)	(number)	(number)
	BUTTER		
<1000	1665	935	303
1000-1499	131	109	31
1500-1999	93	58	20
2000-3999	125	149	40
>4000	48	70	81
Total	2062	1321	475
	CHEESE		
<500	534	306	127
500-749	235	157	53
750-999	137	120	66
1000-1499	133	136	87
1500-2000	57	86	65
>2000	98	119	215
Total	1194	924	613

SOURCE: U. S. Department of Agriculture, Dairy Situation, DS-351 (Washington, 1974), pp. 31-32.

TABLE X

ACTUAL OR ESTIMATED 1968 OUTPUT AND PRODUCTION-SIZE CATEGORY FOR PLANTS IN THE WITHOUT MERGER SITUATION: PREDICTED ANNUAL CHANGE IN PLANT NUMBERS FOR PRODUCTION-SIZE CATEGORIES; AND 1968 ASSUMED, 1971 AND 1978 PREDICTED, AND 1971 AND 1978 ASSUMED PLANT NUMBERS FOR PRODUCTION-SIZE CATEGORIES

	1968 Output Per Plant	Production-Size Category	Predicted Change Per Year	Assumed 1968 Plant Numbers	Predicted 1971 Plant Numbers	Predicted 1978 Plant Numbers	Assumed 1971 Plant Numbers	Assumed 1978 Plant Numbers
	(Thousand lbs. of Product)	(Thousand lbs. of Product)	(Percent)					
				Butter				
Wichita Falls	500*							
Jacksonville	500*	< 1000	-11.45066	3	2.0829	.8891	2.0	1.0
La Grange	500*							
Muenster	1477	1000-1499	-9.95248	1	.7302	.3505	1.0	0.0
Enid	1500	1500-1999	-10.37086	1	.7201	.3346	1.0	1.0
Tulsa	2225							
Arkansas City	2754							
Hillsboro	2751	2000-3999	-8.15009	4	3.0995	1.7094	3.0	2.0
Sulphur Springs	3652							
Oklahoma City	4750	> 4000	3.34096	1	1.1036	1.3891	1.0	1.0
TOTAL	NA	NA	NA	10	7.7363	4.6727	8.0	5.0
				Cheese				
Round Rock	250*							
Ballinger	250*	< 500	-9.95902	3	2.2170	1.0946	2.0	1.0
Fort Worth	490							
Mangum	3291							
San Antonio	4433	> 2000	5.34317	3	3.5070	5.0488	3.0	5.0
Linn	3317*							
TOTAL	NA	NA	NA	6	5.7240	6.1434	5.0	6.0

*Estimated Output
NA: Not Applicable

is the mid-point of the smallest size cheese category. AMPI Southern Region data show the Linn plant processed 33.51 million pounds of whole milk in 1969, the first year any volume data are available for that plant. Dividing 33.51 million pounds by 101.1 pounds of whole milk per pounds of cheese produces an estimate of 3.32 million pounds of cheese manufactured at Linn.

The six 1968 cheese plants fall into two categories: the lowest, covering volumes up to 500,000 pounds, and the largest, including plants with production greater than 2.0 million pounds per year (Table X).

In the United States since 1957, the number of butter and cheese plants decreased dramatically (Table IX). The number of butter plants fell from 2062 in 1957 to 475 in 1972. Cheese plant numbers declined to 613 in 1972 from 1194 in 1957. Most of decline occurred in the small output categories, with butter plants having output less than 1.0 million pounds annually dropping from 1665 to 303 over the period 1957 to 1972. Cheese plants producing less than 500,000 pounds declined from 534 in 1957 to 127 in 1972. Conversely, plant numbers in the largest size categories for both butter and cheese have increased; butter from 48 to 81, and cheese from 98 to 215 over the period 1957 to 1972. This implies the minimum efficient size operation has increased considerably since 1957.

Regression analysis applied to the data in Table IX provides quantitive predictions of the relationships between time and the number of butter or cheese plants operating in the United States. The specified model is:

$$\ln Y_{tc} = A + B_1 X_t + u_{tc} \tag{3.1}$$

where $\ln Y_{tc}$ is the natural logarithm of the number of butter or cheese plants operating in year t in category c; A is the intercept; X_t is the year for which a prediction of plant numbers is desired (last two digits only); and u_{tc} is an error term.

There are two major reasons for specification of a semilog function. First, by stating the dependent variable as a natural logarithm, the estimate obtained for the parameter B_1 is the average annual percentage change in the total number of plants of a given production-size group. For example, regression results for the largest butter production-size group (greater than 4.0 million pounds annually) yield the following equation:

$$\ln Y_{t5} = 2.0332 + 0.0334X_t \quad (3.2)$$

Thus, the average annual increase in the number of butter plants in the United States over the period 1957 to 1972 is 3.34 percent. A negative B_1 coefficient implies a decrease in plant numbers over time.

Second, specifying a semilog relationship prevents negative estimates for total plant numbers. Due to the rapid decrease in the number of plants over the time period covered by the data, predicted values for many size categories are negative when using just the number of plants as the dependent variable rather than the natural logarithm.

The estimates for the B_1 parameter are used to predict the number of AMPI plants that would exist in the years 1971 and 1978 if AMPI had not been created, given the assumed premerger market structure of ten butter-powder plants and six cheese plants. The B_1 parameter resembles in principle a compound interest rate. To determine the predicted plant numbers for any one production-size category for a given year, the estimated coefficient for B_1, is added to one. The resulting value is then raised to a power equal to the number of years from 1968 for which an estimate of plant numbers is desired. In turn, that value is then multiplied by the number of plants actually in that size category in 1968 to get an estimate of plant numbers in the given year. Estimated coefficients for B_1 are listed in Table X.

For example, the smallest butter production-size group has a B_1 coefficient of -.11450655. Subtracting from 1.0 yields a value of .88549345. To predict the number of plants that would exist in 1971, that value is raised to the third power (1971-1968 = 3), to derive a value of .69431422. Since there are three plants in 1968 in the smallest size category for butter, .69431422 is multiplied by 3.0 to produce an estimate of 2.0829 butter plants. Thus based on the trend, if three butter plants existed in the smallest size category for butter in 1968, 2.0829 plants would exist in 1971.

Following the same procedure for all production-size groups for 1971 and 1978 for butter-powder and cheese plants, one obtains estimates of the number of plants for a given category that would exist (Table X). The sum of the estimates for each size category are assumed to estimate total plant numbers in 1971 and 1978. The predicted number of butter plants in 1971 is 7.7363 and 4.6727 in 1978. For cheese, the estimated plant numbers are 5.7240 in 1971 and 6.1434 in 1978 (Table X).

Since fractions of plants cannot exist, each production-size group's estimate is rounded to the nearest whole number to determine the number of plants in that category under the without merger structure. For butter for 1971, the production-size groups, from smallest to largest, have 2.0, 1.0, 1.0, 3.0, and 1.0 plants respectively for a total of 8.0 (Table X). For 1978, the estimated number of plants for the 1.0-1.5 million pounds and 1.5-2.0 million pounds categories are .3505 and .3346, respectively. Rounding both estimates produces a prediction of zero plants for both categories. Doing so would underestimate the total number of plants at 4.0 since 4.6727 rounds to 5.0. Therefore, the Enid plant is assumed to produce butter-powder in 1978. For 1978, then, the number of predicted plants in each category, from smallest to largest, is 1.0, 0.0, 1.0, 2.0, and 1.0 respectively (Table X). Thus, this study assumes 10.0, 8.0 and 6.0 butter-powder plants operated in the without merger market structure for the years 1968, 1971, and 1978, respectively.

For cheese, the 1971 estimate of 3.5070 plants operating in the largest production-size group is rounded downward. Since the assumed market structure of cheese plants includes only the two extremes of production-size groups, it would have been unlikely for one of the smaller plants to increase its production enough over the period 1968 to 1971 so as to move into the largest category. This study supposes the smaller, independent cooperatives lacked financial resources to increase output by such a quantity.

For 1971, two small-size and three large-size cheese plants are assumed to exist in the without merger situation, or a total of 5.0. In 1978, one small-size and five large-size plants are assumed to exist (Table X).

Determining Plant Locations

After estimating how many plants would exist without the emergence of AMPI, one needs to determine which specific plant locations would and would not be operative in the years 1971 and 1978. For example, in 1968, it is assumed three plants have annual butter output less than 1.0 million pounds: Wichita Falls, Jacksonville, and La Grange. It was stated above two plants remain in that category in 1971, and one plant exists in 1978 (Table X). For lack of any other grounds to determine which specific plants exit, the plants assumed to close down are randomly picked. On that basis, the La Grange plant is assumed to exit between 1968 and 1971, and the Jacksonville facility is assumed closed between 1971 and 1978, leaving only the Wichita Falls plant operative in 1978 in the smallest size category (Table XI).

Random selection is also employed for the butter production-size category for 2.0-4.0 million pounds and for the small-size cheese grouping. The Arkansas City butter-powder plant and the Round Rock cheese facility are selected to exit between 1968 and 1971 from their respective categories. The Fort Worth cheese plant is eliminated between 1971 and 1978.

