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Equilibrium Analysis of Income-Improving Adjustments on Farms in the Lake States Dairy Region, 1965

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and

Farm Production Economics Division ■ Economic Research Service
U. S. Department of Agriculture

Recent changes in farm technology, the organization of markets, and the demand for farm products have substantially affected the size and organization of farms that are needed to be efficient and profitable. The situation causes many farmers in the Lake States dairy region to consider shifts to alternative enterprises and ways of lowering production costs. An individual dairyman's decision depends upon the alternatives open to him. Frequently, conflicts arise between his longrun and shortrun interests as well as between the shortrun interests of the individual dairyman and the longrun interests of the dairy industry.

So adjustment opportunities cannot be considered solely from the individual farmer's viewpoint. The aggregative production response is an important part of any adjustment problem. It is necessary to integrate the analysis of adjustment opportunities on individual farms with aggregative effects of these individual adjustments on the industry.

Although no demand sector can be isolated which represents exactly the market for dairy products from the region, an approximation can be made to the general level of market potential for Lake States dairy products at alternative price levels. In this way it is possible to delineate feasible adjustments to attain an equilibrium in the use of farm resources in the Lake States dairy region through farm reorganization. Thus, adjustment problems of the individual farms are integrated with those of the industry.

Since 1958 State Agricultural Experiment Stations in Illinois, Iowa, Michigan, Minnesota, and Wisconsin, and the Farm Production Economics Division, Economic Research Service, U. S. Department of Agriculture, have cooperated in a coordinated study of profitable individual farm and aggregate production adjustments in the Lake States dairy region. Several representatives of each agency collaborated on an informal basis in the initial arrangements and overall plans for the study. Major responsibility for the regional analysis and the preparation of this report was carried by W. B. Sundquist, ERS, University of Minnesota; J. T. Bonnen, Michigan State University; D. E. McKee, ERS, Michigan State University; C. B. Baker, University of Illinois; and L. M. Day, ERS, University of Minnesota (McKee and Day are now stationed at Washington, D.C.).

Other members of the study group who shared in the regional analysis, in developing and coordinating research procedures among state working groups, and in conducting and reporting the cooperative studies in the five states were: J. C. Andersen, ERS, Iowa State University, now at the University of Idaho; Randolph Barker, ERS, Iowa State University, now at Cornell University; M. R. Langham, University of Illinois, now at the University of Florida; and G. A. Peterson, University of Wisconsin. Project leaders for the cooperating agencies were C. B. Baker, University of Illinois; E. O. Heady, Iowa State University; G. L. Johnson, Michigan State University; H. R. Jensen, University of Minnesota; S. D. Staniforth, University of Wisconsin; and C. W. Crickman, ERS, USDA.

Other reports on the Lake States dairy adjustment study have been published by the respective State Agricultural Experiment Stations in cooperation with USDA (see page 55). Publication of this report by the Minnesota Agricultural Experiment Station is by mutual agreement of the cooperating agencies.

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This Report in Brief

This report presents the major assumptions, analyses, and results of a study of profitable adjustments in Lake States dairying. The target date on which the supply and demand analysis centers is 1965.

Supply response is based on an income-maximizing linear programming analysis of typical farms representative of the farming units in 80 farm strata. The farms were selected from a random sample in the study area. The supply relations obtained project income-improving adjustments that could be made in crop and livestock enterprises within the resource limitations of farm firms. Demand analysis is based on the assumption that study area farmers will continue to supply milk and other dairy products to the same portion of the nation's consumers as they supplied in 1959. Formulation of the demand for manufactured milk products is largely in terms of a national market. Demand for fluid milk and cream is assumed to come primarily from a regional consuming population.

The study area includes major portions of Michigan, Minnesota, and Wisconsin and smaller parts of Illinois and Iowa. Although fluid milk is supplied to a number of federal order markets, the Chicago order market dominates much of the area. In addition, since the study area is a milk surplus production region, much of the milk goes into production of manufactured products such as butter, powder, ice cream, and cheese.

Projection of the demand for all milk indicates a slight increase in total demand, despite a substantial per capita reduction in the demand for fluid milk and cream and a smaller per capita decline in the demand for manufactured milk products. Projected population increases of about 10.3 percent nationally more than offset the projected decline in per capita consumption of manufactured milk products between 1959 and 1965. As a result, demand for manufactured milk products is projected to increase 5.5 percent at 1959 prices during this period. However, total demand for fluid milk and cream is projected to decline slightly (1.1 percent), due largely to the rapid decline in per capita consumption.

On the supply side, Lake States farmers would improve income by using improved production practices and substantially increasing production of milk at current and projected price levels if adequate markets were available. Such an increase could be obtained even though there would be a substantial shift to hog and cattle feeding by farmers in the better soil areas of the region, principally in Illinois, Iowa, and south-central Minnesota. In view of the demand at projected prices, however, production increases in some areas would need to be offset by decreases in other areas. Such balancing of supply and demand was a requirement of this study. It was obtained by evaluating income-improving production adjustments in two contexts: (1) with historical intraregional price differentials for milk, and (2) with zero intraregional price differentials for milk.

This equilibrium analysis indicates that three income-improving adjustments are of major importance:

- Grade A producers generally could provide an increased supply of milk as their competitive position in dairying is strong relative to grade B producers. This would be true even with about a one-third reduction in the historical price premium of fluid-eligible milk over manufacturing quality milk.

- Many grade B dairy farmers would find it profitable to decrease or eliminate their dairy enterprise and increase beef and hog feeding. An increase in these enterprises would also be profitable on some grade A dairy farms located on the Corn Belt type soils of the region.

- An increase in cow quality and herd size would improve incomes on those farms staying in dairy production. On many larger, better financed grade A dairy farms a substantial increase in laborsaving loose housing-milking parlor mechanization would also be an income-improving adjustment.

The largest increase in milk production is projected to occur in Michigan where livestock alternatives to dairy are limited. This increase in Michigan milk production results in part from an historically "higher priced fluid market" than for other markets within the region. Since this "higher priced fluid market" is obviously limited, it cannot absorb a major increase in the milk supply. However, a substantial increase in milk production in Michigan is projected to occur even with: (1) zero intraregional price differentials for milk, and (2) a lower than 1959 Class I utilization rate for fluid-eligible milk.

Reductions in milk production on farms on the Corn Belt type soils are indicative, at least in part, of the strong competitive position of cash crops and nondairy livestock enterprises. Some smaller farms in east-central Minnesota and west-central Wisconsin cannot be organized to provide adequate incomes, largely because current land and capital resources do not provide an adequate base from which to make profitable adjustments. These farms will probably be consolidated into larger units.

The results reported here center on a 1965 target date. However, results can be projected to a later date, say 1968, with relatively minor changes in assumptions because, on the supply side, only costs of building materials, motor supplies, and labor are projected to increase substantially from the 1959 base period used. On the demand side, estimates are specified in such a way that they can easily be extended to a later date than 1965.

Equilibrium Analysis of Income-Improving Adjustments on Farms in the Lake States Dairy Region, 1965

Recent years have brought substantial changes in the Lake States dairy industry. Changes continue to occur in all three major phases: (1) the production (farm) sector, (2) the processing and marketing sector, and (3) the demand or consumption sector. Changes have not and are not occurring in the Lake States in isolation from other producing areas. For example, many products of Lake States farmers must find outlets in national markets in competition with production from other regions. However, some changes and problems occurring in the Lake States are unique to this region. In this report, a brief description of recent changes in the dairy industry at the national level precedes a narrower focusing on the Lake States as a region.

Changes in Production

Improvements in breeding, feeding, housing, and milking of dairy cows have resulted in a rapid increase in production per cow. At the same time, the total number of dairymen has declined and dairying has become more specialized. Nationally, since 1950 small dairy producers have dropped out in large numbers with a particularly large percentage decline in farmers with two to nine cows. Largest percentage increases occurred in the number of farmers with more than 20 cows.

Total U.S. milk production in 1960 was up only about 5 percent from 1950; on a fat corrected basis (f.c.b.), total production was virtually unchanged for this 10-year period. However, between 1950 and 1959 the number of farms with cows declined by one-half, the average number of cows per farm increased 59 percent, and output per cow increased 28 percent. In 1961 U.S. farmers fed a record high concentrate ration of 1 pound of concentrates (including grain) for every 3 pounds of milk produced. These feeding rates coupled with improved quality of cows resulted in a record milk production of some 125 billion pounds—up about 4 percent over the 1951-60 average. As a result, government purchases of milk-fat and solids-nonfat in 1961 totaled 6 and 9 percent of total supplies, respectively.

Major technological changes have occurred in the use of labor efficient milking parlor-loose housing dairy setups, pipeline milkers, and bulk tanks. Also, forage and manure handling equipment have reduced labor requirements for many dairymen.

Changes in Marketing

Milk marketed under federal milk order programs increased substantially in the past decade. In 1950 about 19 billion pounds of milk were delivered by producers to regulated handlers in 39 markets. By 1960 this amount was up to 45 billion pounds in 80 markets. Over 75 percent of the U.S. urban population is currently served by milk dealers operating under federal order regulations. Milk order programs insure adequate supplies of milk (by such things as seasonable price incentives) and permit certain inspection and regulation of dairy products. While order programs may provide substantial benefits to order area producers, they also deter the entry of some producers into specific markets.

Part of the increased use of bulk tanks can be attributed to the efficiencies which bulk tank handling affords dairy processors both in pickup and transportation time. These and other volume plant efficiencies coupled with rising costs of many items, particularly labor, resulted in a large reduction in the number of dairy plants in the last decade—both those processing milk for fluid use and those processing it for manufacturing uses (such as butter, ice cream, powder, and evaporated milk).

A revolution in the retailing of dairy products has accompanied the increasing incidence of supermarkets and food chains and the rapid changes in food retailing generally. Home delivery of milk and dairy products declined substantially between 1950 and 1960 as an increased proportion of milk products was marketed in supermarket outlets.

Changes in Consumption

A number of factors contributed to a rapid decline in per capita consumption of dairy products in the last decade. Of primary importance were: (1) the substitution of oleomargarine for butter by many consumers, (2) a general decline in caloric intake as people do less physical work and are increasingly weight conscious, (3) increased fear of *alleged* detrimental effects of cholesterol present in animal fats, and (4) increased fear of the *alleged* uptake of radioactive strontium 90 in milk.

A particularly sharp decline occurred in butter, from 10.7 pounds per capita in 1950 to 7.5 pounds per capita in 1960. More recently, per capita declines have occurred in other dairy products. During the 3-year period ending in 1960, per capita consumption of butter and fluid milk declined but gains in population held aggregate consumption relatively unchanged. However, per capita decreases in 1961 were much greater and resulted in a significant lowering of total consumption.

The structural shift in consumption of dairy products actually began about 1947 but was not evident in per capita consumption data until about 1956. The change in structure was masked by the temporary effect of the postwar increase in the proportion of the population under 20 years of age (Herrmann, 1962).

In the Lake States

The Lake States region is the largest milk producer of any region in the United States. In 1961 milk production in the three-state region of Michigan, Minnesota, and Wisconsin was about 26.8 percent of total U.S. milk production. The second highest region was the Northeast with 20 percent followed by the Corn Belt with 18.1 percent. Significantly, only the Lake States, the Northeast, and the Pacific regions had any substantial increases in dairy production in 1961 as compared to 1950. For the purposes of this study, the Lake States region was expanded to include major dairy areas of northeastern Iowa and Illinois.

The Lake States region, although a major producer of milk, is located a substantial distance from major fluid milk markets on the eastern seaboard. It is thus a region of "surplus" milk production. It does supply much of the fluid milk consumed in Chicago, Detroit, Minneapolis-St. Paul, Milwaukee, and smaller urban areas. Producers sell milk in numerous markets, including several federal order markets. The entire area is dominated by the Chicago market which draws fluid milk from northeast Illinois, southwest Michigan, virtually the whole of Wisconsin (all are in the study), as well as from northwest Indiana (not in the study).

Much of the milk produced in the region, particularly in Minnesota, western Wisconsin, and northeastern Iowa, is not eligible for fluid use; it is processed into manufactured milk products. Markets for this milk have been particularly depressed because of the per capita decline in consumption of butter and some other manufactured milk products. Government acquisition of stocks of manufactured dairy products, coupled with a support price program, has provided the effective price floor and a part of the market.

In the post-World War II period about 75 percent of the milk produced in the three-state region of Michigan, Minnesota, and Wisconsin found a nonfluid-consumption market outlet (Barker, 1960). A greater proportion of the milk produced in the study area of Illinois and Michigan found a market for fluid consumption than in Iowa, Minnesota, and Wisconsin. During the same period about 75 percent of the milk produced in the Northeast found a fluid-consumption market.

The higher incidence of fluid-eligible milk producers in the Northeast and the high fixed costs associated with producing fluid-eligible milk have caused Northeast dairy farmers to be less price responsive than Lake States producers. Another factor contributing to greater responsiveness to milk prices by Lake States producers is the incidence of more nondairy production alternatives. The deficit of feed grains in the Northeast makes cattle feeding and hog production, for example, less feasible.

Using time series data from 1926-58, Barker (1960) found the shortrun elasticity of supply with respect to milk prices (assuming a 2- to 3-year adjustment period) to be greater for Lake States producers than for producers in the Northeast. However, his findings indicate that the supply elasticity of Northeast producers increased with higher prices during the post-World War II period, narrowing the differential between the two areas in recent years.

Adjustment Problems

The changes in the dairy industry described briefly above are only some of the factors causing adjustment problems for Lake States dairy farmers. Changes continue to occur in production technologies, demand, and price levels of alternative farm products which compete for production resources. Changes in wage rates and the availability of off-farm employment provide an incentive and opportunity for adjustment by many farmers, particularly those with the skills demanded in the nonfarm labor market.

Changing costs and resource availabilities are at the same time: (1) the source of numerous adjustment problems for farmers, and (2) the incentive for adopting new technologies which are often output increasing.

Within the region, wide differences are found in factors affecting the quantity of milk supplied by producers. Resources available to producers vary substantially. In some subareas, high quality resources can be used in a large array of alternatives. So milk production in response to price change is greatly affected by prices of products competitive or complementary with milk in terms of production. The result, at least during an intermediate time period of say 5 to 8 years, would be expected to make the price elasticity of supply for milk relatively high.

In other subareas of the region, income from dairying so far exceeds income from alternate uses for resources that milk supply-price relations are little affected by returns from such alternatives. In these areas, milk production would probably persist even at extremely low milk prices since so few alternatives exist for the use of resources relevant for milk production. However, even within these areas, a considerable range might well exist in resource qualities. Therefore the level and structure of costs related to milk production also would vary considerably.

The entry and exit of supplying firms depends on the respective levels of average total and average variable costs of producing milk. However, the response of producing firms depends on the slope of marginal costs of producing milk. In the short run the dominant factor is the cow production response to varied feed input. Abstracting from possible variation over the region with respect to the quality of cows, the major source of response differences is in the quality and/or the price of feed. The price of feed relevant for this analysis is the higher of (1) market price or (2) the value of feed in uses other than dairying. Therefore, these differences represent other reasons why the intraregional variation in production conditions must be taken into account.