For 1978, the large production-size group for cheese is predicted to have five plants. As stated above, it is improbable the Fort Worth or Round Rock plants (from the small-size category) would have the capacity to move into the large-size group. At the same time, random selection procedures eliminated the Tulsa plant and Muenster plant from the butter-powder structure for 1978. This study assumes the Tulsa and Muenster plants convert to cheese production in the

TABLE XI

PLANTS ASSUMED OPERATING IN THE WITHOUT MERGER SITUATION FOR 1968, 1971, AND 1978

1968	1971	1978
	BUTTER	
Hillsboro	Hillsboro	Hillsboro
Arkansas City	Tulsa	Enid
Tulsa	Enid	Oklahoma City
Enid	Oklahoma City	Wichita Falls
Oklahoma City	Wichita Falls	Sulphur Springs
Wichita Falls	Sulphur Springs	
Sulphur Springs	Muenster	
Muenster	Jacksonville	
Jacksonville		
La Grange		
	CHEESE	
Linn	Linn	Linn
Mangum	Mangum	Tulsa
Fort Worth	Fort Worth	Mangum
Ballinger	Ballinger	Muenster
Round Rock	San Antonio	Ballinger
San Antonio		San Antonio

large-size cheese category. Converting those plants' 1968 butter production (Table X) to whole milk equivalents, and then dividing by 10.1 pounds of whole milk per pound of cheese, places the Tulsa and Muenster plants in the large-size cheese category. Tulsa and Muenster equivalent cheese production equals 4.895 million and 3.429 million pounds respectively. Table XI shows the without merger structure of processing facilities for the years 1968, 1971, and 1978.

Plant Volumes

The final step in determining a without merger market structure estimates whole milk volumes processed by each plant in the years 1968, 1971, and 1978. Because of the seasonality of milk production and Class III milk supply, plant volumes are determined for the months of May and October.

Actual surplus milk handled by the AMPI Southern Region over the decade 1969 to 1978 is fairly constant for the months of May and October. Therefore, this study considers the total supply available for Class III constant for the years 1968, 1971 and 1978, for the with and without merger market structure.

Minimization of surplus milk assembly costs using a transportation model determines volumes processed at each plant in the with merger situation. In the without merger structure, volume in an individual plant is some percentage of the constant total Class III supply. Since more plants exist in 1968, a given plant's volume increases in 1971 and 1978 as plant numbers decline.

To determine volumes in the without merger situation for 1978, this study starts with the actual whole milk volume processed by AMPI plants in May 1969, 90.2497 million pounds.[4] The Arkansas City plant's volume is subtracted from the total volume, because it is assumed to be inoperative in 1978. Volumes for other plants not considered part of the 1968 market structure are also subtracted. The estimated whole milk equivalent volumes for the Enid, Wichita Falls, and Ballinger plants (for which no AMPI data on milk processed is available) are added in. This leaves 87.7097 million pounds in 1978 under the without merger structure. Each plant's actual volume processed in 1969 is then divided by 87.7097 pounds to determine each plant's share of the total. In turn, that percentage multiplied by the constant supply of Class III milk gives a plant's volume in the without merger situation. As an example, the Oklahoma City plant processed 19.0250 million pounds in May 1969. Dividing 19.0250 million pounds by 87.7097 million pounds gives .216909. Multiplying this share by the assumed May surplus milk volume 77.4633 million pounds equals 16.8025 million pounds as the volume for the 1978 period.

The sum of the Jacksonville and Fort Worth volumes (assumed inoperative in 1978 but not 1971) for 1969 equals 2.1956 million pounds, which is added to the 1978 volume of 87.7097 million pounds to give a total Class III supply for 1971 of 89.9053 million pounds. Again, each plant's 1969 actual or estimated volume is divided by 89.9053 to yield each plant's share of the total surplus milk supply. Those shares multiplied by 77.4633 pounds give each plant's volume for 1971. For the Oklahoma City plant, 19.0250 million pounds divided by 89.9053 million pounds equals .211612, which is that plant's share of total surplus supply. Multiplying .211612 by 77.4633 million pounds yields a volume for the Oklahoma City plant of 16.3921 million pounds of whole milk processed during May 1971 in the without merger situation.

For 1968 volumes under the without merger structure, the 1969 actual or estimated volumes for Arkansas City, La Grange, and Round Rock are added to 89.3053 million pounds, to give a 1968 surplus milk supply of 100.1370 million pounds. Each plant's actual or estimated 1969 volume is divided by 100.1370 million pounds to determine a plant's share of the 1968 supply. Multiplying that share by 77.4633 million pounds give a plant's volume for 1968. The Oklahoma City's share is .189989, or 14.7172 million pounds of milk. The Oklahoma City plant processes an increasing share of the milk from 1968 to 1978 as plant numbers decline. Individual plant shares under the assumed without merger situation are listed in Table XII, and volumes in Table XIII.

The same procedures used to determine May plant shares and volumes are applied to October data (Table XII and Table XIII). Contrasting the two months, one sees volumes in general are much larger in May, the flush production season. Specifically, the Oklahoma City, Tulsa, and Sulphur Springs plants combined handle 50 percent of the supply during May, but only 10 percent during October. Conversely, the Muenster and Hillsboro plants process 25 percent of the AMPI Southern Region Class III milk in May, and 53 percent in October.

TABLE XII

PLANTS' SHARES OF TOTAL CLASS III MILK SUPPLY
IN THE WITHOUT MERGER SITUATION FOR
1968, 1971, AND 1978

Plant Location	May 1968	May 1971	May 1978	October 1968	October 1971	October 1978
Oklahoma City	.189989	.211611	.216909	.033469	.036553	.037290
Tulsa	.114613	.127656	.130852	.041380	.045193	.046105
Sulphur Springs	.139508	.155384	.159274	.011424	.012476	.012728
Muenster	.129858	.144637	.148257	.261629	.285727	.291492
Hillsboro	.095081	.105901	.108552	.213928	.233643	.238355
Linn	.028848	.032132	.032936	.082694	.090314	.092136
Enid	.045516	.050696	.051965	.037581	.041044	.041871
Wichita Falls	.015170	.016897	.017322	.012527	.013681	.013957
Ballinger	.003448	.003841	.003937	.002847	.003109	.003172
San Antonio	.080889	.090095	.092350	.122003	.133246	.135934
Mangum	.032974	.036726	.037646	.078049	.085245	.086960
Jacksonville	.015170	.016897		.012527	.013681	
Fort Worth	.006758	.007527		.005576	.006089	
Arkansas City	.083559			.069001		
La Grange	.015170			.012527		
Round Rock	.003448			.002847		

TABLE XIII

PLANTS' VOLUMES PROCESSED IN THE WITHOUT MERGER SITUATION FOR MAY AND OCTOBER FOR 1968, 1971, AND 1978

Plant Location	May 1968	May 1971	May 1978	October 1968	October 1971	October 1978
			-Million pounds-			
Oklahoma City	14.717175	16.392080	16.802481	.630220	.688292	.702169
Tulsa	8.878303	9.888651	10.136224	.779184	.850983	.868156
Sulphur Springs	10.806751	12.036553	12.337885	.215114	.234923	.239668
Muenster	10.059231	11.204055	11.484473	4.926296	5.380230	5.488785
Hillsboro	7.365290	8.203438	8.408793	4.028258	4.399471	4.488217
Linn	2.234666	2.489050	2.551330	1.557125	1.700610	1.734918
Enid	3.525823	3.927078	4.025379	.707649	.772857	.788430
Wichita Falls	1.175122	1.308897	1.341819	.235883	.257613	.262810
Ballinger	.267098	.297537	.304973	.053609	.058542	.059729
San Antonio	6.265932	6.979054	7.153733	2.297313	2.509018	2.559633
Mangum	2.554279	2.844916	2.916182	1.469660	1.605161	1.637454
Jacksonville	1.175122	1.308897		.235883	.257613	
Fort Worth	.523501	.583066		.104996	.114656	
Arkansas City	6.472759			1.299287		
La Grange	1.175122			.235883		
Round Rock	.267098			.053609		

FOOTNOTES

[1] Hugh L. Cook, Leo Blakley, and Calvin Berry, Review of Eisenstat, Philip, Robert T. Masson, and David Roddy, "An Economic Analysis of the Associated Milk Producers, Inc. Monopoly," College of Agricultural and Life Sciences Research Bulletin R2790 (University of Wisconsin-Madison, 1976), p. 7.

[2] This study assumes butter and nonfat dry milk are joint products produced in a single plant.

[3] U. S. Department of Agriculture, Dairy Situation, DS-351 (Washington, 1974), pp. 31-32; this study used the data for butter plants to estimate the number of butter-powder plants; DS-351 also presents data for the number of powder plants.

[4] Data furnished by AMPI Southern Region, San Antonio, Texas. 1969 is the earliest year for which plant volumes are available.

CHAPTER IV

A MODEL FOR ESTIMATING ASSEMBLY COSTS

The two important facets of the marketing efficiency of surplus milk are assembly and processing costs. With respect to assembly costs, this study tries to determine how assembly costs have changed since the creation of AMPI. It also seeks to compare assembly costs under the alternative market structures.

Since the 1950's, mathematical programming techniques have been employed to solve a wide variety of problems relating to optimum shipping patterns and plant locations. This study uses a linear programming algorithm, the transporation model, to determine flows that minimize the cost of assembling all classes of milk. This chapter briefly discusses the general linear programming model and transportation problem, and then describes the transportation model used in this study.

The Linear Programming Model

Linear programming deals with the allocation of scarce resources among competing activities in an optimal way.[1] The development of operations research, of which linear programming is a part, stemmed from the need to determine optimal shipping patterns and allocation of material during World War II. Since that time, agricultural economists have applied linear programming to specify optimum farm resource and enterprise organization, to determine optimum product mixes for agricultural marketing firms, and to provide spatial equilibrium patterns in the flow of agricultural products, among other uses.

Linear programming techniques optimize a linear objective function, Z, of n variables subject to m linear equalities or inequalities. In mathematical terms, the problem is stated as

$$Z = \sum_{j=1}^{n} C_j X_j \qquad (4.1a)$$

Subject to

$$\sum_{j=1}^{n} a_{ij} X_j \{ \geq, =, \leq \} b_i \qquad i = 1, \ldots, m \qquad (4.1b)$$

$$X_j \geq 0 \qquad j = 1, \ldots, n \qquad (4.1c)$$

C_j is the price or cost associated with a particular variable or activity, X_j; a_{ij} equals the amount of the i^{th} resource required per unit of the j^{th} activity; and b_i is the amount of the i^{th} resource available. For the linear constraints (Equation 4.1b), only one sign can hold.

The formulation above carries several assumptions.[2] First, the objective function and constraints are linear and additive. Products, powers, and combinations of variables violate the linearity assumption. The activities are additive in the sense when two or more are used, their total product must be the sum of their individual products. Also, linear programming assumes the values for the activities and objective function are infinitely divisible. A third assumption, finiteness, means there is a limit to the number of alternative activities and resource restrictions that need to be considered. Finally, all resource supplies (b_i), technical coefficients (a_{ij}) and prices (C_j) are single-valued and known with certainty.

A solution to a linear programming problem where the number of nonzero valued variables is equal to the number of constraints is said to be basic. A feasible solution meets the nonnegative constraints, and all activities have nonnegative values. Where a solution is a maximum or minimum, the solution is optimal.

The Transportation Problem

The transportation problem is a special case of linear programming where the objective is to minimize the transportation cost of a homogeneous product from m sources to n destinations. Mathematically stated, the problem becomes

$$Z = \sum_{i=1}^{m} \sum_{j=1}^{n} C_{ij} X_{ij} \qquad (4.2a)$$

Subject to

$$\sum_{j=1}^{n} X_{ij} = S_i \qquad i = 1, \ldots, m \qquad (4.2b)$$

$$\sum_{i=1}^{m} X_{ij} = D_j \qquad j = 1, \ldots, n \qquad (4.2c)$$

$$X_{ij} \geq 0 \text{ for all i and j} \qquad (4.2d)$$

Z is the objective function, minimum transportation cost; C_{ij} is the per unit shipping cost between the i^{th} source and j^{th} destination and X_{ij} is the quantity transferred between those two points; S_i equals the amount available for shipping from the i^{th} source, and D_j is the quantity demanded at destination j. The same assumptions of the general linear programming model apply to the transportation problem.

Equation (4.2b) requires the sum of the demands for goods from the i^{th} source at each of the n destinations to equal the supply actually available at i. Similarly, Equation (4.2c) states the sum of the quantities supplied from each of the m sources to the j^{th} destination must equal the quantity actual demanded at j. Combining (4.2b) and (4.2c) yields

$$\sum_{i=1}^{m} \sum_{j=1}^{n} X_{ij} = \sum_{i=1}^{m} S_i = \sum_{j=1}^{n} D_j \qquad (4.3)$$

Equation (4.3) requires the total quantity shipped from all sources to all destinations equal total quantity demanded at all destinations from all sources.

The transportation problem contains m + n constraints. Since the nonzero coefficients of the X_{ij} are ones and any given X_{ij} appears in two and only two of the constraints, the constraints in this linear programming problem have a special structure. This structure results in two features. First, the structure allows computational efficiencies not available to the general linear programming model. Second, at least one of the optimal solutions to the transporation problem is integar valued.

The Transportation Model

The specific objective of the transportation model used in this study is to minimize the cost of assembling AMPI Southern Region Grade A milk to fluid and hard-product processing plants under alternative market structures. Data furnished by AMPI provide volumes to apply to the model. Total milk supply is the sum of producers' deliveries by AMPI Southern Region members. Total fluid milk demands equal the sum of each handler's fluid milk purchased from AMPI, and the surplus milk available for cheese and butter-powder manufacturing at AMPI plants is the difference between total supply and total fluid demand.

Because of the seasonality in milk production, assembly costs are estimated for the months of May and October, for both the with and without merger situations. This study considers the total supply, total fluid demands (and each handler's demand), and the surplus milk supply fixed for all years. From AMPI data, the total milk supply for May 1978 is 397.07 million pounds; that value is considered the May supply for all years. Total fluid demands equal 319.61 million pounds, and the surplus equals 77.46 million pounds for May 1978.

Total supply, total fluid demand, and total class III supply are also assumed fixed for October (based on AMPI October 1977 data). Those volumes equal 363.37 million pounds, 344.54 million pounds, and 18.83 million pounds, respectively.

Supply and demand areas are designated on a county basis. Any county that had AMPI-member production in May 1978 or October 1977 is a separate supply area. Summing all members' production in one county yields the total supply in that county. For May, there are 390 supply areas, and for October, 388 areas.

Demand areas are of two types, fluid and manufacturing. A fluid demand area is any county in which exists a fluid milk processor who purchased Grade A milk from AMPI in May 1978 or October 1977. If there are more than one handler in a county, the sum of the individual handler volumes gives the total fluid demand for that demand area. For May, there are 66 fluid demand areas, and 65 for October.

Manufacturing demand areas are counties in which AMPI plants are located. Depending upon year and market structure under consideration, the number of manufacturing demand areas varies. There is no more than one AMPI plant in any one county, and 17 in total.

This study supposes transportation costs are a linear function of mileages involved in moving milk from the county seat of a supply area to the county seat of a demand area. AMPI data furnished included the distances based on arc length. Those mileage estimates multiplied by 1.21 approximate road distances. A flat rate of \$ .0025 per cwt./mile is assumed, based on the average costs incurred by AMPI in the inter-market transport of milk. The rate is adjusted for 1978 cost conditions.

Only intermarket shipping costs are considered; costs incurred in farm-to-county seat assembly are excluded. Thus, costs estimated here understate actual farm-to-plant costs. Assembly costs in this study reflect the marginal cost of shipping milk some extra distance between markets, opposed to total transportation costs of farm-to-plant assembly.

Figure 5 represents the general linear programming matrix of the transportation problem under consideration. As a computational convenience, a "greater than" constraint is actually used for fluid demand areas. The right-hand side for any fluid demand area is equal to the fluid demand minus one. A "less than" constraint is

	$X_{11}\ X_{12}\ \cdots\ X_{1n} \cdots X_{m1} X_{m2} \cdots X_{mn}$	
Fluid Milk Demand Constraints	1 ... 1 1 . . . 1 ... 1 . . . 1 . . 1 . . 1	= Actual Fluid = Demands = By County
Manufacturing Plant Constraints	1 ... 1 1 . . . 1 ... 1 . . . 1 . . 1 . . 1	= Any Volume or = Some Fixed = Volume
Supply Constraints	1 1 ... 1 . . . 1 1 ... 1	= Actual AMPI Milk = Production by County

Figure 5. Matrix for Transporation Model

applied to the supply areas, also to facilitate computation. Adding one to each county's total supply yields the right-hand side for each supply area. By adding two equality constraints for total supply and demand, the solution equates total supply to total demand.

Since AMPI plants in the with merger situation handle any volumes, a "less than" constraint set at a very high number allows those plants to accept any volume. In the without merger situation, each plant processes a fixed amount of milk determined previously (Chapter III). In the without merger situation, a "greater than" constraint is used with the right-hand side equal to each plant's estimated volume for the manufacturing plants less one pound.

Transport costs are minimized under two sets of conditions. One minimizes the total transportation costs for both fluid and manufacturing milk. This situation reflects the with merger situation where a large regional cooperative can better coordinate intermarket milk movements.

The second initially minimizes the transport costs that satisfy only the fluid demands. In that case, the total supply row becomes a nonconstraint row, or is essentially eliminated. Doing so allows identification of locations and volumes of surplus milk. The shipping costs of the surplus milk to the manufacturing plants is then minimized separately. The second set of conditions represents a without merger situation, where an independent cooperative typically satisfies the fluid demands first, and then assembles and processes the surplus.

FOOTNOTES

[1]Frederick S. Hillier and Gerald J. Lieberman, Operations Research, 2nd ed. (San Francisco, 1974), p. 15.

[2]Earl O. Heady and Wilfred Candler, Linear Programming Methods (Ames, Iowa), 1958, pp. 16-17.

CHAPTER V

RESULTS AND ANALYSIS

Three important functions performed by producers' cooperatives include (1) transporting Grade A milk from farms to firms processing milk for Class I and Class II uses by consumers, (2) transporting surplus Grade A milk from farms to private and cooperative-owned processing plants,[1] and (3) processing the excess milk into manufactured milk products such as butter, nonfat dry milk powder, and cheese. It is in the performances of these functions that important economies might be achieved through coordination of transportation and manufacturing activities.

There are several approaches to measuring the savings that might be achieved due to coordination. This study selects an approach that first determines the costs of assembly and processing under the market structure designated as "without merger". These costs become the base situation and represent the number and size of firms at or just before any merger activities in the study area. Next, the costs of assembly and processing are estimated for a "with merger" market structure under two different assumptions concerning coordination. One assumption is that the coordination is centralized with costs minimized for the transportation of all classes of milk. The other assumption is that coordination is decentralized to the division (state) level with costs minimized for milk needed by fluid handlers. The excess milk, wherever located, is then transported to the closest cooperative-owned processing facility. Under both types of market structures, some plants were actually closed in 1968 as a result of the merger into MPI and were considered operating at 1967 levels for the with merger and without merger situations.