Purpose and Characteristics of This Study

This study's specific purpose was to provide estimates of the optimal organization of farms within the Lake States dairy region. The criterion used was that of maximizing farm income for farm strata with similar resource situations and with similar access to markets. Regional aspects are important relative to:

1. Estimating the supplies of milk and competitive products which could be profitably produced by Lake States farmers at varying prices.

2. Determining the quantity-price relationships for dairy products which might be expected to prevail in markets accessible to Lake States farmers.

3. Assessing the price and quantity of fluid eligible and manufacturing milk which could result in an equilibrium of supply and demand.

The latter assessment should provide insights into: (1) the optimal farm organizations consistent with the quantity-price equilibrium dimensions for milk, and (2) the kinds of intraregional shifts in dairy production indicated by the profit maximization linear programming analysis. Other published reports from this study consider farm management aspects of typical farm situations. This report considers primarily the regional and intraregional supply and demand aspects.

In this report an initial supply-demand equilibrium analysis for milk is based on historical intraregional price differentials for fluid-eligible and manufacturing milk. Because of (1) the shifts in location of milk production at equilibrium prices given existing milk price differentials, and (2) the possibility of technology producing changes in such things as transportation costs, a second equilibrium analysis is presented based on zero intraregional milk price differentials. These two analyses are made for a 1965 target date. Results would be about as valid if analyses were projected to 1967 or 1968 with simple adjustments in the aggregate demand relations.

Special Considerations

Production adjustments are analyzed in this report using the criterion of profit maximization by stratum for numerous strata of producers. This criterion has not historically had predictive accuracy as to what producers will do. This is true because: (1) producers consider nonmonetary returns in making or not making adjustments in resource use and production, and (2) there are effective barriers to adjustment which are not accounted for in any system of analysis simple enough to be operational. So keep in mind that the framework of analysis for the supply aggregates developed and reported in this study have a uniquely specified profit norm rather than one of prediction.

The Lake States dairy region, although a major dairy-producing region, produces only a portion of the total milk supply available for consumption in national and, in some cases, international markets. This being the case, the supply-demand equilibrium analysis and the resultant estimates of equilibrium milk prices will be improved when other major producing areas can be included in the analysis. Similar supply analysis is underway in the Northeast dairy region and will provide data for aggregate analysis.

Methodology

Review of Literature[1]

In the last decade emphasis given by agricultural economists to the estimation of supply functions represents a resumption of a similar interest in the 1920's and the 1930's. In both the 1920's and the 1950's the nonfarm economy was relatively more prosperous than the farm economy. At least one economist (Bean, 1933) ascribed the earlier interests of agricultural economists to their recognition of changes in supply as an important factor in farm prices in the presence of strong and stable product demand outside agriculture. In this particular respect the 1950's resemble some features of the 1920's.

In these early years, correlation analysis dominated the methodology used. Data used typically were time series. Thus, Ezekial et. al. (1932) used correlation analysis (shortcut graphic method) of annual data for 1918-25 to estimate milk supply functions for Vermont. Gans (1927) completed a similar study for the same area using annual data for 1917-26. In both instances, milk supply was related to milk-feed price ratios. Somewhat later, Cassels (1937), Parsons (1938), and Johnson (1937, 1942) used similar methods to obtain comparable estimates with longer time series. The areas were, respectively, Vermont, New York, and selected areas of Vermont. Parsons introduced lags in milk-grain price ratios in an attempt to distinguish between longrun and shortrun responses.

In 1932 Black published his monograph on *Research in Farm Management*, creating a strong and widespread interest in applying budgeting to problems in agricultural economics research. A series of studies using budgeting methods spread through the New England and Midwestern states. Such studies used cross section farm data in place of time series market data to estimate longrun milk supply relations. From a benchmark farm organization, profit-maximizing responses to milk price changes were used as a basis for inferring supply-price relations. Prominent contributors included Allen, et. al. (1940), Baumann and Hill (1941), Christensen and Mighell (1941), Fowler (1942), and Strand and Hole (1941).

A landmark study by Mighell and Black (1951) climaxed this series of studies. Supply estimates made with 1936 data in the New England and Lake States regions were checked by resurvey in 1946. Results in the Lake States region were so reassuring that the authors concluded that budgeting based on relatively small samples was an effective procedure for estimating supply relations for milk in regions as homogeneous as the Lake States. They experienced substantially less success in New England due to the greater difficulty of sampling in the more variable region.

Studies of the 1950's used more sophisticated but related methods than those used in earlier studies. Cromarty (1958) used time series in national aggregates over 1929-53 to estimate shortrun price elasticities of supply (0.212) of "dairy products" using a single equation regression model. For a later period (1947-56), Cochrane (1958) estimated a shortrun price elasticity of supply of

[1] This section is based partly on materials found in M. R. Langham, *Effects of Economic Adjustments on the Supply of Milk in Northeastern Illinois*, Unpublished Ph.D. thesis, University of Illinois, 1961.

0.30 to 0.40 for whole milk, using regression analysis with national aggregates.

In a more elaborate study, Halvorson (1958) estimated that shortrun price elasticities differed by season (summer and winter) and between falling and rising prices; longrun price elasticities differed between falling and rising prices. Shortrun elasticities ranged from 0.1 to 0.312, the former a summer season response, the latter an annual response estimated with a distributed lag model. Halvorson found the response to rising prices to vary over a wider range than did the response to falling prices in the short run but the reverse in the long run. Longrun estimates ranged from 0.154 (from a distributed lag model) to 1.821 (a response to falling prices).

In the past decade, supply estimation was dominated by the use of linear programming methods. Parametric programming was used to yield optimal responses to varied prices for milk and such other products and resources as the investigator selected. Thus these studies are closely related to the budgeting studies of the 1930's. They differ mainly in the wider range of production alternatives considered and prices used.

Exceptions are found in studies reported by Davidson (1955), Schuh (1957), and Kadlec (1960). In Davidson's study, a marginal cost curve for milk was estimated with a partial budget technique. This allowed, in a shortrun analysis, for change in feed input in response to change in milk price. In a longrun analysis, response was expanded to include changes in crop system. In a similar manner, Schuh used farm data supplemented with experimental data to synthesize marginal cost functions. Kadlec synthesized marginal cost functions directly from sample data for the dairy enterprise. Elasticities reported by Davidson and Schuh were substantially smaller than those found in linear programming studies, resembling those of the later regression studies. On the other hand, Kadlec reported elasticities from 0.73 to 3.07 based on data from the Louisville milkshed.

Linear programming methods have been extended from farm level models to inter-region models in attempts to estimate equilibria in inter-region flows of products. Studies of this character were provided by Fox (1953), Fox and Taeuber (1955), Judge and Wallace (1959), Snodgrass and French (1958), and Egbert and Heady (1961). Applications of such models will be greatly improved by estimates generated in regional studies such as this one.

In reviewing these and related studies, Nerlove (1961) suggested that, while useful in policy decisions, analyses based on time series are limited in problems where structural change is important. Learn and Cochrane (1961) concurred and suggested that regression models, incapable of yielding predictions of structural change, must be supplemented with use of microdata gathered over time.

To improve empirical relevance of linear programming models, Day (1961) suggested the use of constraints on the rate of adoption of improved production practices. Such constraints might be based on historic evidence of adjustment rates actually observed for farms.

Supply Analysis Used

This study developed estimates of the regional milk supply relations through the aggregation of supply relations for representative farms within the region. Since hog production was a major production alternative in the study area, hog supply relations were also aggregated. These estimates of supply relations were derived through linear programming procedures which account for the complementary, supplementary, and competitive relationships among product and enterprise alternatives of farm firms.

The supply relations obtained reflect consequences of changes in product prices if the most profitable adjustments are made within the resource limitations of farm firms. Aggregate supply relations are obtained by a weighted summation of the representative farm supply relations. Weights are the estimated total number of farms in the population represented by each representative farm situation programmed. The weights used are based on data from the 1959 Census of Agriculture and the sample survey.

Aggregate supply relations are then compared to corresponding demand relations. This provides the basis for assessing which product price expectations are consistent with the aggregate effect of all farmers making production adjustments to maximize income from their individual farm businesses.

Farm Survey and Development of Representative Farms

The characteristics of representative farm situations are defined on the basis of data obtained from a random sample survey of farms within the region. Major dairy-producing counties within Illinois, Iowa, Minnesota, Wisconsin, and Michigan were identified on the basis of Census of Agriculture data. These counties were then grouped into relatively homogeneous producing areas within each state upon the basis of soil characteristics, location relative to markets, and similarity of economic conditions confronting farms within the area (e.g., alternative employment for labor and other resources).

Five distinct producing areas were defined in Michigan and four in Minnesota. Counties surveyed in Iowa and Wisconsin were grouped into two separate areas within each state. A single producing area was defined in Illinois. In total, 14 separate producing areas were defined for the region (figure 1, page 21).

Within each state or production area a random sample of farms was drawn using an area sampling procedure based on the Master Sample of Agriculture. All farmers within a sample segment were interviewed provided: (1) their 1958 gross income exceeded $1,200, and (2) they were not operating specialized poultry, fruit and vegetable, or truck crop farms. These latter farms were excluded because the primary focus of the study is on adjustments in dairying; there was little likelihood that such specialized farms would shift into dairying under any reasonable price condition.

Schedules were obtained from the 14 production areas in the summer of 1959. Data were collected regarding each farm's current crop and livestock enterprises, the type and capacities of crop and livestock equipment and facilities, family composition and labor supply, capital structure, and land area. In addition, data were obtained on tenure and leasing arrangements, production practices used, and farm expenses by major categories. This information provided the basis for describing representative farm situations and specifying resource restriction levels in the strata programming models.

Representative farm strata or groups of farms were defined on the basis of cropland acreage; type of farm; and for dairy farms, size of the dairy enterprise and type of market. These farm characteristics appeared to be the main distinguishing features among the different farm resource situations found within the Lake States region. Other features might be of importance in distinguishing among different farm strata. However, the size of sample drawn and resources available for the study did not justify a more detailed separation. In total, 80 such farm strata were defined from the 14 production areas. Next, a detailed description of the resources of a representative farm for each class was developed from the survey data. This description provided the base or benchmark from which adjustment alternatives were considered.

The Programming Model

The programming model applied to each representative farm situation included the principal farm enterprises available to farmers within that production area. The adjustment alternatives included both current technologies and technologies of production which were commercially feasible but not necessarily in current use. Where an alternative represented a new product for the farm or the use of a new technology, an investment charge necessary to accomplish the adjustment was made. The alternatives of making investments necessary to expand an existing enterprise or the continued use of an existing production technology were also considered.

Most livestock alternatives and input-output relations were the same for all representative farm situations analyzed. Principal differences were those of dairy market alternatives. Cropping alternatives, however, were developed separately for each production area since differences in soils and climatic conditions materially affect the crop input-output relations and type of crop alternatives. Care was taken to develop estimates of resource requirements of the cropping alternatives on a common basis so that differences in results among areas would reflect differences in conditions prevailing in each area rather than differences in assumptions and procedures underlying the results. Input-output relations reflect the use of recommended cultural and management practices (where profitable within capital restrictions) and normal environmental conditions.

A tabular summary of adjustment alternatives included in the analysis is presented in table 1. While this study's main focus is upon dairy adjustments, hog, beef, and crop alternatives are included. This is done to take into account the complementary, supplementary, or competitive relationships that these product alternatives bear to the dairy enterprise and the influence they exert on the milk supply function of the representative farm. Formulation of the programming model followed customary procedures using maximization of annual net farm income as the criterion of optimal resource allocation.

A tabular summary of the principal restrictions included in the programming model is given in table 2. Any production alternative could be included in farm organizations up to the capacity of the facilities currently present on the farm. If income returns from an enterprise were sufficient to cover the cost of the investment amortized over a 15-year period at 5½ percent interest, the size of the enterprise could be expanded beyond the present capacities of the facilities. This could be done by making additional

Table 1. Production and investment alternatives included in the linear programming model

Crops*	Hogs†	Beef	Dairy
Shelled corn	One-litter system	Beef cow-calf system	Stanchion system
Corn silage	Two-litter system	Calves fed in drylot	Parlor-loose housing system
Oats		Calves fed on pasture	Milking herd rations:
Rotation meadow		Calves deferred fed	1:2½ grain-milk ratio
Corn sale		Long yearling system	1:4 grain-milk ratio
Corn purchase		Feeder calf purchase or sale	1:6 grain-milk ratio
Grass silage			
Baled hay			

Building Investment	Labor‡	Credit
Milking parlor and loose housing	Seasonal labor hiring	Real estate mortgage
Stanchion barn		Chattel mortgage
Silo		
Beef housing and equipment		
Farrowing house and equipment		
Hog feeding facilities		

* In areas where relevant the alternatives included production of wheat, sugar beets, field beans, and soybeans.

† In areas where relevant the alternatives of specialized feeder pigs production and the feeding of purchased feeder pigs were also included.

‡ In areas where relevant the alternative of nonfarm employment of the farm operator was also included.

Table 2. Restrictions included in the linear programming model

Crop	Livestock	Labor	Capital
Cropland	Farrowing capacity	Operator and family labor supply by season	Cash on hand
Wheat acreage allotment	Hog feeding capacity	Seasonal labor hiring maximum by season	Real estate credit
Rotation requirements*	Beef housing capacity		Chattel credit
Permanent pasture	Stanchion barn capacity		
Silo capacity	Milking parlor-loose housing capacity		

* The method of handling rotation limitations varied depending upon the nature of cropping alternatives and technological conditions within the area. In some cases, rotation requirements were imposed by defining rotation activities involving various combinations of crops. In other cases, minimum or maximum restrictions were imposed on certain crop types such as row crops, sod crops, and small grain crops.

investments to the extent that capital and other required resources were available. Investments in permanent buildings were made through the use of real estate credit which was restricted solely to this use. Chattel credit could be used to supplement operator capital for production expenses and for purchase of livestock, provided returns covered the cost of repayment plus interest. Interest charges for credit and cash downpayment requirements on items purchased were based on current rates within each production area.

With enterprise alternatives involving breeding herds, herd replacements were assumed to be produced on the farm. Further, it was assumed that expansion in herd size would be accomplished by purchase of additional breeding stock.

Cows in the dairy herd were assumed to have a producing capacity of 10,000 pounds of milk per year when fed at a grain to milk ratio of 1:4. Two other grain-feeding levels were included among alternatives, one higher and the other lower. The milking system used could be either a stanchion system or a labor-efficient double 4 herringbone milking parlor, depending upon which would be the more profitable. Programming procedures were designed so that the two milking systems were regarded as mutually exclusive alternatives. Further, the model was constructed so that the labor and capital investment requirements of the two systems were a declining function of herd size.

Labor requirements of the production alternatives were expressed in hourly terms for their distribution over six subperiods of the year. In addition to operator and family labor, some seasonal labor could be hired to meet labor needs. The amount of seasonal labor that could be hired was limited to the amount previously hired on farms in each representative class.