Data for the study includes monthly quantities for May and October. Two approaches for computing annual costs include (1) estimating per unit costs for each of the two months, averaging the estimates and applying the average to annual quantities, and (2) estimating the factor which each month's quantity represents of the annual quantity and use this factor to expand the monthly cost to an estimated annual cost. Both types of cost estimates are made, but the final conclusions emphasize the first set of estimates.

Without Merger Market Structure

The without merger market structure reflects a scenario where a local independent cooperative serves a single or a few markets. Under this situation, the cooperative supposedly minimizes the transportation costs of milk to meet fluid handlers demands and diverts the surplus to cooperative-owned manufacturing plants. To simulate the flows of milk to fluid plants and manufacturing facilities, the transportation model first minimizes the cost of assembling milk to fluid handlers, and separately minimizes the cost of moving surplus milk to cooperative butter-powder or cheese plants. Volumes flowing to manufacturing plants are assumed to be some share of the Class III milk supply. These shares increase for remaining plants as other facilities exit from the industry. Processing costs are estimated using the cost functions previously derived and applied to each plant's effective annual volume.

Assembly Activities

In the without merger situation, fluid transportation costs are minimized independently of surplus milk shipping costs. Since total milk supply and fluid demands are the same for all years, the fluid milk shipping costs are constant on an annual basis for May of each year. The May (October) fluid costs are converted to annual costs by dividing the monthly cost by 0.083 (0.086), the May (October) percentage of the total annual fluid milk demand. May costs were 7.173 million dollars, or $ .186 per cwt. (Table XIV and XV). Annual fluid milk assembly costs based on October data are 7.994 million dollars, or $ .202 per cwt. (Tables XV and XVI).

Minimum transportation costs for surplus milk decrease little from May 1968 to May 1978, falling from 2.836 million dollars ($ .500 per cwt.) to 2.826 million dollars ($ .497 per cwt.) on an annual basis for May (Tables XIV and XV). For October, cost declines from 5.536 million dollars ($ .900 per cwt.) in 1968 to 5.530 million dollars ($ .899 per cwt.) in 1978 (Tables XV and XVI).

The high cost of shipping surplus milk in the without merger situation can be attributed to two reasons. First, minimization of fluid costs separately generally leaves the surplus milk farther away from manufacturing plants, which increases the distance and cost of moving the surplus milk. Second, in the without merger situation each butter-powder or cheese plant has a volume equality constraint. This means some milk that could have been shipped to

TABLE XIV

ANNUAL PROCESSING AND TRANSPORT COST UNDER ALTERNATIVE MARKET STRUCTURES PROJECTED FROM MAY DATA, AMPI SOUTHERN REGION, SELECTED YEARS 1968-78

Type of Cost	1968	1971	1978
	Without Merger Structure		
Manufacturing	$ 7,338,798	$ 6,743,090	$ 7,552,109
Fluid Assembly	7,173,020	7,173,020	7,173,020
Surplus Assembly	2,836,218	2,834,469	2,826,368
Total	17,348,036	16,750,579	17,551,497
	With Merger Structure: Central Coordination		
Manufacturing	$ 6,620,076	$ 5,853,127	$ 5,633,939
Fluid Assembly	8,595,713	8,648,444	7,468,433
Surplus Assembly	750,670	751,212	723,856
Total	16,066,459	15,252,783	13,826,228
	With Merger Structure: Division Coordination		
Manufacturing	$ 6,936,931	$ 6,698,252	$ 5,860,307
Fluid Assembly	7,173,020	7,173,020	7,173,020
Surplus Assembly	2,671,087	2,788,151	1,491,424
Total	16,781,038	16,659,423	14,524,751

TABLE XV

AVERAGE ANNUAL FLUID MILK, SURPLUS MILK, AND COMBINED TRANSPORT COST UNDER ALTERNATIVE MARKET STRUCTURES, AMPI SOUTHERN REGION, SELECTED YEARS 1968-1975

	May Conditions			October Conditions		
	1968 ($/cwt)	1971 ($/cwt)	1978 ($/cwt)	1968 ($/cwt)	1971 ($/cwt)	1978 ($/cwt)
	Without Merger Structure					
Fluid	.1859	.1859	.1859	.2022	.2022	.2022
Surplus	.5003	.5000	.4986	.8999	.9066	.8989
Combined	.2472	.2472	.2469	.2384	.2387	.2383
	With Merger Structure: Central Coordination					
Fluid	.2228	.2241	.1936	.2151	.2157	.2056
Surplus	.1324	.1325	.1277	.0961	.0938	.1183
Combined	.2052	.2063	.1807	.2089	.2094	.2011
	With Merger Structure: Division Coordination					
Fluid	.1859	.1859	.1859	.2022	.2022	.2022
Surplus	.4712	.4918	.2631	.7384	.8041	.2324
Combined	.2415	.2456	.2010	.2300	.2334	.2038

TABLE XVI

ANNUAL PROCESSING AND TRANSPORT COST UNDER ALTERNATIVE MARKET STRUCTURES PROJECTED FROM OCTOBER DATA, AMPI SOUTHERN REGION, SELECTED YEARS 1968-1978

Type of Cost	1968	1971	1978
	Without Merger Structure		
Manufacturing	$ 8,837,693	$ 7,762,464	$ 8,625,905
Fluid Assembly	7,994,296	7,994,296	7,994,296
Surplus Assembly	5,535,646	5,576,973	5,529,635
Total	21,917,635	21,333,733	22,149,836
	With Merger Structure: Central Coordination		
Manufacturing	$ 5,461,980	$ 5,282,616	$ 4,377,376
Fluid Assembly	8,502,031	8,525,425	8,129,359
Surplus Assembly	591,128	576,982	728,015
Total	14,555,140	14,385,023	13,234,750
	With Merger Structure: Division Coordination		
Manufacturing	$ 7,007,250	$ 6,177,114	$ 4,353,375
Fluid Assembly	7,994,296	7,994,296	7,994,296
Surplus Assembly	4,542,482	4,946,706	1,429,535
Total	19,544,028	19,118,116	13,777,306

other facilities at a lesser cost must be diverted to other plants to meet the restrictions.

Manufacturing Activities

Total annual processing costs based on May and October annualized volumes are higher in 1978 than in 1968 (Table XIV and Table XVI). Annualized volume is based on an expansion from a May (October) volume equal to .137 (.031) of the annual manufacturing milk volume.

From the results it appears processing costs increase as fewer plants take on larger volumes, contrary to long-run cost theory. But at all volumes, cheese is more expensive than butter-powder to manufacture. The percentage of the surplus milk supply going into cheese production during May increases from less than 20 percent in 1968 and 1971 to 45 percent in 1978. For October, that percentage rises to 66 percent in 1978 from around 30 percent during 1968. Therefore the greater total processing cost in 1978 can be explained by the doubling of cheese volume.

To obtain a notion if economies of size in processing are evident, one needs to compare the change in the per unit costs of butter-powder manufacturing and cheese processing. Unit costs for butter-powder manufacturing based on May volumes decline continuously between 1968 and 1978 (Table XVII). For cheese production, costs decline continuously over the period for May volumes (Table XVII) and October volumes (Table XVIII).

Unit costs based on May volumes reflect conditions where quantities of surplus milk are at or near a maximum; October costs represent a case where quantities of surplus milk are at or near a

TABLE XVII

TOTAL ANNUAL WHOLE MILK VOLUMES PROCESSED INTO BUTTER-POWDER OR CHEESE AND AVERAGE PROCESSING COST UNDER ALTERNATIVE MARKET STRUCTURES PROJECTED FROM MAY DATA, AMPI SOUTHERN REGION, SELECTED YEARS 1968-1978

Product Type	1968		1971		1978	
	Annual Effective Volume (million lbs.)	Average Cost ($/cwt)	Annual Effective Volume (million lbs.)	Average Cost ($/cwt)	Annual Effective Volume (million lbs.)	Average Cost ($/cwt)
			Without Merger Structure			
Butter-Powder	478.26	1.062	470.35	.933	314.08	.897
Cheese	88.64	2.548	96.56	2.438	252.83	1.873
		With Merger Structure: Central Coordination				
Butter-Powder	501.77	.964	310.10	.690	320.18	.784
Cheese	65.13	2.739	256.80	1.446	246.72	1.267
		With Merger Structure: Division Coordination				
Butter-Powder	451.23	.957	263.10	.748	264.30	.871
Cheese	115.67	2.420	303.80	1.557	302.60	1.176

TABLE XVIII

TOTAL ANNUAL WHOLE MILK VOLUMES PROCESSED INTO BUTTER-POWDER OR CHEESE AND AVERAGE PROCESSING COST UNDER ALTERNATIVE MARKET STRUCTURES PROJECTED FROM OCTOBER DATA, AMPI SOUTHERN REGION, SELECTED YEARS 1968-1978

Product Type	1968		1971		1978	
	Annual Effective Volume (million lbs.)	Average Cost ($/cwt)	Annual Effective Volume (million lbs.)	Average Cost ($/cwt)	Annual Effective Volume (million lbs.)	Average Cost ($/cwt)
	Without Merger Structure					
Butter-Powder	434.30	1.132	419.55	1.001	211.74	1.152
Cheese	180.87	1.919	195.63	1.821	403.43	1.534
	With Merger Structure: Central Coordination					
Butter-Powder	499.23	.702	399.64	.563	406.23	.533
Cheese	115.94	1.690	275.54	1.221	208.94	1.059
	With Merger Structure: Division Coordination					
Butter-Powder	304.67	.805	160.11	.577	413.95	.530
Cheese	310.49	1.467	455.06	1.154	201.23	1.073

minimum. Thus actual annual average manufacturing costs probably lie in the range between the May and October estimates. For example, the May 1968 cheese cost estimate is \$2.548 per cwt., and the October 1968 cheese cost estimate equals \$1.919 per cwt. The actual cost of processing whole milk into cheese for 1968, then, may lie between \$2.548 per cwt. and \$1.919 per cwt.

Combined Activities

This study considers three marketing functions performed by cooperatives: assembling and allocating members' milk to fluid handlers, assembling the surplus Grade A milk to cooperative processing facilities, and manufacturing butter-powder or cheese at those facilities. Total annual costs of performing those activities provide insight into the most efficient market organization. Total marketing costs with May volumes are shown in Table XIV. Those estimates suggest 1971 as the most efficient organization. But due to the larger percentage of milk going into the more expensive cheese production, the 1978 organization has larger total processing costs. Average costs, though, decrease from 1971 to 1978 (Table XVII), indicating that economies of size are obtained. October annual costs, portrayed in Table XVI, indicate that transportation costs are almost equal over all years, so again the higher 1978 total cost is biased due to the larger quantities of milk being used for cheese.

With Merger Market Structure: Central Coordination

The with merger market structure includes only those plants actually operated in 1971 and 1978. For 1968, the with merger situation includes the same sixteen plants as the 1968 without merger structure. In the case where a cooperative controls a large part of the supply over a region, it coordinates movements of milk to both fluid plants and cooperative facilities so as to minimize total transportation cost. Volumes flowing to butter-powder or cheese plants are given by the transportation model when assembly costs are minimized. An upper restriction is placed on each plant's volume processed in one month. These restrictions equal the maximum volume of whole milk processed in any one month for a year or group of years. For example, the Oklahoma City plant has an upper limit (or capacity) of 16.0 million pounds per month in 1978. That volume equals the largest quantity processed in any one month during the period 1976 to 1978 at the Oklahoma City plant. Processing costs, as in the without merger structure, are computed on the basis of annual effective volumes using the previously derived cost functions.

Assembly Activities

Fluid milk assembly costs under the with merger situation based on May volumes decrease between 1968 and 1978 (Tables XIV and XVI). Surplus milk assembly costs also decrease over the decade (Tables XIV and XVI). Hence, total assembly costs decrease from 9.35 million dollars in 1968 to 8.28 million dollars in 1978 (Table XIV).

A priori, one would assume total transportation costs to increase with time as surplus plants are closed down, and distances to operating plants increase, rather than decrease as they do in the with merger situation. But in reality, AMPI added a processing plant at

El Paso, Texas between 1971 and 1977. This plant handles primarily surplus milk from nearby Dona Ana County, New Mexico, and El Paso County, Texas. In prior years, that milk has been moved much greater distances to such points as Lubbock and Midland, Texas, and Albuquerque, New Mexico. This is the major reason for the large decrease in shipping costs for 1978.

For volumes based on October data, fluid assembly costs fall over the period 1968 to 1978, while surplus assembly costs increase. Total transportation costs decline over the period 1968 to 1978 from 9.09 million dollars to 8.86 million dollars. Presumably, coordination allows significant reductions in the cost of assembling fluid milk. Those savings more than offset the increase in moving the surplus milk longer distances to fewer manufacturing plants.

Manufacturing Activities

Annual combined costs of manufacturing butter-powder and cheese under May supply conditions (Table XIV) and October conditions (Table XVI) decrease continually from 1968 to 1978. From the results, it appears AMPI realizes economies of size in processing operations, but the higher cost of cheese manufacturing versus butter-powder manufacturing has affected the results. Unit costs, though, provide clues whether economies are actually obtained. For May, the average cost of butter-powder processing declines in 1971 but rises in 1978 (Table XVII). For cheese, average cost decreases steadily over the period considered (Table XVII). This indicates most economies of size in manufacturing came early (within three years) after establishment of AMPI. The $ .094 per cwt. higher average cost for butter-powder manufacturing in 1978 versus 1971 is more than offset by a decrease in the cheese unit cost of $ .179 per cwt. This represents a net saving of 219.2 thousand dollars in manufacturing costs.

Average annual butter-powder and cheese manufacturing costs using October data fall uninterrupted from 1968 to 1978 (Table XVIII). Thus, both total processing costs and average costs for October volumes for manufacturing butter-powder and cheese decline from 1968 to 1971 to 1978. The creation of AMPI apparently allows these economies to be realized by concentrating larger volumes in fewer plants.

Combined Activities

The total marketing cost is the sum of the costs in assembling and allocating milk to fluid handlers and cooperative manufacturing plants, and manufacturing the surplus milk. Based on May volumes, total marketing costs equal 16.07 million dollars in 1968, 15.25 million dollars in 1971, and 13.83 million dollars in 1978 (Table XIV). Total marketing costs using October volumes are 14.56 million dollars, 14.39 million dollars, and 13.24 million dollars in 1968, 1971, and 1978 respectively (Table XV).

The 2.24 million dollar saving between 1968 and 1978 based on May supply conditions results largely from eliminiation of excess capacity by closing smaller, less efficient plants. That savings equals .986 million dollars. The rest of the saving comes from a decrease in total transportation cost of 1.254 million dollars. That decrease results mainly from location of a manufacturing plant at El Paso. For October supply conditions, a 1.32 million dollar savings between 1968 and 1978 can be attributed to 1.085 million dollar decline in manufacturing cost and a .235 million dollar savings in total assembly costs. October's total marketing cost declines because of the same reasons the May marketing cost does.

With Merger Market Structure: Division Coordination

As a means of comparing how coordination affects the costs of assembling milk and manufacturing surplus milk into dairy products, this study considers a with merger market structure where coordination is done at the division level. This situation assumes the with merger/central coordination plant configurations and plant constraints for 1968, 1971 and 1978. But it also supposes the without merger procedure of minimizing fluid milk transportation costs separate of the surplus milk assembly costs. The with merger/division coordination structure portrays a situation where plant numbers and locations are those of AMPI's actual operating facilities but milk flows are coordinated on a division (statewide) basis rather than on a regional basis.

Assembly Activities

The transportation model minimizes fluid costs separately from the surplus milk under this structure. With a fixed supply and fluid demand for all years, the fluid assembly cost is the same for all years under May supply conditions and totals 7.173 million dollars, or \$ .1859 per cwt. (Tables XIV and XV). Surplus milk costs decrease substantially from 1968 to 1978 (Tables XIV and XVI). The large decrease in surplus milk assembly costs is due to the larger volume restrictions put on AMPI plants for 1978 versus 1971. In 1971, three plants take on capacity volumes whereas only one does in 1978. These larger restrictions allow some surplus milk to flow to plants closer to the supply than in 1971, decreasing costs.

Based on October supply conditions, fluid milk transport cost equals 7.994 million dollars, or $ .2022 per cwt. (Tables XV and XVI). Surplus milk assembly cost increases in 1971 but decreases dramatically in 1978 (Table XV and XVI). The large decrease in transportation cost of surplus milk in 1978 comes from the establishment of a plant at El Paso. In October 1978, El Paso accepts surplus milk from Pima County, Arizona and Dona Ana County, New Mexico. In October 1971, the same volumes of milk from those two counties are transported to the San Antonio manufacturing facility. Since Sl Paso is approximately 600 miles closer to Pima County and Dona Ana County, such a decrease in transportation costs between 1971 and 1978 is plausible.

Manufacturing Activities

Manufacturing costs based on May volumes decrease steadily from 1968 to 1978 (Table XIV), as do costs based on October volumes (Table XVI). Average costs of manufacturing butter-powder and cheese under May conditions are shown in Table XVII; for October volumes, Table XVIII presents average manufacturing costs.

Total costs decrease continuously from 1968 to 1978 under both May and October supply conditions. This suggests economies of size as plant numbers decrease, although unit costs provide a more reliable guide. Since May volumes reflect a maximum surplus milk supply condition and October volumes a minimum surplus milk condition, actual annual average cost probably lies between the two estimates.

Combined Activities

Total marketing costs under May supply conditions decrease from 16.781 million dollars in 1968 to 16.659 million dollars in 1971, and further decrease to 14.524 million dollars in 1978 (Table XIV). Of the 2.257 million dollar saving under the 1978 organization versus the 1968, 1.077 million dollars is due to economies in manufacturing hard dairy products from concentrating greater volumes in fewer plants. The remainder, 1.180 million dollars, accrues from savings in the assembly of surplus milk. Once again, the addition of the El Paso plant reduces substantially assembly costs because it is closer to the source of surplus milk.

For October, total marketing costs equal 19.544 million dollars in 1968, 19.118 million dollars in 1971, and 13.777 million dollars in 1978 (Table XVI). A saving of 2.654 million dollars occurs because of manufacturing economies. Over 67 percent of the surplus milk supply goes into butter-powder production in 1978, versus only 50 percent in 1968, which biases total costs downward. Also, 1978 manufacturing activities take place in three plants, while in 1968 there were eight operating plants. With respect to assembly activities, there is a saving of 3.133 million dollars annually under the 1978 structure; the El Paso plant's handling of surplus milk is again the reason: in 1968, surplus milk from Pima County, Arizona, and Dona Ana County, New Mexico flows to the Mangum, Oklahoma plant and the San Antonio facility.