A series of different beef feeding systems was included as possible alternatives. These reflected differences in the proportion of roughages and grains fed and in the timing of production. Beef production alternatives permitted the possibility of a beef system producing feeder calves for sale or fattening, as well as the possibility of a system of feeding purchased feeder cattle, or some combination of these systems.

Hog alternatives differed among the production areas. A one-litter and a two-litter farrowing system were included as alternatives in all production areas with the pigs farrowed being fed out to slaughter weight. In most production areas, alternatives of purchasing or selling feeder pigs were also included. This permitted the possibility of arriving at a system of specialized feeder pig production or pig feeding through the purchase of feeder pigs and the elimination or curtailment of the farm's farrowing operation.

The method of specifying cropping alternatives varied among areas, depending upon soil and climatic conditions. Where soil conditions necessitated, rotation requirements were imposed. These were specified by including combinations of crops or rotations as activities in the model or by imposing minimum or maximum restrictions on the proportion of cropland which could be used for certain crop classes. The latter method was used in areas where the number of crop alternatives was relatively large and several crops would serve as substitutes in a rotation.

"Recommended" as well as "current" levels of fertilizer application were included as alternatives with appropriate cost differentials. The model permitted selling of feed grain or supplementing home-produced feed by feed purchases. Forage supplies, however, were restricted to those produced on the farm.

The land area of representative farms was assumed fixed at the existing acreage. While expansion of farm size is an important aspect of the adjustment process that agriculture is currently experiencing, land is not freely available to all farmers. The availability of land to a particular farmer is more often the result of a set of fortuitous circumstances than of an open and freely competitive market. Also, without some kind of multistage programming that would permit a total land constraint to be introduced for an area, the possibility of aggregate purchases of land exceeding the available supply would be an unrealistic but possible result. Therefore, the alternative of acquiring additional land was excluded; the analysis concentrates upon adjustments along the intensive margin of farm operations.

Price Assumptions

The analysis of income-maximizing plans for the representative farms was based upon an assumed set of input and product prices projected to 1965. Optimal solutions were obtained for a series of milk and hog prices both above and below the 1965 projected price level in order to derive milk and hog supply schedules. All other product prices and all input prices were held constant at the 1965 projected level.

In arriving at price assumptions, projections were made for U. S. average prices by commodity. These projections were then converted to area prices by applying historical price differentials. Thus, if the U. S. average price of corn is $1.10 per bushel, the equivalent price of corn in Illinois is $1.13 per bushel and in Wisconsin $1.07 per bushel. The aggregate supply schedules for milk and hogs were first obtained by summing the estimated area supplies for each area's historical equivalent of a given U. S. average price level.

So a set of historical price differentials is built into the analysis. This procedure has the disadvantage that if the production adjustment results in areas shifting from a surplus to a deficit status, or *vice versa,* the price differentials applied would no longer be appropriate. Due to this possibility, a second aggregation of milk supply schedules was made with no (zero) intraregional milk price differentials.

The projected average U. S. prices used in this study are summarized in table 3. The historical price relationship between beef cattle and hog grades was used. Prices of purchased inputs were assumed to be the same as in 1959 with the exception of buildings, fencing, and motor supplies. Building and fencing prices were assumed to exceed 1959 prices by 12 percent, the price of motor supplies, by 10 percent.

Intraregional Product Price Differentials

Projected U. S. prices were adjusted by appropriate price differentials for each subarea within the study area. Of particular consequence in the programming analysis are the price differentials for milk and hogs. These price differentials are presented in table 4.

These intraregional price differentials for milk reflect several phenomena in-

Table 3. Projected prices assumed for 1965

Item	Unit	Average U.S. prices received by farmers
Corn	Bushel	$ 1.10
Oats	Bushel	0.65
Barley	Bushel	0.90
Soybeans	Bushel	2.00
Sugar beets	Ton	14.35
Dry beans	Cwt.	6.20
Hogs (all)	Cwt.	14.50
Beef cattle (all)	Cwt.	17.00
Milk (all)	Cwt.	4.00
Milk (fluid-eligible)	Cwt.	4.53
Milk (manufacturing)	Cwt.	3.16

Table 4. Intraregional price differentials for milk and hogs

	Price per cwt.					
Product	United States	Minnesota	Illinois	Iowa	Wisconsin	Michigan
Hogs (all)	$14.50	$14.10	$14.60	$14.10	$14.10	$14.70
Milk eligible for fluid market	4.53*	3.65	3.74	3.98	3.49	4.06
Manufacturing milk	3.16*	2.93	3.09	3.00	3.10	3.18

* These prices were historically comparable to a U.S. all milk price of $4 as determined by averaging the prices for the 6 years from 1948 to 1958 when the U.S. all milk price was $4 ± $0.15 per cwt. and then correcting to the $4 price level.

cluding: (1) transportation costs to consumption centers, (2) pricing policies in federal order markets, and (3) types of manufactured milk products produced. As an example of the latter, a higher proportion of the milk used in manufacturing in the Detroit market goes into higher value products (e.g., ice cream) than in Minnesota where a high proportion of the milk is used for dry powder, a lower value product.

The historical intraregional milk differentials used in the programming analysis were similar to those existing in the base year, 1959, when the U. S. all milk price was $4.16.

Demand Analysis Used

In contrast to the normative method of supply analysis used in this study, the demand analysis is a projection of expected demand for dairy products. More specifically, it is a projection of the demand for dairy products produced in the Lake States study area under a set of assumed conditions. The target date on which the demand projections are focused is the same as that for the supply analysis, 1965.

Given prices, the three factors which will most influence the change in the quantity of milk demanded from Lake States producers are: (1) change in size of the demanding population, (2) personal income growth of the demanding population, and (3) per capita consumption effects of changing tastes of the demanding population. The approach used here is one of establishing a 1959 base quantity of Lake States milk consumed to which the above factors are applied in order to estimate a projection of the change in quantity of milk required for consumption in 1965.

Primary Assumption

Milk products, particularly manufactured milk products, are sold in national markets. So the population supplied by Lake States milk producers may not be identified simply as the population residing within study area boundaries. Some set of assumptions must be made to identify a relevant demand sector. The principal assumption made in this analysis is that study area producers will continue to supply the same proportion of the U. S. domestic population that they serviced in a base period, 1959 (the same base year used in the supply analysis).[2] This assumption appears realistic and is easily modified by anyone considering the additional possibilities of study area producers supplying milk either to a larger or a smaller proportion of the total U. S. population. Other assumptions are discussed later.

Procedure

The essentials of the procedure followed in evaluating the changing demand for milk produced in the study area are:

1. In order to integrate the demand analysis with the supply framework so as to arrive at an equilibrium, the consuming population supplied by Lake States milk producers was differentiated into two distinct subpopulations: (1) those utilizing milk and cream for fluid consumption, and (2) those utilizing manufactured milk products. The quantities of milk supplied from the study area for these two end use categories were established directly from state utilization data and from local milk order market statistics. By dividing the quantities of these two types of milk supplied from the study area in 1959 by U. S. 1959 per capita consumption rates of fluid milk and cream and manufactured milk products, estimates were made of the two subpopulations supplied by study area producers in 1959.[3]

The only absolute measurements necessary to the demand model are those of prices and quantities of milk utilized in the two different markets. It is possible to quantify these variables directly from available data sources and it is believed they are quite accurate. These two statistics constitute estimates of single points on the demand functions for fluid and for manufacturing milk relevant to study area producers in 1959. The price dimensions of these two points are the prices for fluid and manufacturing milk in the 1959 base period, both of which are obtained directly from USDA published price statistics.

2. With the establishment of reference points completed for the relevant populations and the quantities and prices of milk consumed, the impact of changes on these variables over the projection period is next established. Shifts between 1959 and 1965 in per capita consumption of fluid milk and cream are estimated on basis of the expected effects on demand of:

- percentage change in population (Z_{F1}).
- percentage change in personal income per capita (Z_{F2}).
- the income elasticity of demand for fluid milk and cream (η_F).
- percentage change in tastes (Z_{F3}).

A similar procedure is followed for manufactured milk products.

Demand shifters for fluid milk and cream are estimated on the basis of the above four factors. Fluid milk and cream

[2] Allocation of the entire production of milk to the domestic consuming population is not entirely accurate; net exports and government purchases are also sources of disappearance. However, net government purchases of milk fat in 1959 were only 0.04 million cwt.; net exports were only 0.12 million cwt. Net government purchases of solids-not-fat totaled 5.73 million cwt. in 1959; net exports totaled 0.59 million cwt. (see Stat. Bull. 303, ERS, USDA). In the case of both milk fat and solids-not-fat, ending 1959 inventories were less than beginning inventories.

[3] This procedure does not necessarily produce a highly accurate estimate of the actual number of persons supplied by area producers. Rather it provides an index of these populations which is adequate as a population reference point when the model of *demand* is constructed entirely in terms of relative (percentage) change, as is the one here. The outcome or results of such a demand model are expressed entirely in terms of relative change; absolute values of variables are not of operational concern.

produced in the Lake States study area are consumed mainly within the five states. Thus, the effect of population changes (Z_{F1}) on the quantity of fluid milk required (at the given price relationships) was assumed to be directly proportionate to the change in the population of the Lake States area. Since it is not possible with available data to identify directly the population actually being supplied fluid milk by study area producers, these population figures serve as an index of the relevant population and are used as a directly proportional demand shifter.

The projected change in per capita disposable income (Z_{F2}) is based on U. S. average figures since none are available for the Lake States study area.[4] The projected percentage change from the base period to 1965 is a linear extrapolation of change in real per capita disposable income over the 1949-59 period. The change in disposable income is translated into its effect on demand for fluid milk by the income elasticity of demand for fluid milk (η_F).

The actual elasticity estimate used is drawn from Brandow's (1961) demand model of the agricultural economy. The Brandow model is the only statistically estimated detailed commodity model available that is cast in an aggregative equilibrium framework. The Lake States dairy study reported here is similarly constructed with an aggregative equilibrium framework, albeit a less complex one as far as demand is concerned, and with a specialized focus on the dairy production organization of the Lake States. Also the empirical base of the Brandow model, 1955-57, is close in time to the 1959 base of the Lake States model. All these factors lend substantial empirical compatibility to the use of statistics from the Brandow model.

A demand shifter for changing tastes (Z_{F3}) was estimated on the basis of direct data on trends in per capita consumption of fluid milk, adjusted for prices and per capita disposable income. Part of the data for the estimations was developed from work by Herrmann (1962) on the impact of changes in population composition on fluid milk consumption. This shifter, as with the others above, was formulated in terms of percentage changes in the 1959 base quantity of fluid milk and cream consumed per capita.

The demand shifters are aggregated in a linear multiplicative manner:

$$Q_{F65} = \frac{(100 + Z_{F1})}{100} \cdot \frac{[100 + (Z_{F2} \cdot \eta_F)]}{100} \cdot \frac{(100 + Z_{F3})}{100} (Q_{F59})$$

where Q_{F65} is the total quantity of fluid milk and cream estimated to be consumed in 1965 at the 1959 base price, and Q_{F59} is the total quantity of fluid milk and cream consumed in 1959.

The net effect of the factors Z_{F1}, Z_{F2}, η_F, and Z_{F3} was to project a slight reduction in demand for fluid milk and cream in 1965 from the total quantity consumed in 1959.

Demand shifters for manufacturing milk products are estimated similarly. Since manufactured milk produced in the Lake States study area is marketed nationally, the population shifter was constructed from U. S. population projections. The same disposable income measure was used along with the income elasticity of demand for manufactured milk products from the Brandow[5]

[4] An attempt to break out Lake States disposable income did not produce acceptable data. Investigation of the proportion of U.S. personal income accounted for by the five states did not indicate any major shifts in relative structure in the post-World War II period, thus supporting the assumption involved in using U. S. figures for this purpose.

[5] The income elasticity of demand for manufacturing milk was computed from the elasticities of the various manufactured milk end products found in G. E. Brandow, *Interrelations Among Demands for Farm Products and Implications for Control of Market Supply*. Penn. State Univ. Agr. Expt. Sta. Bull. 680, August 1961, table 1. Brandow's 1955-57 utilization figures were used for aggregation weight purposes (table 9).

model. The change in taste shifter for manufactured milk was estimated entirely from historical time series of per capita consumption of manufactured milk adjusted for changes in prices and per capita disposable income.

The net effect of these demand shifters was to project an increase in total demand for manufactured milk products in 1965 as compared to 1959.

Estimation of the slope of the demand functions for: (1) fluid milk and cream, and (2) manufactured milk products is the final step in constructing the aggregative demand framework for the equilibrium processes of the model. Up to this point we have computed (1) the 1959 price-quantity position on the 1959 demand function, and (2) the shift of that position (and function) that is projected for 1965. We now need only to establish the slope of the 1965 demand function to have a demand framework that will provide an estimate of the price effect of any change in production between the 1959 base and the 1965 time horizon of the model.

Slopes for the demand functions for fluid milk and cream and for manufactured milk products used in the model were derived by Brandow (Brandow, 1961, appendix table 8). Slope coefficients for individual milk products were weighted by their relative importance as indicated by the utilization of milk produced in the Lake States in 1959. Since Brandow's slope coefficients were derived for the United States, the scale of coefficients relevant to the Lake States was determined by computing the proportion of total U. S. milk supplied by Lake States producers in 1959.

Results of the Study

Location, Resource Base, and Current Organization of Producing Units

The 14 production areas within the five-state study region are shown in figure 1. Major characteristics and weight factors for each of the 80 producer strata in these 14 areas are shown in appendix table 1.

Minnesota

Areas 1 to 4 are located in the major dairy section of Minnesota. Area 1, to the north of the Twin Cities, is a transitional farming area with small dairy farms and less fertile land than to the south.

Area 2 includes more productive cropland with some larger farms and a wider range of crop and livestock alternatives, particularly in the south which includes Corn Belt type soil. Dairying is an important but less necessary enterprise than in Area 1.

Area 3 includes the section immediately surrounding the Twin Cities. Its northerly location and variable soils are not conducive to Corn Belt type agriculture. Dairying predominates with a number of farms producing fluid-eligible milk for the Minneapolis-St. Paul market.

Area 4 includes the rougher Fayette-Tama soils in southeastern Minnesota where, although the soils are highly productive, topography has prevented use of intensive row crop rotations. This area is often referred to as the southeast Minnesota dairy area because the dairy enterprise dominates many farm organizations.

Iowa

Area 5 in extreme northeastern Iowa is a continuation of the rougher Fayette-Tama soil area along the Mississippi River. Farm organizations have much the same characteristics as Area 4.

Area 6 is a transitional Corn Belt—dairy farming area where dairying is an important but a less necessary enterprise than in Area 5. Soils are productive and level enough to permit rather intensive row crop farming.

Wisconsin

Areas 7 and 8 are located in western and eastern Wisconsin, respectively. Part of Area 7 is in the rougher Fayette-Tama soils area of the westernmost part of the state. The southern tiers of counties in Area 7 include heavier, more productive soils as well as a longer growing season than the northern counties. Although this area supplies part of the fluid-eligible milk for the Twin Cities and Chicago markets, much production is for manufacturing uses.