An Alternative Approach

An additional approach that may be used to estimate savings from coordination is to multiply the per hundredweight savings in performing the assembly and manufacturing functions by the respective volumes involved in each function. Because of the disparate product mixes between butter-powder and cheese among the various years and market structures, the per hundredweight savings for manufacturing are based on the per hundredweight cost for the average annual volume per plant. For example, in the with merger/central coordination scenario, total whole milk volume processed in May 1968 equals 501.77 million pounds. Dividing that number by nine, the number of plants manufacturing butter-powder, yields an average plant volume of 55.75 million pounds (Table XIX). The per hundredweight savings are applied to the volumes that actually went into AMPI (or MPI) butter-powder or cheese plants to determine total manufacturing cost savings. For example, in 1969, 525.6 million pounds went to AMPI plants predominantly processing butter and/or powder (Table XX). Multiplying 5.256 million hundredweight by the per hundredweight savings of $0.265 for the with merger/central coordination situation yields a total savings of 1.39 million dollars in butter-powder production costs. Volumes and per hundredweight costs for the average plant size, per hundredweight savings, and total savings for butter-powder manufacturing are shown in Table XIX, and in Table XXI for cheese manufacturing.

With respect to assembly costs, the total savings are based on the combined assembly costs per hundredweight as shown previously in Table XV, and are applied to the combined fluid and surplus annual

TABLE XIX

AVERAGE ANNUAL VOLUME PER PLANT AND AVERAGE COST, PER HUNDREDWEIGHT PROCESSING SAVINGS, AND TOTAL ANNUAL PROCESSING SAVINGS FOR BUTTER-POWDER PLANTS THREE MARKET STRUCTURES, AMPI SOUTHERN REGION, SELECTED YEARS 1968-1978

	1968		1971		1978	
	Average Annual Volume Per Plant (million lbs.)	Cost Per Cwt. ($)	Average Annual Volume Per Plant (million lbs.)	Cost Per Cwt. ($)	Average Annual Volume Per Plant (million lbs.)	Cost Per Cwt. ($)
Without Merger						
May	47.83	1.062	58.79	.933	62.816	.897
October	43.43	1.132	52.44	1.001	42.35	1.152
Average	-	1.097	-	.967	-	1.024
With Merger						
Central Coordination						
May	55.75	.963	103.37	.696	80.04	.784
October	99.85	.702	169.32	.565	203.12	.533
Average	-	.832	-	.625	-	.659
Division Coordination						
May	56.40	.957	87.70	.748	66.08	.871
October	76.17	.805	160.11	.577	206.98	.530
Average	-	.881	-	.662	-	.700
Unit Savings From						
Division Coordination		.216		.300		.324
Central Coordination		.265		.342		.365
Total Savings From (million dollars)						
Division Coordination		1.14		1.47		1.08
Central Coordination		1.39		1.67		1.22

TABLE XX

ACTUAL VOLUMES OF WHOLE MILK PROCESSED IN AMPI BUTTER-POWDER AND CHEESE PLANTS FOR SELECTED YEARS, 1968-1978

	1968 Volume	1971 Volume	1978 Volume
		Millions of Pounds	
Butter-Powder	525.605	489.788	333.276
Cheese	103.862	287.654	333.276
Total	629.467	777.442	666.532

SOURCE: Data furnished by AMPI Southern Region, San Antonio, Texas

TABLE XXI

AVERAGE ANNUAL VOLUME PER PLANT AND AVERAGE COST, PER HUNDREDWEIGHT PROCESSING SAVINGS, AND TOTAL ANNUAL PROCESSING SAVINGS FOR CHEESE PLANTS THREE MARKET STRUCTURES, AMPI SOUTHERN REGION, SELECTED YEARS 1968-1978

	1968		1971		1978	
	Average Annual Volume Per Plant (million lbs.)	Cost Per Cwt. ($)	Average Annual Volume Per Plant (million lbs.)	Cost Per Cwt. ($)	Average Annual Volume Per Plant (million lbs.)	Cost Per Cwt. ($)
Without Merger						
May	14.78	3.017	19.31	2.851	42.18	2.189
October	30.15	2.504	39.14	2.263	67.23	1.726
Average	-	2.761	-	2.557	-	1.956
With Merger						
Central Coordination						
May	13.03	3.084	85.60	1.508	123.36	1.262
October	57.96	1.871	137.77	1.210	208.92	1.059
Average	-	2.478	-	1.359	-	1.161
Division Coordination						
May	19.28	2.852	75.95	1.612	151.30	1.173
October	77.62	1.592	151.69	1.172	201.25	1.073
Average	-	2.222	-	1.392	-	1.123
Unit Savings From						
Division Coordination		.539		1.165		.833
Central Coordination		.283		1.198		.795
Total Annual Savings (million dollars) From						
Division Coordination		0.56		3.35		2.78
Central Coordination		0.29		3.45		2.65

volumes. To obtain annualized fluid milk volumes, the May and October monthly fluid volumes (319.61 million pounds and 344.54 million pounds, respectively) are divided by their respective conversion factors of 0.083 and 0.087; the resulting values are averaged to determine annual fluid volume for all years; that value equals 39.06 million hundredweight. The total pounds actually processed by AMPI plants (Table XX) are added to the fluid total to give the combined volume. The May and October combined costs per hundredweight are averaged; savings per hundredweight (based on that average) multiplied by the combined fluid and surplus milk volumes yields total transportation savings.

Following this approach, the annual savings are shown in Table XXII. The results indicate that substantial economies of size have resulted from the merger with savings for manufacturing and transportation activities in excess of 5.5 million dollars annually under both division and central coordination. They also suggest the bulk of the savings occurred early after the merger, since 1971 savings are more than double those in 1968, but level off in 1978. It is noted the substantially larger volume of surplus milk processed in 1971 will increase savings due to manufacturing efficiencies relative to the 1978 manufacturing savings.

An alternative procedure for measuring savings would be to compare total costs as given in Tables XIV and XVI under the various market structures. Annual savings based on May data and October data are averaged to give an estimate of annual average savings. For 1978, the average annual savings of the with merger structure/central coordination compared to the without merger situation equal 6.32 million

TABLE XXII

ESTIMATED ANNUAL SAVINGS IN TRANSPORTATION AND PROCESSING COSTS UNDER THE WITH MERGER STRUCTURE WITH CENTRAL AND DIVISION COORDINATION, AMPI SOUTHERN REGION, SELECTED YEARS 1968-1979

	1968 (million $)	1971 (million $)	1978 (million $)
Central Coordination			
Butter-Powder Mfg.	1.39	1.67	1.22
Cheese Mfg.	.29	3.45	2.65
Transportation	1.62	2.23	2.36
Total	3.30	7.35	6.23
Division Coordination			
Butter-Powder Mfg.	1.14	1.47	1.08
Cheese Mfg.	.56	3.35	2.78
Transportation	.32	.65	1.84
Total	2.02	5.47	5.70

dollars, which is similar to the estimate of 6.23 million dollars using the first approach. But using this procedure will exaggerate savings due to the fact October surplus milk transport costs are converted to an annual basis by dividing cost by 0.031, which has the effect of greatly inflating assembly costs. Because of the differing product mix for all years under the three types of market structures, manufacturing costs can differ greatly and also affect the savings estimates.

FOOTNOTES

[1]Processing and manufacturing are synonymous terms in this study.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Summary

Technological innovations and inspection reciprocity after World War II created large potential economies of size in fluid milk processing and distribution. As a result, the number of fluid processors declined dramatically with the remaining firms increasing their volume and geographic coverage.

During this period, a single milk producers' cooperative typically served fluid handlers in each major city or market area. Due to the large decrease in the number of fluid processors, local cooperatives came to depend on fewer customers, mainly large national or regional proprietary firms with marketing activities in many markets. Thus, a cooperative often found itself competing with cooperatives in other milksheds that supplied a common firm operating in several markets. Cooperatives retained little market power against these fluid milk handlers. Low returns to producers characterized the period. As a response to these conditions, producers' organizations federated with a primary objective of increasing producers' market power through coordination of marketing activities. To perpetuate and expand the gains from federation, many member cooperatives pursued merger. As a result, several cooperatives regional in scope were created.

Large regional cooperatives have assumed the role of procuring producers' milk and allocating the specified quantities when and where fluid handlers want them. Milk supplies over and above quantities demanded for fluid purposes are sold or processed at cooperative-owned manufacturing facilities. Actual milk movements minimize the total transportation cost for all milk. The overall effect of increased coordination is a stronger horizontal marketing base at the producer and first handler level and forward vertical integration by cooperatives.

In many market areas, regional cooperatives controlled large shares of the supply. The existence of Associated Milk Producers, Incorporated as a large producer organization resulted in high visibility and a Justice Department suit in 1972 alleging predatory and exclusionary conduct in violation of antitrust laws. A report prepared for use by the Justice Department considers only AMPI's Class I premiums and producer payout efficiency as performance measures. Doing so ignores technical efficiencies accruing to the milk marketing system due to increased coordination by AMPI.

The overall objective of this study is to determine marketing costs (assembly cost of Class I and Class II milk, assembly cost of Class III milk, and manufacturing cost of Class III milk) under the actual market structure of AMPI and an alternative structure where it is assumed AMPI was not created. Doing so permits the determination of changes in efficiency possible with the existence of a large regional milk cooperative.

The shape of the long-run average cost curve gives clues as to whether or not potential economies of size exist. Cost curves and cost functions for butter-powder manufacturing and cheese manufacturing are derived from estimates in previous studies. Where necessary, the curves and functions are adjusted to reflect 1978 and AMPI Southern Region cost conditions.