Area 8, in eastern Wisconsin, supplies fluid-eligible milk to Milwaukee and smaller urban centers in Wisconsin. It also provides part of the milk going into the Chicago fluid market. Most milk produced in the northern section is sold for manufacturing uses. Again, because of somewhat less productive soils and a shorter growing season, the northern tiers of counties have more limited farm enterprise alternatives than in the southern counties with Corn Belt type soils.

Illinois

The seven-county study area, Area 9, in Illinois immediately surrounds urban Cook County (Chicago). Milk produced is all fluid eligible and is sold in the Chicago market. In addition to dairying, the productive soils in this area permit sizable hog and cattle feeding operations, particularly the latter.

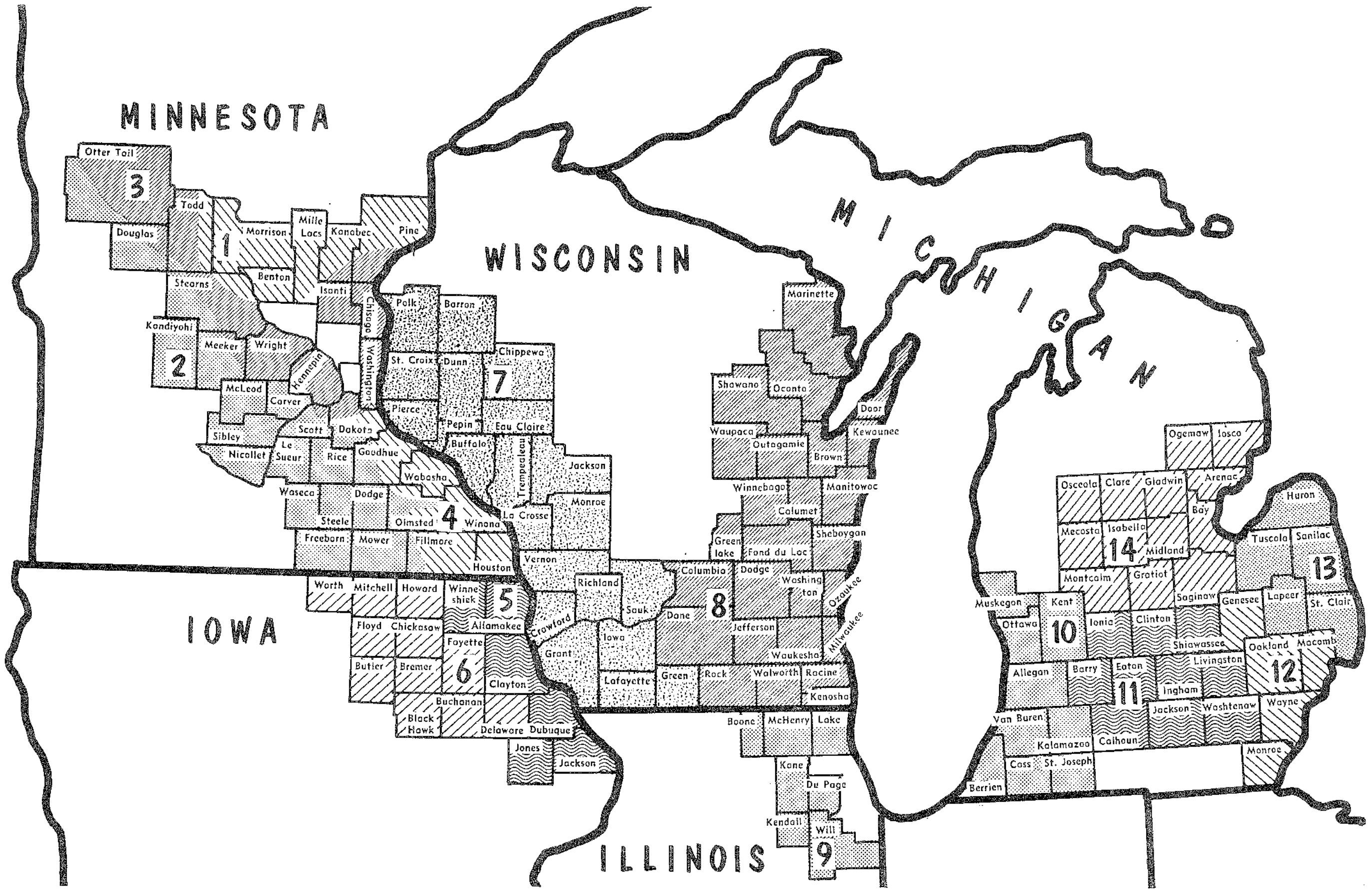

Figure 1. The Lake States study area.

Michigan

The five production study areas in Michigan contain over two-thirds of the lower peninsula and most of the more productive soil areas in south and central Michigan where dairying is an important alternative.

Area 10, in southwestern Michigan, provides a wide range in farm organizations including fruit farms along Lake Michigan, general farms throughout the area, and dairy farms producing primarily fluid-eligible milk for Chicago, South Bend, and Grand Rapids markets.

Area 11, in south central Michigan, includes a tier of southern counties with Corn Belt type soils; slightly less productive soils predominate in the north-central portion of the area. The area includes a high incidence of dairying with substantial hog production and cattle feeding in the southern counties.

Area 12, in southeastern Michigan, surrounds the urban Detroit area. It has a high concentration of specialized dairy farms selling fluid-eligible milk in the Detroit market. Part of the land is intensively used in truck crop production, and much of the land is priced high due to its future potential for urban use.

Area 13, the Saginaw Thumb section, is a highly fertile and level glacial lake plain. In addition to dairying, corn, and small grain production, much of the land area has an alternative use in production of field beans and sugar beets. A number of well organized dairy farms produce fluid-eligible milk for the Detroit market.

Area 14 includes a range of soils and types of farming. Land in the southernmost part is suitable for intensive small grain and row crop production including wheat, corn, soybeans, and field beans. In addition, a number of dairy and dairy-hog farm organizations are present. In the northernmost portion of this area, soil is less fertile and a higher proportion of forage crops is produced. Dairy enterprises dominate the farm organization on many farms in the northernmost tiers of counties.

Milk Production, 1959

The 1959 milk marketings and utilization for individual states in the study area are shown in table 5. Production in the study area of each state is shown in table 6, both in absolute quantity and as a proportion of total milk produced in each state. Production includes both milk marketed and milk consumed on farms as butter or fluid milk.

Milk production in the study areas within respective states amounted to an estimated 22.22 percent of total milk production in Illinois, 40.55 percent in Iowa, 70.31 percent in Minnesota, 81.16 percent in Wisconsin, and 75.29 percent in Michigan. Of the almost 278.1 million cwt. of milk produced in the study area

Table 5. Total marketings and utilization of milk in the Lake States, 1959

State	Total amount of milk marketed by farmers in the state*	Quantity used for manufacture†	Percent utilization manufacture‡
	........million cwt........		
Illinois	40.45	........§	45.91§
Iowa	55.13	45.29	82.15
Michigan	47.44	19.31	40.70
Minnesota	95.04	87.38	91.94
Wisconsin	168.97	128.76	76.20

* Source: USDA Stat. Bull. 303, tables 50-98.

† Source: USDA Stat. Bull. 303, table 314.

‡ Divide column 2 by column 1 except for Illinois.

§ Chicago market order data rather than state data are used to compute the portion of Illinois study area milk going to alternative uses. Consequently, no Illinois State quantity is computed for the quantity of milk used for manufacture.

Table 6. Production of milk in Lake States study area, 1959, and its utilization

State	Percentage of state milk produced by study area farmers*	Milk produced by study area farmers†	Fluid utilization	Manufacturing utilization
		cwt.		
Illinois	22.22	8,986,786	4,860,951	4,125,833
Iowa	40.55	23,450,065	4,967,375	18,482,690
Michigan	75.29	37,223,376	22,556,884	14,666,492
Minnesota	70.31	68,510,064	6,995,845	61,514,219
Wisconsin	81.16	139,903,608	35,353,296	104,550,312
Total	....	278,073,899	74,734,351	203,339,546

* 1959 Census of Agriculture, statistics for counties for the percentage of total milk produced in the counties included in the study area.

† Includes farm consumption of fluid milk and butter not reported as marketings, but does not include milk consumed by livestock.

in 1959, an estimated 203.3 million cwt. went into manufacturing uses and more than 74.7 million cwt. were consumed as fluid milk and cream. An estimated 65.1 percent of fluid-eligible milk produced in the study area in 1959 was actually used for fluid consumption.[6] Thus, an estimated 114.8 million cwt. of the milk produced in 1959 were of a fluid eligible quality and the remaining 163.3 million cwt. were eligible for manufacturing uses only.

Projected Supply Aggregates with Historical Milk Price Differentials

The term "projected" supply is used here to depict the supply of products resulting from aggregation of the income maximizing output from each of the 80 producer strata. The aggregate supplies assume adjustment to income maximizing farm plans by all producing units in the study area. Supplies are computed with projected prices for major inputs and products (table 3). The supply aggregates are represented here prior to their evaluation in terms of projected demand.

The quantities of milk that maximize producers' net incomes at alternative prices for milk and hogs for each of the five states are shown in appendix table 3. The total supplies of fluid-eligible milk, manufacturing quality milk, and hogs that are most profitable for all prices on the 6 x 6 price grid are shown in table 7. The results show major changes in aggregate milk production in response to changes in either milk or hog prices. The sequence of graphs in figure 2 shows the effect of changes in milk and hog prices on aggregate supplies of milk.

Similar graphs in appendix figure 1 show the effect of milk and hog prices on hog supplies. Although hog production in the study area is not a major portion of total U. S. hog production, hogs are an important supplementary and competitive product on many Lake States dairy farms. These graphs illustrate the prices and quantities at which the two products become competitive on an extensive basis.

General Effect of Changes in Milk Prices on Total Supply

Figure 2 indicates the extent to which milk supplies vary with milk prices if all farms are organized to obtain maximum net incomes. In the case of *fluid-eligible* milk, major increases in supply occur be-

[6] This percentage is based on a weighted average of fluid-eligible milk marketed through federal order regulated dealers handling milk produced in the study area in 1959. Data used in making this computation were taken from *Federal Milk Order Market Statistics*. Stat. Bull. 248, AMS, USDA, supplement for 1959. For details see appendix table 2.

Table 7. Total Lake States supplies of milk and hogs that would be optimal at alternative prices

Price of hogs	Price of all milk	Supply of fluid-eligible milk	Supply of manufacturing quality milk	Supply of hogs
U. S. average		cwt.		
$11.50	$3.20	126,358,877	67,272,765	....
11.50	3.60	175,879,314	130,094,394	....
11.50	4.00	249,953,406	166,978,948	....
11.50	4.40	269,486,428	217,132,997	....
11.50	4.80	287,436,074	340,993,599	....
11.50	5.20	312,333,023	413,232,948	....
13.00	3.20	125,325,663	66,243,126	37,786,554
13.00	3.60	176,152,905	129,854,690	35,669,238
13.00	4.00	250,233,842	165,657,938	35,304,875
13.00	4.40	270,528,791	209,809,810	36,608,099
13.00	4.80	288,643,205	341,035,723	29,337,806
13.00	5.20	313,075,026	414,290,921	30,074,047
14.50	3.20	125,793,164	65,760,001	54,085,582
14.50	3.60	174,432,370	120,545,503	58,105,415
14.50	4.00	249,616,013	157,348,674	58,237,132
14.50	4.40	271,076,636	216,902,167	54,637,184
14.50	4.80	289,111,230	328,678,015	56,330,286
14.50	5.20	316,230,994	414,215,796	55,956,176
16.00	3.20	124,302,090	64,891,205	119,947,567
16.00	3.60	177,902,060	108,039,571	110,959,721
16.00	4.00	243,631,498	140,442,888	109,778,838
16.00	4.40	270,759,488	212,254,224	104,804,173
16.00	4.80	287,068,804	305,507,233	91,281,196
16.00	5.20	318,125,051	409,780,509	74,415,768
17.50	3.20	107,285,876	68,146,057	329,730,380
17.50	3.60	154,831,906	114,966,229	384,699,275
17.50	4.00	219,502,180	128,810,753	381,859,312
17.50	4.40	240,710,987	169,692,052	348,654,593
17.50	4.80	273,926,775	232,015,867	302,524,536
17.50	5.20	304,765,323	316,921,290	241,545,444
19.00	3.20	46,009,575	58,749,338	445,607,922
19.00	3.60	129,170,673	100,389,516	534,661,419
19.00	4.00	149,501,573	112,781,841	535,490,050
19.00	4.40	221,466,024	132,442,676	510,025,283
19.00	4.80	240,999,908	165,577,621	462,226,681
19.00	5.20	263,951,540	212,803,224	432,786,385

tween U. S. average milk prices of $3.20 and $4 per cwt. The quantities of milk forthcoming over this price range (between 125 and 250 million cwt.) are well in excess of 1959 production. An exception is with a projected price of $19 hogs; a U. S. average price for all milk of $4.80 per cwt. is required to bring fluid-eligible milk supplies up to about 250 million cwt. The aggregate supply function beyond 250 million cwt. becomes less elastic because further expansion of supply requires extensive building of additional dairy facilities.

The supply of *manufacturing milk* exhibits greater elasticity than fluid-eligible milk over the entire range of milk prices considered. Producers of manufacturing quality milk have greater flexibility in farm organization due to a smaller investment in specialized dairy facilities. At the lowest prices for manufacturing milk it is more profitable for these producers to feed cattle or hogs than to milk cows.

The general shape of the supply schedules for the two classes of milk is consistent with the hypothesis that the supply schedule for a more specialized

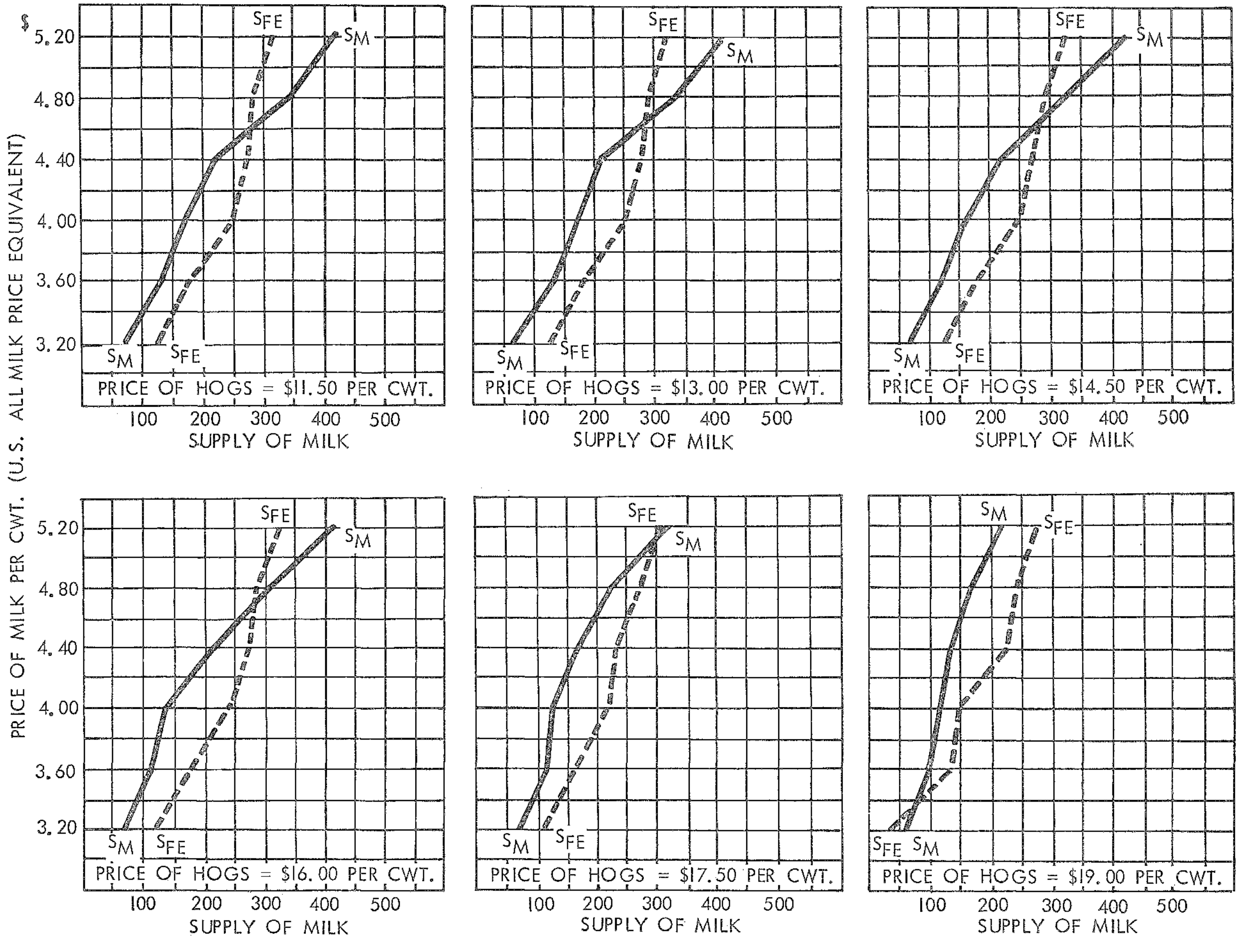

Figure 2. Most profitable supply of milk with alternative hog prices, million cwt. (S_{Fe} = supply of fluid-eligible milk, S_M = supply of manufacturing quality milk.)

(higher fixed resource) product, in this case fluid-eligible milk, is less elastic than one for a less specialized product, manufacturing milk. Manufacturing milk prices, based on the U. S. average price for all milk, of $4.40 result in a supply of manufacturing milk of 200 million cwt. or more, except at the two highest hog prices. Prices higher than $4.40 cause major increases in the programmed supply of manufactured milk as compared to actual production in the 1959 base period.

Elasticities of supply for fluid eligible and manufacturing milk are shown in table 8. Since these elasticities are computed from normative supply schedules, one would expect them to exceed supply elasticities estimated for predictive purposes. Elasticities presented in table 8 are computed with U. S. all hog prices of $14.50 per cwt. The elasticities would be virtually unchanged, however, with hog prices at $16 per cwt.

Effect of Hog Prices on Total Milk Supply

Hog prices lower than $17.50 do not make hog production a competitive alternative on most dairy farms with a fluid-eligible milk market. Of the hog prices considered, only the highest price, $19, results in a major reduction in the aggregate supply of fluid-eligible milk. The relationship between hog prices and the supply of manufacturing milk is more significant, with some competition for resources becoming apparent even with $16 hog prices. With prices of $19 for hogs, the programmed supply curve for fluid milk shifts substantially to the left as hogs become competitive with dairy for major farm resources (see table 7, figure 2, and appendix table 1).

Regional Supply Aggregates with Zero Price Differentials

In order to appraise the effect of intraregional price differentials on location of programmed milk supplies, a second set of regional milk supply aggregates was constructed assuming zero intraregional price differentials. Regional supply aggregates are presented at $0.10 intervals in table 9. Individual state aggregates are shown in appendix tables 4 and 5. Since supplies were estimated at $0.40 intervals, intermediate observations are linear interpolations.

The price range shown in these tables was chosen to insure inclusion of observations for a price-quantity equilibrium. As

Table 8. Elasticities of supply for Lake States milk*

U. S. price of all milk	Fluid eligible milk: Weighted Lake States price	Fluid eligible milk: Supply elasticity	Manufacturing grade milk: Weighted Lake States price	Manufacturing grade milk: Supply elasticity
$3.20	$3.04		$2.30	
		2.71		4.66
3.60	3.45		2.64	
		3.16		1.88
4.00	3.86		3.04	
		0.84		2.64
4.40	4.26		3.43	
		0.74		3.90
4.80	4.65		3.81	
		1.14		2.31
5.20	5.03		4.21	

* These are arc elasticities computed from programmed supplies. The use of U. S. all milk prices would bias the elasticity estimates (the elasticity estimates for manufacturing quality milk particularly would be biased upwards). Hence, the prices used for fluid-eligible and manufacturing grade milk are individual Lake State prices corresponding to each U. S. all milk price and weighted by the percentage of study area milk programmed for that state at that price.

Table 9. Total Lake States supplies of milk that would be optimal at alternative prices with zero intraregional price differentials

U.S. price of all hogs	Price of fluid-eligible milk*	Supply of fluid-eligible milk	Price of manufacturing milk*	Supply of manufacturing quality milk
....per cwt....		cwt.	per cwt.	cwt.
$14.50	$3.20	152,920,374	$2.60	123,269,122
14.50	3.30	163,532,407	2.70	132,469,916
14.50	3.40	174,269,739	2.80	141,670,708
14.50	3.50	185,007,071	2.90	150,871,501
14.50	3.60	196,273,591	3.00	162,726,434
14.50	3.70	210,911,193	3.10	177,614,808
16.00	3.20	146,110,946	2.60	104,603,128
16.00	3.30	156,956,497	2.70	114,771,864
16.00	3.40	167,891,307	2.80	124,940,600
16.00	3.50	178,826,117	2.90	135,109,338
16.00	3.60	190,085,877	3.00	146,450,528
16.00	3.70	206,535,341	3.10	164,403,363

* Quantity weighted Lake States price.

might be expected, the zero price differential supply aggregates (as compared to those with historical price differentials) show a larger proportion of total milk supplies coming from historically "lower priced" milk areas.

Projected Demand Aggregates

Population Supplied

The portion of the total U. S. population supplied by study area milk producers in 1959 was estimated as follows:

1. For fluid milk and cream: population $= \dfrac{74{,}734{,}351 \text{ million cwt.}^{7}}{3.30 \text{ cwt./capita}}$ $= 22.6467$ million persons.
2. For manufactured milk products: population $= \dfrac{203{,}339{,}546 \text{ million cwt.}^{7}}{3.36 \text{ cwt./capita}}$ $= 60.5177$ million persons.

Demand Shifters

The demand shifters considered relevant from 1959 to 1965 and their respective effects (shown in detail in appendix tables 8 and 9) are:

1. For fluid milk and cream:
   - (a) Z_{F1}, the regional study area population change 1959 to 1965 = +8.73 percent, a change from 22.647 million to 24.624 million persons (see appendix table 7).
   - (b) Z_{F2}, the personal income change 1959 to 1965[8] = +9.08 percent.
   - (c) η_F, the income elasticity of demand (Brandow, 1961) = +0.06.
   - (d) Z_{F3}, the per capita consumption change due to change in tastes = −9.56 percent.

[7] See table 6 for quantities of fluid and manufacturing milk supplied by study area producers. The 1959 population supplied milk by Lake States producers is estimated as follows: (a) the population supplied fluid milk and cream is estimated by dividing total 1959 fluid milk and cream provided by study area producers (Q_{F59} = 74.7343 million cwt.) by 330 pounds per capita which is the average 1959 per capita consumption of fluid milk and cream, (b) the population supplied milk for manufacturing uses is estimated by dividing total 1959 manufacturing milk provided by study area producers (Q_{M59} = 203.3395 million cwt.) by 336 pounds per capita which is the average 1959 per capita U. S. consumption of manufactured milk products (see *Dairy Situation* DS-292, USDA, Washington, D.C., November 1962).

[8] Estimates of U. S. per capita income changes were applied to the region. This was done by a linear projection of the 1949-59 U. S. trend in real per capita disposable income. Source: *Economic Report of the President*, Council of Economic Advisers, Washington, D.C., 1963, p. 191.

(e) Since the total effect of (a) through (d) = −1.1 percent, Q_{F65} = 98.9 (74.7344) = 73.9123 million cwt.

2. For manufactured milk products:

   (a) U. S. population change 1959 to 1965 = +10.34 percent, a change from 60.5177 to 66.7510 million persons (see appendix table 7).

   (b) Personal income change 1959 to 1965 = +9.08 percent.

   (c) Income elasticity of demand (Brandow, 1961) = +0.26.

   (d) Per capita consumption change due to change in tastes = −6.62 percent.

   (e) Since the total effect of (a) through (d) = +5.5 percent, Q_{M65} = 105.5 (203.3395) = 214.5232 million cwt.

Slope Coefficients

Slope coefficients were derived by weighting the coefficients derived by Brandow (1961) by the proportion of the U. S. population supplied by study area producers as follows:

1. For fluid milk and cream:

   (a) Slope coefficient for U. S. = −15.99 million cwt./$1

   (b) 1959 population supplied by $\frac{\text{Lake States producers}}{\text{1959 U. S. population}} =$

   $$\frac{22.647 \text{ million}}{177.830 \text{ million}} = 0.1273519$$

   (c) slope coefficient for study area = −15.99 (0.1273519) = −2.036356 million cwt./$1

2. For manufactured milk products:

   (a) Slope coefficient for U. S. = −100.523 million cwt./$1

   (b) 1959 population supplied by $\frac{\text{Lake States producers}}{\text{1959 U. S. population}} =$

   $$\frac{60.5177 \text{ million}}{177.830 \text{ million}} = 0.340312$$

   (c) Slope coefficient for study area = −100.523 (0.340312) = −34.209183 million cwt/$1.

Demand Projections

The average U. S. price for all milk in 1959 was $4.16 per cwt. At this price we estimated that 74.7344 million cwt. of study area produced fluid milk and cream were consumed. By 1965, evaluation of demand shifters indicates this quantity will be reduced 1.1 percent to 73.9123 million cwt. With a slope coefficient of −2.036 million cwt. per $1 change in milk price relevant to the study area, we can evaluate the demand for fluid milk and cream in 1965 as: 73.9123 −(2.036) (P_i^f − $4.16), where P_i^f is the price of fluid-eligible milk at the farm level translated into its equivalent U.S. price of all milk. This demand relation is shown graphically in figure 3.

A similar evaluation of the demand for milk for utilization in manufactured dairy products is as follows:

In 1959, study area-produced manufactured milk products required 203.3395 million cwt. of milk.

Consumption in 1959 plus the effect of demand shifters expected by 1965 amounts to a demand of 214.5232 million cwt. at the 1959 market price (U. S. all milk price of $4.16 per cwt.). With a slope coefficient of −34.2092 million cwt. per $1 change in milk price relevant to the study area, we can evaluate the demand for manufactured milk products in 1965 as: 214.5232 − (34.209) (P_i^m − $4.16), where P_i^m is the price of manufacturing milk at the farm level translated into its equivalent U. S. price of all milk.

Demand aggregates for milk produced in the study area are shown in table 10 and figure 3. These aggregates are estimated under the assumption that study area producers would service the same proportion of the total U. S. market for fluid and manufactured products that they supplied in 1959.

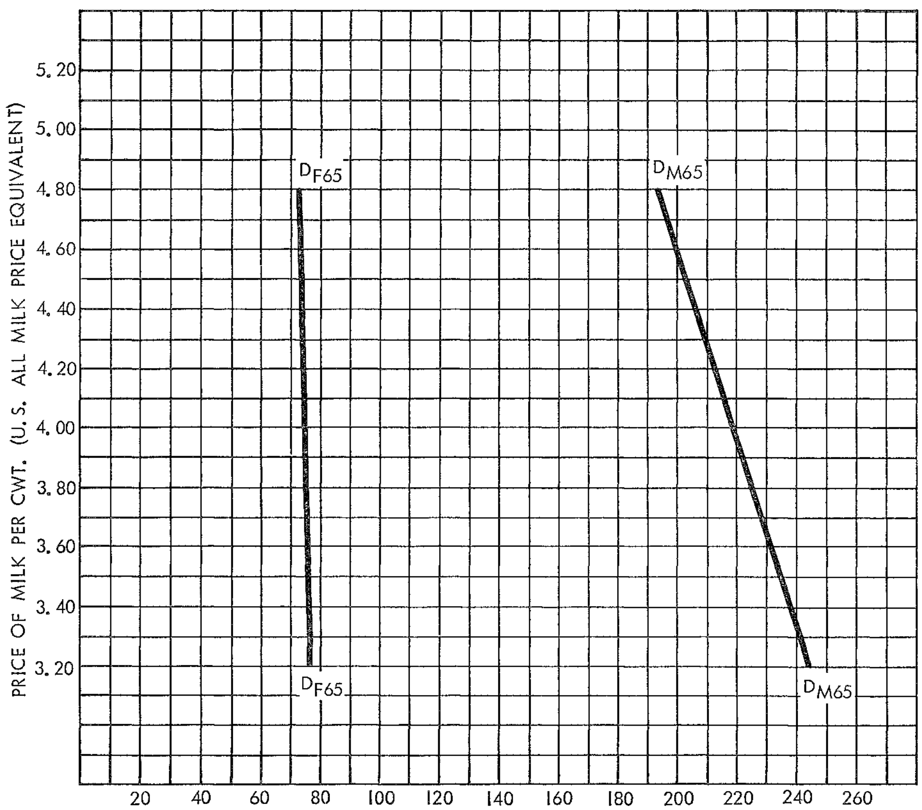

Figure 3. Demand for milk produced in study area, 1965, million cwt. (Based on the assumption that the same proportion of U. S. consumers are supplied with milk produced in the study area as was estimated to be the case in 1959. D_{F65} = demand for fluid uses, D_{M65} = demand for manufacturing uses.)

Table 10. Estimated demand aggregates for study area produced milk, 1965

U. S. all milk price	Demand for milk for fluid use	Demand for milk for manu-facturing use	Total demand for milk
per cwt.	million cwt.		
$3.20	75.867	247.364	323.231
3.40	75.395	240.522	315.917
3.60	74.988	233.680	308.668
3.80	74.581	226.838	301.419
4.00	74.173	219.997	294.170
4.20	73.766	213.155	286.921
4.40	73.359	206.313	279.672
4.60	72.952	199.471	272.423
4.80	72.545	192.629	265.174

Demand and Supply Aggregates Compared

Of particular importance in this study was the evaluation of normative milk supplies and predicted demand for milk, given the expected equilibrium prices of farm products competing with dairy for production resources. Equilibrium prices for all such products[9] were projected both exogenous to and prior to the programming analysis. Milk supply and demand aggregates are evaluated with two alternative projected prices for hogs: $14.50 and $16 per cwt. U. S. average, all hogs.