This study uses U. S. data on the actual number of butter and cheese plants in selected years to estimate a trend on the rate of exit of firms from each production-size group. That rate determines the number of plants assumed to exist in a without merger situation. Individual plants of a given size selected to exit in the without merger case are chosen randomly. In the with merger situation, plant numbers and locations are the same for 1968 as they are in the without merger situation; for other years; the actual AMPI plant locations are used. A transportation model that minimizes transportation costs of either all milk or just the surplus determines plant volumes in the with merger case.

To compare assembly costs under alternative market structures, a transportation model is employed. To reflect the without merger situation and the with merger case with division coordination, the model minimizes the transportation cost of first satisfying only the fluid demands. The cost of moving milk not needed for fluid demands to the manufacturing plants is then minimized. In the with merger case, with central coordination present, the transportation model determines the minimum total cost of shipping all classes of milk. AMPI manufacturing plants will take any volume up to certain capacity restrictions.

With respect to assembly activities, the with merger market structure under centralized coordination is the most efficient. The combined 1978 annual average cost of transportation for fluid and surplus milk under May supply conditions is $ .1807 per cwt., and is $ .2011 per cwt. for October conditions. Estimated 1978 average transportation costs for the without merger structure equal $ .2469 per cwt. and $ .2383 per cwt. under May and October supply conditions, respectively. The with merger structure under division coordination is not as efficient as with centralized coordination with 1978 annual average costs of $ .2010 per cwt. for May, and $ .2038 per cwt. for October.

The with merger market structure for 1978 also provides for the most efficient manufacturing operations. The 1978 annual manufacturing costs under May supply conditions for the with merger and without merger structures range from 5.63 million dollars to 7.55 million dollars. For October conditions, 1978 total manufacturing costs range from 4.35 million dollars to 8.63 million dollars for those market structures.

Considering the combined costs of transportation and manufacturing, the with merger structure is the most efficient organization, with annual savings estimated to range from 3.3 million to 6.2 million dollars from 1968 through 1978. Savings under division coordination are somewhat less, 2.0 to 5.7 million dollars over the same period.

Conclusions

Implications

Results obtained for the three market structures considered indicate organizational and technical efficiencies have accrued to the milk marketing system in the Southwest United States due to the creation of AMPI as a large regional cooperative. Both assembly and manufacturing costs are less. This implies a large regional cooperative such as AMPI can better coordinate the intermarket movements of milk and decrease assembly costs. Although fluid milk assembly is more expensive under the with merger situation, all milk flows are coordinated such that savings in the cost of moving the surplus milk to cooperative-owned plants more than offsets the larger fluid transport cost.

With respect to the divisionally coordinated merged structure, there are savings of 4.8 percent (May) to 3.9 percent (October) in annual marketing costs in 1978.

Manufacturing activities are less costly under the with merger structure than the without merger structure. A large regional cooperative can eliminate excess capacity, represented by smaller, inefficient plants, to achieve economies in surplus milk handling. It also can add to capacity at optimum locations. For example, the new El Paso plant was acquired by AMPI to handle surplus milk primarily from Pima County, Arizona, Dona Ana County, New Mexico, and El Paso County, Texas. By doing so, AMPI decreased considerably its total transportation costs in 1978 since that milk in 1968 and 1971 flowed to such fluid demand areas as Lubbock and Midland in Texas, and Albuquerque, New Mexico. There might be some question whether an independent cooperative serving the El Paso fluid market would have had the necessary financial resources to acquire such a facility. A large regional cooperative like AMPI, though, can acquire such a facility and spread the cost among its members in order to decrease long-run costs of both assembly and manufacturing.

As plant numbers decline in all three market structures, average processing costs decline. This suggests that for the with merger situation, further reduction in plant numbers may create more potential economies in surplus milk handling. This would depend on the extra cost of shipping milk farther distances to fewer plants versus the savings due to larger volumes being processed in each plant. For example, the Oklahoma City plant under the with merger situation processed an annual volume of 6.29 million pounds of whole milk at a cost of $5.636 per cwt. in May 1978. Because of that high cost, it might be feasible to ship that milk to alternative plants in Tulsa, Muenster, or Sulphur Springs. Because of the relatively high fixed costs connected with dairy manufacturing, though, such a small volume might be processed at Oklahoma City keeping total surplus milk handling costs at a minimum.

This study ignores the cost of assembling milk from the farm to the county seat. Therefore it understates both fluid and surplus actual assembly costs and the savings that accrue from the elimination of duplicate hauling routes.

Limitations

Marketing costs under the alternative market structures provide clues to the most efficient organization of milk cooperatives in the Southwest United States. Several limitations, though, must be cited. Several problems are inherent in the without merger market structure assumed by this study. One is the accuracy with which the data predicts the rate of exit from various production-size groups for butter and cheese plants in the Southwest United States. Those predictions are used to determine the without merger market structure. If the predicted trend is not accurate, an increase (decrease) in plant numbers in the AMPI Southern Region would decrease (increase) each plant's volume, which in turn increases (decreases) average manufacturing costs.

Some plant locations assumed to exit between 1968 and 1978 were randomly selected. Doing so in no way reflects the viability of a particular smaller independent cooperative to remain in operation. The procedure for establishing volumes for each manufacturing plant is another limiting factor. Volumes were arbitrarily estimated for some plants, half-way between the limits of their respective size categories. Also, as plant numbers decline, each remaining plant takes on a larger volume. This does not allow for increasing or decreasing volume shares of one plant relative to another, which is likely to happen under dynamic economic and physical conditions.

The respective cost functions limit the analysis to the extent they actually represent AMPI Southern Region cost conditions. Data upon which the butter-powder cost function are based reflect Minnesota milk supply conditions, which are less variable. Although the estimates are adjusted on the basis of a seasonal index of surplus milk availability, the estimates may be biased to the extent the seasonal index represents AMPI Southern Region rather than general Southwest milk supply conditions. Both the cost functions for butter-powder manufacturing and cheese production are adjusted to 1978 cost conditions based on the Commodity Credit Corporation make allowances.

Thus the cost functions mirror 1978 cost conditions only in as much the make allowance represents actual manufacturing costs in 1971 and 1975. Finally, the functional form assumed may limit accuracy of the cost estimates, although probably not the analysis. The long-run average cost curve for cheese production is a hybrid curve, with its form being a fifth-degree polynomial up to volumes of 309.4 million pounds, and a rectangular hyperbola at greater volumes. Since few diseconomies of size have been empirically verified for dairy manufacturing, that form may be plausible.

Another limiting factor is the extent AMPI producer deliveries, fluid sales, and surplus milk availability and location in May 1978 and October 1977 are representative of 1968 and 1971 supply and demand conditions. If data for May 1978 and October 1977 are not reflective of 1968 and 1971 conditions, estimates of milk flows, assembly costs, and processing costs all would be affected.

Need for Further Study

Further investigation can take place on two planes. First, further study concerning AMPI's role in coordination of the fluid milk supply in the AMPI Southern Region. Doing so would evaluate the impact of cooperative mergers on deliveries to handlers when and where needed and on the size of reserve supplies needed for Class I markets. Such a study could also investigate type, quantity, and cost of providing market services to fluid handlers under alternative market structures. Finally, it could predict changes in cooperative market shares if AMPI had not been created.

A second avenue of investigation would be to measure the impacts of cooperative mergers on assembling and allocating milk and manufacturing surplus milk in other regions of the country, specifically, a study of the impacts in the Upper Midwest where surplus milk volumes are much greater. In such a case, changes in farm to county seat assembly costs should be estimated since it is possible for many competing cooperatives or proprietary firms to operate overlapping milk routes. Elimination of those routes could decrease marketing costs substantially. Such a study would also provide a contrast to this study where there is only one major milk cooperative. But in the Upper Midwest, AMPI is only one of many marketing and operating cooperatives. The more competitive conditions of the Upper Midwest might render results and conclusions unlike those of this study.

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APPENDIX

TABLES

TABLE XXIII

ANNUAL EFFECTIVE VOLUME AND AVERAGE PROCESSING COST PROJECTED FROM MAY DATA, UNDER THE WITH MERGER STRUCTURE WITH CENTRAL COORDINATION, AMPI SOUTHERN REGION, SELECTED YEARS 1968-1978

Plant Location	May 1968 Annual Effective Volume (million lbs.)	May 1968 Cost Per Cwt. ($)	May 1971 Annual Effective Volume (million lbs.)	May 1971 Cost Per Cwt. ($)	May 1978 Annual Effective Volume (million lbs.)	May 1978 Cost Per Cwt. ($)
Butter						
Arkansas City	34.11	1.340	-	-	-	-
Hillsboro	69.52	.846	-	-	-	-
Tulsa	84.16	.763	92.21	.699	103.19	.691
Oklahoma City	60.76	.914	100.79	.653	6.29	5.636
Enid	33.66	1.353	-	-	-	-
Wichita Falls	10.98	3.385	-	-	-	-
Muenster	95.14	.718	-	-	-	-
Sulphur Springs	102.46	.693	117.09	.729	127.82	.629
Jacksonville	10.98	3.385	-	-	-	-
La Grange	-	-	-	-	-	-
El Paso	-	-	-	-	82.88	.769
Combined Volume and Cost	501.77	.964	310.10	.690	320.18	.784
Cheese						
Linn	24.88	2.665	28.06	2.566	-	-
Hillsboro	-	-	94.09	1.434	103.04	1.369
Mangum	29.27	2.530	-	-	-	-
Muenster	-	-	134.66	1.220	143.68	1.193
Fort Worth	5.12	3.414	-	-	-	-
Round Rock	2.93	3.514	-	-	-	-
Ballinger	2.93	3.514	-	-	-	-
San Antonio	-	-	-	-	-	-
Combined Volume and Cost	65.13	2.739	256.80	1.446	246.72	1.267