Equilibrium Analysis with Intraregional Price Differentials for Milk

Table 11 indicates normative supply and predicted demand schedules at the farm level for milk produced in the study area. The fluid milk demand schedule is for *milk for fluid use;* corresponding supply aggregates are for *fluid-eligible milk.*

Table 11. Normative supplies and predicted demand for milk in the study area, 1965 (with intraregional supply price differentials)

U.S. all-milk price	U.S. all-hog price	D_{F65}*	D_{M65}	S_{Fe}	S_M	D_{T65}	S_T
per cwt.		million cwt.					
$3.20	$14.50	75.867	247.364	125.793	65.760	323.231	191.553
3.60	14.50	74.988	233.680	174.432	120.545	308.668	294.977
4.00	14.50	74.173	219.997	249.616	157.349	294.170	406.965
4.40	14.50	73.359	206.313	271.077	216.902	279.672	487.979
4.80	14.50	72.545	192.629	289.111	328.678	265.174	617.789
3.20	16.00	75.867	247.364	124.302	64.891	323.231	189.193
3.60	16.00	74.988	233.680	177.902	108.040	308.668	285.942
4.00	16.00	74.173	219.997	243.631	140.443	294.170	384.074
4.40	16.00	73.359	206.313	270.759	212.254	279.672	483.013
4.80	16.00	72.545	192.629	287.069	305.507	265.174	592.576

* Subscripts: F = fluid milk and cream, Fe = milk eligible for fluid use, M = manufacturing quality milk, and T = total.

[9] Study area production of products such as beef and cash crops was assumed to be in such small volume, relative to total supplies, so as not to affect their equilibrium prices. Variable pricing of hogs does not assume U. S. hog prices to be determined exclusively, nor even in significant part, by hog production in the study area. Rather, this variable pricing was accomplished to determine the degree of stability of optimal farm organizations and to have milk supply schedules with alternative hog prices in the event a single projected price was thought to be erroneous.

Whether these supply-demand aggregates for milk are evaluated at $14.50 or $16 per cwt. hog prices, total quantities are in equilibrium at U. S. prices for all milk of between $3.60 and $4 per cwt. Linear approximation of the total supply and demand schedules between $3.60 and $4 milk prices provides an equilibrium at about $3.64 with $14.50 hogs —approximately $0.50 per cwt. less than the 1959 price. However, such an equilibrium in total milk supplies provides a market for only about 115.1 million cwt. of fluid-eligible milk with the 65.104 percent Class I utilization rate of the year 1959.[10]

In order to market the estimated supply of fluid-eligible milk at this price, a Class I utilization rate of about 41.2 percent provides for the equilibrium demand of fluid milk and cream.[11] However, this results in overestimating the price that is paid for fluid-eligible milk and the amount of fluid-eligible milk which is supplied under equilibrium conditions.[12] Thus, it is necessary to reevaluate the supply functions for milk with a lower Class I utilization rate and a change in the relationship among prices for fluid-eligible milk, manufacturing milk, and all milk.

Since increased diversion of fluid-eligible milk lowers the blend-milk price relative to manufacturing quality milk, the historical relation between these two prices and the U. S. all milk price is no longer projected to continue unchanged.[13] Intraregional price differentials are retained unchanged from those existing historically. The adjustment to equilibrium is attained by a reduction in the price differential between fluid-eligible and manufacturing grade milk.

Since the demand for fluid milk is very inelastic, the diversion rate is expected to be only slightly higher than the 41.2-percent estimate. Successive approximations leading to a new equilibrium indicate that such an equilibrium is achieved with a Class I utilization rate for fluid-eligible milk of about 44.7 percent and a reduction of more than $0.21 per cwt. in the price premium of fluid-eligible milk over manufacturing milk.[14] Total utilization at this equilibrium with $14.50 per cwt. hogs is about 303.3 million cwt.; 168.0 million cwt. is fluid-eligible milk and 135.3 million cwt. of manufacturing quality.

With hog prices at $16 per cwt. the equilibrium situation differs. Hogs become a more competitive enterprise, particularly on farms producing manufacturing quality milk. A supply-demand equilibrium with $16 hogs occurs with a supply of about 301.3 million cwt. of milk. Since a higher proportion of the total milk is supplied by fluid-eligible milk producers than was the case with $14.50 hogs, the Class I utilization rate is reduced to less than 43 percent. And the price premium of fluid-eligible over manufacturing quality milk is reduced by about $0.23 per cwt. The equilibrium quantity of fluid milk demanded of about 75.0 million cwt. and the quantity of manufacturing milk demanded of 226.3 million cwt. are supplied by about 175.7 million cwt. of fluid-eligible milk and

[10] A market for a slightly larger amount of fluid-eligible milk is provided if hog prices are at $16, but the same general magnitude of decrease in fluid utilization rate is the case.

[11] The proportion of fluid-eligible milk going into fluid uses can in no case approach 100 percent; some substantial amount of diversion is a technical necessity. This is true because of within week and within year variations in demand and flush and slack within year production periods. However, these excess needs can be well accommodated with a utilization rate of 65.1 percent (as in 1959).

[12] The lower rate of fluid utilization causes the blend milk price to decrease relative to both the U. S. all milk price and the manufacturing milk price. The all milk price also declines relative to the manufacturing milk price.

[13] The relationships between U. S. all milk prices and fluid-eligible milk prices particularly are different at the projected equilibrium than they were in 1959. However, since the supply-demand equilibrating adjustment in price occurs in fluid-eligible milk and the demand for fluid milk is very inelastic, the demand projections based on U.S. all milk prices should remain virtually unchanged. They are assumed to do so for the purpose of this analysis.

[14] The 1959 quantity weighted price differential between fluid-eligible and manufacturing milk in the study area was about $0.68 per cwt. Thus, reducing the Class I utilization rate from 65.104 to 44.7 percent reduces the price differential by about 21.3 cents per cwt.

125.6 million cwt. of manufacturing quality milk.

Equilibrium Analysis with Zero Regional Price Differentials

Normative supply aggregates for milk with 1959 quantity weighted Lake States prices and with zero intraregional price differentials are shown in table 9. The price dimensions for these supply aggregates are well below those for the United States. Demand aggregates are also translated to Lake States prices. The supply and demand schedules used in the equilibrium analysis are shown in table 12.

With $14.50 hogs, an equilibrium exists with a total milk supply of about 303.3 million cwt. Equilibrium prices of about $2.80 per cwt. for manufacturing quality milk result in a programmed supply of 141.6 million cwt. of this milk. An equilibrium price of about $3.28 per cwt. for fluid-eligible milk provides a programmed supply of 161.7 cwt. and a Class I utilization rate of about 46.4 percent.

If hog prices are $16 per cwt., the situation changes somewhat. A higher proportion of the total milk supply comes from fluid-eligible milk producers. The equilibrium milk supply of about 299.7 million cwt. is produced as follows: 134.9 million cwt. by manufacturing quality milk producers and 164.8 million cwt. by fluid-eligible milk producers. With a Class I utilization rate of about 45.4 percent, 74.9 million cwt. of milk goes to service fluid demand and 224.8 million cwt. to manufacturing uses. The price premium of fluid-eligible over manufacturing quality milk is reduced from $0.68 in 1959 to about $0.47 at the point of equilibrium.

The Four Equilibrium Situations Compared

A comparison of the four supply-demand equilibrium situations is shown in table 13. In order to make the comparison meaningful, all milk prices are shown as quantity weighted Lake States prices. The general magnitudes of milk supplies are similar for all four situations, as are the reductions in price premiums of fluid-eligible over manufacturing quality milk.

The two primary differences between these equilibrium situations are: (1) a decreased portion of total milk supplies comes from manufacturing quality producers as hog prices increase from $14.50 to $16, and (2) a larger portion of total milk supplies comes from manufacturing quality producers in historically "low

Table 12. Normative supplies and predicted demand for milk in the study area, 1965 (with zero intraregional supply price differentials)

U. S. all hog price	Price of fluid-eligible milk*	D_{F65}†	S_{Fe}	Price of manufacturing quality milk*	D_{M65}	S_M
per cwt.		million cwt.		per cwt.	million cwt.	
$14.50	$3.20	75.294	152.920	$2.60	235.049	123.269
14.50	3.30	75.091	163.532	2.70	231.628	132.470
14.50	3.40	74.888	174.270	2.80	228.207	141.671
14.50	3.50	74.685	185.007	2.90	224.786	150.872
14.50	3.60	74.481	196.274	3.00	221.365	162.726
14.50	3.70	74.278	210.911	3.10	217.944	177.615
16.00	3.20	75.294	146.111	2.60	235.049	104.603
16.00	3.30	75.091	156.956	2.70	231.628	114.772
16.00	3.40	74.888	167.892	2.80	228.207	124.941
16.00	3.50	74.685	178.826	2.90	224.786	135.109
16.00	3.60	74.481	190.086	3.00	221.365	146.451
16.00	3.70	74.278	206.535	3.10	217.944	164.403

* Quantity weighted Lake States price.

† Subscripts: F = fluid milk and cream, Fe = milk eligible for fluid use, and M = manufacturing quality milk.

Table 13. Supply-demand equilibrium situations

Item	U.S. price of all hogs = $14.50 per cwt.		U.S. price of all hogs = $16 per cwt.	
	Solution with historical intra-regional price differentials	Solution with zero intra-regional price differentials	Solution with historical intra-regional price differentials	Solution with zero intra-regional price differentials
Price of fluid-eligible milk (cwt.)*	$3.267	$3.283	$3.303	$3.372
Supply of fluid-eligible milk (million cwt.)	168.0	161.7	175.7	164.8
Demand for fluid use milk (million cwt.)	75.1	75.1	75.0	74.9
Percent Class I utilization of fluid-eligible milk	44.7	46.4	42.7	45.4
Price of milk used in manufacturing (cwt.)*	$2.80	$2.799	$2.857	$2.898
Supply of manufacturing quality milk (million cwt.)	135.3	141.6	125.6	134.9
Demand for manufacturing use milk (million cwt.)	228.2	228.2	226.3	224.8
Price premium of fluid-eligible over manufacturing quality milk (cwt.)†	$0.467	$0.484	$0.446	$0.474
Total milk supplied and demanded (million cwt.)	303.3	303.3	301.3	299.7

* These prices are in terms of the quantity weighted Lake States milk price and are translated to individual state prices later in this report.

† The quantity weighted study area price differential between fluid-eligible and manufacturing quality milk was $0.68 per cwt. in 1959.

price producing areas" when intraregional price differentials are eliminated. Such differentials cannot, of course, be eliminated in their entirety since they reflect some necessary cost differentials such as transportation costs. However, future technologies may result in changes in intraregional cost differentials.

Special Perspective Required

At this point it is again worthwhile to point out the distinction between the "programmed normative" supply aggregates and the "predicted" demand aggregates equated here. The equilibria posed here are not expected ones but those projected when productive resources of representative farms in the study area are optimally organized according to the criterion of profit maximization. Thus, the normative milk supplies probably set an "upper bound" to potential production and provide a "maximum" price effect; that is, equilibrium prices would be lower than in an "expected" or "projected" context.

The main purposes of performing the equilibrium-type comparison of supply and demand for milk in the study area are threefold: (1) to evaluate intraregional adjustments consistent with results of the normative programming analysis and expected demand for milk products; (2) to determine locational effects of intraregional price differentials on dairy production within the study area; and (3) to determine the general price levels which would prevail for fluid-eligible and manufacturing milk if farms were optimally organized and, therefore, to have a "most likely" price level for milk if such adjustments were indeed carried out.

The implications of and reasons for a lower Class I utilization rate for fluid-eligible milk require further elaboration. Results of the programming analysis indicate that, given the assumptions of the analysis, price differentials between fluid-eligible and manufacturing quality milk could be less than they have been historically and still provide enough fluid-eligible milk to service effective Lake States demand for fluid milk and cream.[15] Given the location and fixed assets committed to dairy production by fluid-eligible milk producers, and given their access to a higher price market, nondairy alternatives are less profitable for fluid-eligible milk producers at equilibrium prices than for those producing manufacturing quality milk.

Perhaps the most significant implication of the comparison between supply and demand aggregates is that, within the framework of optimum production defined here, a larger proportion of total milk would be produced by fluid-eligible milk producers than was the case in 1959. This is true even with the price-depressing effects on blend-milk prices for fluid-eligible milk caused by a higher diversion rate for fluid-eligible milk. Aside from the analysis here, stricter sanitation requirements for producers of manufacturing quality milk may add incentive for nondairy enterprises on many farms now producing this milk. The aggregate supply-demand comparisons have differing implications for areas within the Lake States. These are discussed in a later section.

Other Aggregate Relationships

Aggregates for several major inputs and products important to Lake States agriculture were tabulated concurrently with the aggregate normative supply of milk and hogs. These aggregate data are evaluated here only briefly in order to better depict the type of aggregate adjustments that were programmed to be optimal for the study area.[16]

Corn

Aggregate corn purchases and sales for the study area are shown in appendix table 6. Net corn purchases are large; about 250 million bushels at the equilibrium milk price with market hogs at $14.50. Total purchases are about doubled (502 million bushels) if hog prices are projected at $16 per cwt. Substantial corn purchases, particularly in Wisconsin, with lower hog prices ($11.50 and $13) reflect the profitability of feeding cattle when hog prices are relatively unfavorable.

Beef Cattle

The incidence of purchase and fattening of feeder cattle is substantially in excess of 1959 levels (by as much as 500 percent) with low hog and milk prices. Although somewhat competitive with dairy at the lowest milk prices programmed, beef feeding competes primarily with hog production in the study area. Since beef prices were programmed at only one level, $17 per cwt. all beef cattle,[17] the programmed aggregates are determined by variations in hog and milk prices only. At hog prices of $17.50 per cwt. or higher, the optimal levels of beef feeding (about 2.4 million head) are closer to the volume of beef cattle feeding occurring in the study area in 1959.

Feeder Pig Purchases

Optimal feeder pig purchases total about 2 million head with equilibrium

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[15] This phenomenon is also indicated outside of the programming analysis by the increased diversion of fluid-eligible milk into manufacturing uses since the 1959 base period, particularly in some Michigan markets (see statistics on disposition of milk handled by federal order market regulated handlers), and in the dropout of producers not eligible for a fluid market.

[16] Only the aggregate data corresponding to the equilibrium situations *with* historical intraregional milk price differentials are discussed here. Although these aggregates are somewhat different for the zero intraregional price differential situations, direction and general magnitudes of adjustments are the same.

[17] Although this price level varies slightly between states, it is roughly equivalent in the study area to a price of $22 per cwt. for fat cattle, good grade.

milk prices and hog prices of $14.50, and about 3.4 million head with market hog prices of $16 per cwt. With market hog prices higher than $16 per cwt. it is profitable to increase feeder pig purchases to over 10 million head. Since much of the supply of feeder pigs must come from outside of the study area, it is impossible to evaluate these aggregates. However, the purchase of 2 million head of feeder pigs represents an increase of at least 50 percent from total purchases reported by study area farmers in 1959. With such a large increase, the price of feeder pigs relative to market hog prices might increase and dampen the programmed purchases of feeder pigs. If so, more of the hogs finished would probably be home raised.

Crop Production

Projected production of all crops is slightly higher than in 1959, reflecting some improvements in technology. However, differences in aggregate production of cash crops including soybeans, sugar beets, and wheat are small in comparison with total U. S. production. Greater production of corn and forage crops (by roughly 20 percent) largely results from improved yields due to use of more fertilizer than in 1959. These increased yields are mostly utilized in servicing larger livestock enterprises.

Capital

Almost all (over 90 percent) of the reorganized representative farms use more capital than in 1959. At equilibrium prices for milk and with $14.50 or $16 hogs, further expansion of the farm business is limited by the capital (including credit) restraint on about 60 percent of the representative farms. Many farms use from $20,000 to $40,000 more capital in their optimal organizations then they used in 1959.

Intraregional Implications

Implications of the aggregative analysis vary somewhat by states, areas, and individual farm strata. So major implications are assessed for the part of each state studied. References to areas and individual strata are made briefly and generally. Inferences are based primarily on analysis results with equilibrium prices and quantities of milk with a projected U. S. price of all hogs of $14.50. However, the effect of projecting a $16 hog price is also considered briefly.

Minnesota

• **With historical intraregional price differentials for milk:** Supplies of milk at equilibrium prices equal about 61.728 million cwt.—90.1 percent of the volume supplied in 1959. The amount supplied by fluid-eligible milk producers, however, increases with a total Class I utilization of 9.001 million cwt. of milk compared to 6.996 million cwt. in 1959.[18] Equilibrium prices for Minnesota are about $2.69 per cwt. for manufacturing milk and about $3.20 for fluid-eligible milk.

In addition to the shift in increased milk production by fluid-eligible milk producers, optimal programs show a shift to increased beef and hog production, particularly by producers not on a grade A milk market. Hog feeding is generally more profitable than beef feeding when hog prices are $17.50 per cwt. or higher. However, a substantial amount of hog production is profitable with hog prices of $14.50 per cwt. or higher.

A projected equilibrium hog price of $16 per cwt. has the effect of reducing the supply of manufacturing milk by more than 10 percent (as compared with $14.50 hogs) but has virtually no effect on the supply of fluid-eligible milk. This increase in hog prices has the effect of making hog production a commercial enterprise on many dairy farms producing manufacturing quality milk. Equi-

[18] Assuming Class I utilization in 1959 as shown in table 6, and Class I utilization of programmed supplies equal to equilibrium supplies of fluid-eligible milk times the equilibrium Class I utilization rate of 44.7 percent.

librium milk prices increase about $0.04 per cwt. for fluid-eligible milk and $0.06 per cwt. for manufacturing quality milk (as compared to $14.50 hogs).

● **With zero intraregional price differentials for milk:** With $14.50 hogs, supplies of milk at equilibrium prices (about $2.80 for manufacturing quality milk and $3.30 for fluid-eligible milk) are about 65.889 million cwt.—96.2 percent of 1959 production. As with historical price differentials, a higher proportion of total milk production is from fluid-eligible milk producers than in 1959.

If hog prices increase to $16 per cwt., equilibrium supplies of fluid-eligible milk go up about 4 percent in response to the higher equilibrium milk price. Meanwhile, supplies of manufacturing quality milk decrease by more than 3 million cwt. This leaves total Minnesota milk supplies virtually unchanged from those with $14.50 hogs. This phenomenon is again illustrative of $16 hogs being competitive with production of manufacturing quality milk.

In each equilibrium situation examined here, several strata of small farms, particularly in Areas 1 and 3, do not produce net incomes above $4,500 even when optimally organized. This is particularly true for farms not producing fluid-eligible milk. Larger farms in Areas 2 and 4 can be profitably organized with or without dairy; concentrate feed supplies and capital are adequate to utilize available labor in livestock enterprises less labor intensive than dairy.

Wisconsin

● **With historical intraregional price differentials for milk:** With $14.50 hogs, programmed milk supplies from the Wisconsin study area total 127.505 million cwt.—91.1 percent of the total produced in 1959. Of this total, 45.377 million cwt. are produced by fluid-eligible milk producers, and 82.128 million cwt. by milk producers not on a grade A market. Class I utilization of 20.285 million cwt. only equals 57.4 percent of estimated Class I utilization in 1959.

Equilibrium prices of about $3.04 for fluid-eligible milk and $2.86 for manufacturing milk reflect the fact that, historically, prices of fluid-eligible milk in Wisconsin have been low. This has been due to: (1) a high rate of diversion into manufacturing uses, and (2) relatively high intraregional transportation costs for fluid-eligible milk. This phenomenon has existed because of a large volume of production and limited access to large nearby urban markets except Milwaukee and the Twin Cities. Much fluid-eligible milk must be transported some distance into the Chicago market where, historically, the Class I utilization rate has been low.

The effect on milk supply of projecting an equilibrium price of hogs of $16 per cwt. is to increase production of fluid-eligible milk slightly and decrease production of manufacturing quality milk slightly. However, a major effect of the increase in hog prices is a reduction in the volume of beef cattle feeding by about 20 percent for fluid-eligible milk producers and by about 40 percent for grade B milk producers. In both cases, resources released from beef cattle feeding would go largely into hog production.

The volume of beef cattle finishing and hog production increases substantially, largely due to resources released by the reduction in optimal total milk production. However, substantial corn purchases are required to service these livestock enterprises.

● **With zero intraregional price differentials for milk:** Because of unfavorable historical prices, the equilibrium analysis with zero intraregional price differentials shows a larger portion of total milk production coming from Wisconsin producers. With $14.50 hogs, milk supplies total 148.9 million cwt.—6.5 percent more than actual 1959 production. Compared to the programmed supply with historical price differentials, all of the increase in supply is from fluid-eligible milk producers.

The equilibrium price of about $3.30 for fluid-eligible milk is, however, $0.26 per cwt. higher than the price in the previous equilibrium analysis. Thus, a relatively small reduction in the historical intraregional milk price differential in favor of Wisconsin producers substantially increases the competitive position of dairying on many farms.

Hog prices of $16 have relatively little effect on milk supplies as compared to the $14.50 hog price situation. The major result of increased hog prices is a shift from beef cattle feeding to hog production.

As in Areas 1 and 3 in Minnesota, several strata of producers in Area 7 of Wisconsin would find it difficult to shift to an "adequate income" farm organization at equilibrium prices because of an inadequate resource base. Among their alternatives in farming, however, dairying is generally the most profitable.

Iowa

● **With historical intraregional price differentials for milk:** Milk supplies from the Iowa study area total 21.102 million cwt. as compared to an estimated 23.450 million cwt. in 1959. So the projected supply is about 90 percent of 1959 production. This includes an increase in production of fluid-eligible milk but a reduction in Class I utilization of about 16 percent. At equilibrium milk prices and with hogs at $14.50 per cwt., grade A milk producers do not produce hogs and they feed only a few beef cattle. Producers of manufacturing quality milk, on the other hand, reduce milk production from that of 1959 and become major hog and beef cattle feeders at these prices.

A major reason for these differences in production as compared to Wisconsin, for example, is the large price premium for fluid-eligible milk (compared to manufacturing quality milk) which has historically gone to Iowa producers. Equilibrium prices are $2.76 per cwt. for manufacturing milk and about $3.53 for fluid-eligible milk. The $0.77 spread in these two prices is $0.21 less than the historical price differential (table 4).

Hog prices of $16 per cwt. as compared to $14.50 result in a substantial reduction in production of both fluid-eligible and manufacturing quality milk at equilibrium milk prices. Hog production increases substantially and reduces the production of both milk and beef. As in Areas 2 and 4 in Minnesota, larger grade B dairy farms in both Areas 5 and 6 in Iowa could be profitably organized without dairying as well as with it.

● **With zero intraregional price differentials for milk:** The equilibrium milk supply is reduced slightly (from 21.102 to 20.867 million cwt.) by elimination of historical price differentials for milk. In addition to this reduction in total milk supplied by Iowa producers, the proportion of milk supplied by fluid-eligible milk producers decreases relative to that supplied by grade B producers. In fact, total milk production from grade B producers increases slightly even in absolute quantities.

With $16 hogs, milk production is reduced (as compared to that with $14.50 hogs). The principal reduction comes from producers of manufacturing quality milk who find increased hog production profitable at the $16 hog price.

Illinois

● **With historical intraregional price differentials for milk:** With equilibrium prices for milk and hogs at either $14.50 or $16, Illinois farm strata in the study area are more profitably organized without dairy. The area produced an estimated 8.987 million cwt. of milk in 1959. All study area producers were producing fluid-eligible milk for the Chicago market. The U. S. all milk equilibrium price equivalent for fluid-eligible milk in Illinois was estimated to be $3.29 per cwt. But even with an equilibrium price somewhat higher, milk production is not profitable. This phenomenon reflects at least the first of the following two factors:

1. Study area farmers had good livestock alternatives. They can profitably finance and feed large numbers of beef cattle and hogs, particularly the former.

2. The Illinois milk prices programmed probably did not adequately reflect the

intrastate locational price premium which study area producers have historically received.

The first factor, good livestock alternatives, and the high cost of hired labor because of proximity to Chicago, probably were major determinants of the programming results.

Additional analysis is being conducted at the University of Illinois on some very "specialized" dairy farms supplying milk to the Chicago market. These specialized operations appear capable of maximizing net incomes by producing milk at equilibrium prices determined for Illinois.

● **With zero intraregional price differentials for milk:** Equilibrium analysis with the historical intraregional milk price differential removed shows dairy remaining a less profitable enterprise than a combination of beef cattle feeding, hog production, and production of cash crops.

Michigan

● **With historical intraregional price differentials for milk:** With $14.50 hogs, the equilibrium price equivalent of fluid-eligible milk in Michigan was estimated to be about $3.61 per cwt. This price is substantially above that of all study area states except Iowa, and it is $0.08 per cwt. above the equilibrium price in Iowa. As in the case of Illinois, all Michigan farm strata were programmed only with the alternatives of no dairy or grade A dairy; no grade B milk production alternative was considered.

The equilibrium supply of 92.919 million cwt. represents an increase of 149 percent from production in 1959, with almost a doubling of the amount of milk going into fluid utilization. Areas 11, 12, 13, and 14 each produce in excess of 20 million cwt. of milk at the equilibrium price. Only Areas 12 and 14 produce any hogs at the equilibrium price. However, all areas contain some individual strata where beef cattle fattening enterprises are profitable. However, beef cattle fattening is much less extensive in Michigan than in any other study area state. Note, however, that Branch, Hillsdale, and Lenawee Counties (three Corn Belt type counties in southern Michigan) were not included in the study area.

An equilibrium with a price of $16 per cwt. for hogs changes milk supplies very little from the situation with $14.50 hogs. Although some increase in hog production occurs, dairying remains the primary livestock enterprise.

● **With zero intraregional price differentials for milk:** With hog prices projected at $14.50 per cwt. the quantity of milk production by Michigan producers is reduced from 92.919 million cwt. (with intraregional price differentials) to 67.644 million cwt. (with a zero intraregional price differential for milk). This quantity is an increase of about 82 percent from the amount produced in 1959.

A price of $16 per cwt. for hogs as compared to $14.50 has little effect on the milk supplies from Michigan producers.

Relatively high land values, large fixed investments in dairy, and lack of good livestock alternatives make expansion of dairy profitable on most Michigan farm strata with the programming assumptions. The chief alternative on small farms is that of off-farm employment. Several smaller strata, particularly at low dairy prices, are most profitably organized with off-farm employment on a relatively "full-time" basis.

In Summary

The intraregional implications of the aggregative analysis indicate that with the assumptions of normative supply and projected demand, the equilibrium utilization of milk produced in the study area is up about 9 percent over 1959. This increase results from an increase in population, an increase in consumer income, and a lower farm level price for milk. Despite the increase in total milk utilization, total Class I utilization does not differ significantly from that of 1959.

Normative analysis of the type presented here cannot be assumed to be an accurate predictor of future changes in milk production. This is true because of nonincome considerations of producers, differences in managerial abilities of farm operators, within strata differences in degree of specialization, risk and uncertainty in farming, and so on. The general supply adjustments found in this study, however, have economic validity. Further, they set an upper bound to income-improving adjustments on study area farms within the range of alternatives considered.

Intraregional supply changes programmed to be optimal center on two adjustments:

1. An increased supply of milk from grade A milk producers generally, as their competitive position in dairying is strong relative to grade B producers. This is true even with a reduction of about one-third in the historical price premium of $0.68 per cwt. for fluid-eligible over manufacturing quality milk. On many larger and better financed grade A dairy farms, a shift from stanchion barn dairying to a large capacity, labor efficient, loose housing-milking parlor type dairy is profitable.

2. Increased beef and hog production on (a) grade B milk farms generally, and (b) some strata of grade A dairy farms located in the more productive soil areas where cash crops and livestock feeding enterprises are profitable.

The largest increase in milk production occurs in Michigan where livestock alternatives to dairy are limited. This large increase results in part from a historically "higher priced fluid milk market" than is the case for other markets within the region. Since this "higher priced" market is obviously limited, it could not absorb the magnitude of Michigan milk supplies programmed with historical intraregional milk price differential. However, a large production increase is projected for Michigan producers even with a zero intraregional price differential for milk.

A reduction in milk production in other states is indicative, at least in part, of the strong competitive position of non-dairy livestock enterprises. This is particularly true in the Corn Belt type soil areas.

Appendix

Appendix table 1. 1959 resource base of producer strata

State	Area	Stratum	Market*	Cropland	Dairy capacity†	Labor supply: Family	Labor supply: Hired	Dairy cows	Sow capacity	Sows farrowed	Weight
				acres	cows	annual hours	annual hours	in 1959	at one time	in 1959	number of farms
Minnesota	1	1	B	50	St 12	3,606	36	9	3	3	2,002
	1	2	B	53	St 23	4,417	86	16	6	4	1,334
	1	3	B	98	St 27	4,771	314	22	5	6	1,835
	2	1	B	56	St 12	3,536	14	7	5	8	2,168
	2	2	B	73	St 18	4,177	60	12	3	5	2,002
	2	3	B	80	St 25	5,144	302	16	4	5	1,668
	2	4	B	135	St 12	3,645	278	12	9	4	2,836
	2	5	B	136	St 19	3,697	29	14	7	9	3,503
	2	6	B	136	St 28	4,402	263	20	7	9	3,169
	2	7	B	252	St 14	4,485	574	12	12	12	2,502
	2	8	B	266	St 30	4,916	744	18	9	16	2,502
	3	1	B	39	St 12	3,318	0	9	3	3	2,002
	3	2	B	53	St 22	5,984	110	14	7	2	1,501
	3	3	B	100	St 16	4,367	16	14	6	8	2,335
	3	4	B	102	St 22	5,304	35	18	7	5	1,835
	3	5	B	114	St 28	5,106	47	18	7	9	2,168
	3	6	B	196	St 25	5,645	78	24	16	12	1,501
	4	1	B	96	St 20	3,974	30	17	9	13	2,836
	4	2	B	164	St 26	4,313	277	23	16	12	3,836
	4	3	B	263	St 28	7,336	1,897	25	16	15	4,170
	Mixed‡	1	O	143	0	2,700	297	0	5	5	5,338
	Mixed‡	2	A	229	Lh 41	5,215	1,760	41	6	6	1,168
	Mixed‡	3	A	93	St 24	5,049	430	19	5	5	3,169
	Mixed‡	4	A	200	St 37	5,064	1,124	32	6	5	2,335

* Market A = eligible for fluid use; Market B = eligible for manufacturing uses only; O = no market currently. In programming the "no milk market farms," Illinois and Michigan strata were given a fluid-eligible milk market alternative; Iowa, Minnesota, and Wisconsin strata were given a manufacturing milk market alternative.