TABLE XXIV

ANNUAL EFFECTIVE VOLUME AND AVERAGE PROCESSING COST PROJECTED FROM OCTOBER DATA, UNDER THE WITH MERGER STRUCTURE WITH CENTRAL COORDINATION, AMPI SOUTHERN REGION, SELECTED YEARS 1968-1978

Plant Location	October 1968 Annual Effective Volume (million lbs.)	October 1968 Cost Per Cwt. ($)	October 1971 Annual Effective Volume (million lbs.)	October 1971 Cost Per Cwt. ($)	October 1978 Annual Effective Volume (million lbs.)	October 1978 Cost Per Cwt. ($)
Butter						
Arkansas City	16.43	2.385	-	-	-	-
Hillsboro	163.84	.572	-	-	-	-
Tulsa	263.80	.496	-	-	-	-
Oklahoma City	-	-	-	-	-	-
Enid	-	-	-	-	-	-
Wichita Falls	49.00	1.046	-	-	-	-
Muenster	-	-	263.80	.496	146.14	.597
Sulphur Springs	6.15	5.745	75.84	.807	-	-
Jacksonville	-	-	-	-	-	-
La Grange	-	-	-	-	-	-
El Paso	-	-	-	-	260.09	.497
Combined Volume and Cost	499.23	.702	339.64	.565	406.23	.533
Cheese						
Linn	93.62	1.438	93.62	1.438	-	-
Hillsboro	-	-	181.91	1.109	208.94	1.059
Mangum	22.32	2.748	-	-	-	-
Muenster	-	-	-	-	-	-
Fort Worth	-	-	-	-	-	-
Round Rock	-	-	-	-	-	-
Ballinger	-	-	-	-	-	-
San Antonio	-	-	-	-	-	-
Combined Volume and Cost	115.94	1.690	275.54	1.221	208.94	1.059

TABLE XXV

ANNUAL EFFECTIVE VOLUME AND AVERAGE PROCESSING COST PROJECTED FROM MAY DATA, UNDER THE WITH MERGER STRUCTURE WITH DIVISION COORDINATION, AMPI SOUTHERN REGION, SELECTED YEARS 1968-1978

Plant Locations	May 1968 Annual Effective Volume (million lbs.)	May 1968 Cost Per Cwt. ($)	May 1971 Annual Effective Volume (million lbs.)	May 1971 Cost Per Cwt. ($)	May 1978 Annual Effective Volume (million lbs.)	May 1978 Cost Per Cwt. (4)
Butter						
Arkansas City	24.77	1.706	-	-	-	-
Hillsboro	57.26	.948	-	-	-	-
Tulsa	84.16	.763	92.10	.729	100.20	.700
Oklahoma City	58.07	.940	65.64	.874	40.52	1.187
Enid	18.41	2.168	-	-	-	-
Wichita Falls	10.98	3.385	-	-	-	-
Muenster	95.14	.718	-	-	-	-
Sulphur Springs	102.46	.693	105.25	.685	40.85	1.180
Jacksonville	-	-	-	-	-	-
La Grange	-	-	-	-	-	-
El Paso	-	-	-	-	82.74	1.770
Combined Volume and Cost	451.23	.957	263.10	.748	264.30	.871
Cheese						
Linn	24.88	2.665	28.62	2.549	-	-
Hillsboro	-	-	80.51	1.560	103.54	1.366
Mangum	29.27	2.530	-	-	-	-
Muenster	-	-	134.66	1.220	199.06	1.077
Fort Worth	5.12	3.414	-	-	-	-
Round Rock	2.93	3.514	-	-	-	-
Ballinger	2.93	3.514	.	-	-	-
San Antonio	50.34	2.009	60.01	1.837	-	-
Combined Volume and Cost	115.67	2.420	303.80	1.557	302.60	1.176

TABLE XXVI

ANNUAL EFFECTIVE VOLUME AND AVERAGE PROCESSING COST PROJECTED FROM OCTOBER DATA, UNDER THE WITH MERGER STRUCTURE WITH DIVISION COORDINATION, AMPI SOUTHERN REGION, SELECTED YEARS 1968-1978

	October 1968		October 1971		October 1978	
Plant Location	Annual Effective Volume (million lbs.)	Cost Per Cwt. ($)	Annual Effective Volume (million lbs.)	Cost Per Cwt. ($)	Annual Effective Volume (million lbs.)	Cost Per Cwt. ($)
Butter						
Arkansas City	19.33	2.082	-	-	-	-
Hillsboro	76.23	.804	-	-	-	-
Tulsa	160.11	.577	160.00	.577	160.11	.577
Oklahoma City	-	-	-	-	-	-
Enid	-	-	-	-	-	-
Wichita Falls	49.00	1.046	-	-	-	-
Muenster	-	-	-	-	-	-
Sulphur Springs	-	-	-	-	-	-
Jacksonville	-	-	-	-	-	-
La Grange	-	-	-	-	-	-
El Paso	-	-	-	-	253.83	.501
Combined Volume and Cost	304.67	.805	160.11	.577	413.95	.530
Cheese						
Linn	105.66	1.352	105.66	1.352	-	-
Hillsboro	-	-	95.56	1.422	201.23	1.073
Mangum	130.68	1.234	-	-	-	-
Muenster	-	-	-	-	-	-
Fort Worth	-	-	-	-	-	-
Round Rock	-	-	-	-	-	-
Ballinger	13.07	3.083	-	-	-	-
San Antonio	61.08	1.819	253.83	.971	-	-
Combined Volume and Cost	310.49	1.467	455.06	1.154	201.23	1.073

TABLE XXVII

ANNUAL EFFECTIVE VOLUME AND AVERAGE PROCESSING COST PROJECTED FROM MAY DATA, UNDER THE WITHOUT MERGER STRUCTURE, AMPI SOUTHERN REGION, SELECTED YEARS 1968-1978

	May 1968		May 1971		May 1978	
Plant Location	Annual Effective Volume (million lbs.)	Cost Per Cwt. ($)	Annual Effective Volume (million lbs.)	Cost Per Cwt. ($)	Annual Effective Volume (million lbs.)	Cost Per Cwt. ($)
Butter						
Arkansas City	43.47	1.069	-	-	-	-
Hillsboro	53.90	.984	60.04	.921	61.54	.908
Tulsa	64.97	.880	72.37	.827	-	-
Oklahoma City	107.71	.667	119.96	.646	122.97	.639
Enid	25.80	1.653	28.74	1.552	29.46	1.494
Wichita Falls	8.60	4.218	9.58	3.825	9.82	3.740
Muenster	73.62	.819	81.99	.774	-	-
Sulphur Springs	79.09	.789	88.09	.746	90.29	.737
Jacksonville	8.60	4.218	9.58	3.825	-	-
La Grange	8.60	4.218	-	-	-	-
Group Volume and Cost	478.26	1.062	470.35	.933	314.08	.897
Cheese						
Linn	16.35	2.958	18.22	2.890	18.67	2.874
Tulsa	-	-	-	-	74.17	1.633
Mangum	18.69	2.873	20.82	2.799	21.32	2.781
Muenster	-	-	-	-	84.05	1.524
Fort Worth	3.83	3.472	4.72	3.453	-	-
Round Rock	1.95	3.559	-	-	-	-
Ballinger	1.95	3.559	2.18	3.549	2.23	3.546
San Antonio	45.87	2.106	51.08	1.998	52.35	1.973
Group Volume and Cost	88.64	2.548	96.56	2.438	252.83	1.873

TABLE XXVIII

ANNUAL EFFECTIVE VOLUME AND AVERAGE PROCESSING COST PROJECTED FROM OCTOBER DATA, UNDER THE WITHOUT MERGER STRUCTURE, AMPI SOUTHERN REGION, SELECTED YEARS 1968-1978

Plant Location	October 1968		October 1971		October 1978	
	Annual Effective Volume (million lbs.)	Cost Per Cwt. ($)	Annual Effective Volume (million lbs.)	Cost Per Cwt. ($)	Annual Effective Volume (million lbs.)	Cost Per Cwt. ($)
Butter						
Arkansas City	42.45	1.150	-	-	-	-
Hillsboro	131.60	.622	143.73	.600	146.63	.596
Tulsa	25.46	1.670	27.80	1.561	-	-
Oklahoma City	20.59	1.978	22.49	1.842	22.94	1.813
Enid	23.12	1.802	25.25	1.681	25.76	1.655
Wichita Falls	7.71	4.665	8.42	4.302	8.59	4.225
Muenster	160.94	.576	175.77	.558	-	-
Sulphur Springs	7.93	5.080	7.67	4.682	7.83	4.597
Jacksonville	7.71	4.665	8.42	4.302	-	-
La Grange	7.71	4.665	-	-	-	-
Group Volume and Cost	434.30	1.132	419.55	1.001	211.74	1.152
Cheese						
Linn	50.87	2.002	55.56	1.914	56.68	1.894
Tulsa	-	-	-	-	28.36	2.557
Mangum	48.01	2.060	52.44	1.972	53.50	1.952
Muenster	-	-	-	-	179.32	1.114
Fort Worth	3.43	3.491	3.75	3.476	-	-
Round Rock	1.75	3.569	-	-	-	-
Ballinger	1.75	3.569	1.91	3.561	1.95	3.559
San Antonio	75.05	1.623	81.97	1.545	83.62	1.528
Group Volume and Cost	180.87	1.919	195.63	1.821	403.43	1.534

VITA[2]

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