† St = stanchion; Lh = loose housing.

‡ Includes farms from more than one area.

Appendix table 1 (continued)

State	Area	Stratum	Market*	Cropland	Dairy capacity†	Labor supply: Family	Labor supply: Hired	Dairy cows	Sow capacity	Sows farrowed	Weight
				acres	cows	annual hours		in 1959	at one time	in 1959	number of farms
Iowa	5	1	A	172.8	St 41	4,935	599	31	20	13	1,363
	5	2	O	72.5	0	2,734	1,029	0	17	9	1,874
	5	3	O	189.8	0	3,120	1,278	0	21	22	2,214
	5	4	B	90.5	St 16	3,797	446	14	14	12	6,472
	5	5	B	214.8	St 21	4,572	729	18	22	23	5,621
	6	1	A	272.1	St 40	6,071	488	35	16	14	411
	6	2	O	75.8	0	2,084	953	0	7	7	616
	6	3	O	234.7	0	3,819	923	0	29	15	1,439
	6	4	B	96.8	St 18	3,747	368	11	12	11	4,729
	6	5	B	196.8	St 19	4,375	378	13	16	15	3,392
Wisconsin	7	1,111	A	65	St 24	5,209	43	20	1	1	1,185
	7	1,122	A	103	St 30	5,364	268	24	3	4	2,814
	7	1,133	A	178	St 40	6,225	227	33	10	11	2,962
	7	1,214	B	53	St 17	4,710	60	14	4	3	7,259
	7	1,215	B	66	St 31	4,337	62	22	5	1	1,777
	7	1,226	B	102	St 21	5,221	115	16	6	7	3,852
	7	1,227	B	102	St 32	5,929	222	24	8	11	4,296
	7	1,238	B	205	St 20	5,087	110	15	13	15	1,481
	7	1,239	B	180	St 37	5,831	170	29	10	13	2,814
	8	2,111	A	59	St 24	4,941	33	18	3	1	1,654
	8	2,122	A	102	St 22	5,320	194	21	3	4	2,206
	8	2,123	A	103	St 32	5,137	71	28	3	3	3,860
	8	2,134	A	205	St 40	4,922	206	34	5	5	5,333
	8	2,215	B	57	St 18	4,200	50	12	1	1	5,882
	8	2,226	B	98	St 21	5,793	8	17	4	6	4,963
	8	2,227	B	104	St 33	5,248	207	24	4	7	2,022
	8	2,239	B	177	St 32	5,810	143	29	9	11	3,309

* Market A = eligible for fluid use; Market B = eligible for manufacturing uses only; O = no market currently. In programming the "no milk market farms," Illinois and Michigan strata were given a fluid-eligible milk market alternative; Iowa, Minnesota, and Wisconsin strata were given a manufacturing milk market alternative.

† St = stanchion; Lh = loose housing.

Appendix table 1 (continued)

State	Area	Stratum	Market*	Cropland	Dairy capacity†	Labor supply: Family	Labor supply: Hired	Dairy cows	Sow capacity	Sows farrowed	Weight
				acres	cows	annual hours		in 1959	at one time	in 1959	number of farms
Illinois	9	6	O	280	0	5,972	141	0	22	148	2,294
	9	5	O	119	0	3,317	24	0	15	28	1,682
	9	4	A	269	St 51	8,894	177	44	11	26	1,071
	9	3	A	242	St 23	6,013	83	20	11	104	765
	9	2	A	147	St 37	6,188	23	30	11	23	688
	9	1	A	110	St 24	4,935	190	19	11	19	994
Michigan	10	A	O	90	0	3,187	562	0	0	0	1,530
	10	B	O	88	0	3,187	0	0	10	10	765
	10	C	A	125	St 14	3,187	0	10	0	0	2,733
	10	D	A	167	St 15	3,187	361	11	11	11	1,749
	11	A	O	132	0	3,187	0	0	0	0	1,980
	11	B	O	93	0	3,187	0	0	9	9	1,733
	11	C	A	67	St 14	3,187	0	7	0	0	2,476
	11	D	A	150	St 23	3,187	0	16	0	0	2,599
	11	E	A	125	St 6	3,187	0	12	7	7	2,599
	12	A	O	55	0	4,536	713	0	1	1	1,539
	12	B	B	90	St 10	3,187	0	2	0	0	495
	12	C	A	88	St 11	4,536	3,696	2	4	4	550
	12	D	A	65	St 16	3,187	0	13	0	0	220
	12	E	A	161	St 31	4,536	1,128	26	0	0	386
	12	F	A	285	St 24	3,187	0	27	0	0	495
	13	A	A	118	0	3,187	1,255	0	0	0	2,541
	13	B	A	69	St 16	3,187	0	8	0	0	2,445
	13	C	A	160	St 21	4,536	0	19	0	0	3,002
	13	D	A	169	St 16	3,187	0	14	10	10	1,155
	14	A	A	146	0	3,187	0	0	1	1	1,003
	14	B	A	62	St 14	4,536	0	10	0	0	3,295
	14	C	A	177	St 19	3,187	0	19	0	0	3,868
	14	D	A	182	St 17	3,187	0	13	5	5	716

* Market A = eligible for fluid use; Market B = eligible for manufacturing uses only; O = no market currently. In programming the "no milk market farms," Illinois and Michigan strata were given a fluid-eligible milk market alternative; Iowa, Minnesota, and Wisconsin strata were given a manufacturing milk market alternative.

† St = stanchion; Lh = loose housing.

Appendix table 2. Calculations for determining percentage of fluid-eligible milk in fluid utilization (markets supplied by study area producers)

Federal order market	1959 total milk	1959 fluid utilization	Total fluid utilization
	cwt.	percent	cwt.
Muskegon	787,200	79	621,890
Detroit	13,029,350	64	8,338,780
Northeast Wisconsin	2,758,030	75	2,068,520
Milwaukee	4,705,350	79	3,717,230
Rockford-Freeport	460,800	86	396,290
Chicago (70 percent)*	16,767,440	54	9,054,418
Minneapolis-St. Paul	5,824,020	68	3,960,330
North-central Iowa	1,857,060	88	1,634,210
Dubuque	292,420	58	169,600
Cedar Rapids-Iowa City	1,588,620	84	1,334,440
Total	48,070,290		31,295,708
		Percent of total	65.104

* Estimated percentage of total fluid-eligible milk in Chicago market supplied by study area producers.
Source: Supplement for 1959 to Federal Milk Order Market Statistics.

Appendix table 3. Supplies of milk that would be optimal at alternative prices (by states)

		Minnesota		Iowa		Wisconsin		Illinois	Michigan
Price of all hogs	Price of all milk	Supply of fluid-eligible milk	Supply of manufac-turing qual-ity milk	Supply of fluid-eligible milk	Supply of manufac-turing qual-ity milk	Supply of fluid-eligible milk	Supply of manufac-turing qual-ity milk	Supply of fluid-eligible milk	Supply of fluid-eligible milk
U. S. average		cwt.							
$11.50	$3.20	16,965,925	....	7,699,705	....	35,821,287	67,272,765	....	65,871,960
11.50	3.60	20,621,544	39,303,274	9,837,569	13,866,250	48,369,581	76,924,870	....	97,050,620
11.50	4.00	24,778,362	51,090,559	13,889,705	24,080,979	64,655,262	91,807,410	2,095,800	144,534,277
11.50	4.40	27,936,371	69,762,460	13,889,705	40,350,819	70,260,948	107,019,718	5,590,000	151,809,404
11.50	4.80	28,796,837	121,585,021	13,957,855	104,949,635	72,669,099	114,458,943	17,963,500	154,048,783
11.50	5.20	28,895,380	161,215,843	13,957,855	117,836,581	84,077,099	134,180,524	29,809,500	155,593,189
13.00	3.20	16,965,925	....	7,699,705	....	34,788,073	66,243,126	....	65,871,960
13.00	3.60	20,621,544	39,303,274	9,837,569	13,866,250	48,643,172	76,685,166	....	97,050,620
13.00	4.00	24,777,836	51,098,892	13,889,705	24,080,979	64,936,224	90,478,067	2,095,800	144,534,277
13.00	4.40	27,936,371	69,762,074	13,889,705	40,350,819	71,303,311	99,696,917	5,590,000	151,809,404
13.00	4.80	28,796,837	121,585,019	13,957,855	104,949,635	72,928,130	114,501,069	18,911,600	154,048,783
13.00	5.20	28,895,380	161,215,843	13,957,855	117,836,581	84,819,102	135,238,497	29,809,500	155,593,189
14.50	3.20	16,965,925	....	7,699,705	....	35,255,574	65,760,001	....	65,871,960
14.50	3.60	20,621,544	37,232,900	9,837,569	6,722,716	46,922,637	76,589,887	....	97,050,620
14.50	4.00	24,778,362	48,127,377	13,889,705	18,786,036	64,317,869	90,435,261	2,095,800	144,534,277
14.50	4.40	27,936,371	69,638,417	13,889,705	40,350,819	69,793,856	106,912,931	7,647,300	151,809,404
14.50	4.80	28,796,837	104,060,865	13,957,855	104,949,635	73,120,855	119,667,515	19,186,900	154,048,783
14.50	5.20	28,895,380	161,223,976	13,957,855	117,836,581	83,731,870	135,155,239	34,052,700	155,593,189

Appendix table 3 (continued)

		Minnesota		Iowa		Wisconsin		Illinois	Michigan
Price of all hogs	Price of all milk	Supply of fluid-eligible milk	Supply of manufacturing quality milk	Supply of fluid-eligible milk	Supply of manufacturing quality milk	Supply of fluid-eligible milk	Supply of manufacturing quality milk	Supply of fluid-eligible milk	Supply of fluid-eligible milk
..........U. S. average..........		....		....	...... cwt.	....			
$16.00	$3.20	16,445,309	....	6,426,427	....	35,990,208	64,891,205	....	65,440,146
16.00	3.60	20,621,544	32,683,125	7,779,439	....	52,713,243	75,356,446	....	96,787,834
16.00	4.00	25,154,815	43,752,230	10,212,394	9,090,270	62,189,020	87,600,388	1,299,800	144,775,469
16.00	4.40	28,287,448	67,782,790	13,889,705	41,255,800	68,694,284	103,215,634	8,251,300	151,636,751
16.00	4.80	29,194,388	119,419,010	13,957,855	69,623,924	78,238,478	116,464,299	11,647,300	154,030,783
16.00	5.20	29,334,460	162,309,665	13,957,855	113,087,597	84,905,037	134,383,247	34,213,200	155,714,499
17.50	3.20	10,100,507	....	300,441	....	33,405,638	68,146,057	....	63,479,290
17.50	3.60	12,269,367	39,629,860	6,421,084	....	40,483,542	75,336,369	....	95,657,913
17.50	4.00	24,719,715	46,038,350	7,488,040	3,816,000	43,345,205	78,956,403	....	143,949,220
17.50	4.40	26,369,337	60,811,278	10,311,893	11,471,824	54,685,879	97,408,950	....	149,343,878
17.50	4.80	27,719,520	80,763,963	13,763,863	44,196,351	69,182,971	107,055,553	11,433,100	151,827,321
17.50	5.20	28,885,099	139,727,543	13,908,946	60,289,315	74,689,246	116,904,432	33,647,100	153,634,932
19.00	3.20	6,214,339	....	....	....	30,710,930	58,749,338	....	9,084,306
19.00	3.60	10,305,202	33,989,737	295,920	....	33,662,454	66,399,779	....	84,907,097
19.00	4.00	10,305,202	37,812,390	5,468,456	....	38,909,012	74,969,451	....	94,818,903
19.00	4.40	20,450,939	49,997,299	7,542,703	3,056,192	43,759,448	79,389,185	....	149,712,934
19.00	4.80	25,417,895	61,895,310	9,499,545	9,957,036	51,922,390	93,725,275	....	154,160,078
19.00	5.20	26,439,252	81,407,907	13,720,297	27,467,802	54,144,322	103,927,515	12,511,400	157,136,269

Appendix table 4. Supplies of fluid-eligible milk that are optimal at alternative prices with zero intraregional price differentials (by states)

U. S. price of all hogs	Price of fluid-eligible milk*	Supply of fluid-eligible milk				
		Illinois	Minnesota	Wisconsin	Michigan	Iowa
...per cwt...		...cwt...				
$14.50	$3.20	....	19,707,639	64,317,869	61,195,161	7,699,705
14.50	3.30	....	20,621,544	65,686,866	68,989,826	8,234,171
14.50	3.40	....	21,660,748	67,055,863	76,784,491	8,768,637
14.50	3.50	....	22,699,952	68,424,860	84,579,156	9,303,103
14.50	3.60	529,189	23,739,156	69,793,856	92,373,821	9,837,569
14.50	3.70	1,058,379	24,778,362	70,625,606	101,798,986	10,850,603
16.00	3.20	....	19,577,485	62,189,020	57,918,014	6,426,427
16.00	3.30	....	20,621,544	63,815,336	65,754,937	6,764,680
16.00	3.40	....	21,754,862	65,441,652	73,591,860	7,102,933
16.00	3.50	....	22,888,180	67,067,968	81,428,783	7,441,186
16.00	3.60	324,950	24,021,498	68,694,284	89,265,706	7,779,439
16.00	3.70	649,900	25,154,815	71,080,333	101,262,615	8,387,678

* Quantity weighted Lake States price.

Appendix table 5. Supplies of manufacturing grade milk that are optimal at alternative prices with zero intraregional price differentials (by states)

U. S. price of all hogs	Price of manufacturing grade milk*	Supply of manufacturing grade milk		
		Wisconsin	Minnesota	Iowa
...per cwt...		...cwt...		
$14.50	$2.60	76,589,887	39,956,519	6,722,716
14.50	2.70	80,051,231	42,680,139	9,738,546
14.50	2.80	83,512,574	45,403,758	12,754,376
14.50	2.90	86,973,918	48,127,377	15,770,206
14.50	3.00	90,435,261	53,505,137	18,786,036
14.50	3.10	94,554,679	58,882,897	24,177,232
16.00	2.60	75,356,446	29,246,682	....
16.00	2.70	78,417,432	34,081,864	2,272,568
16.00	2.80	81,478,418	38,917,046	4,545,136
16.00	2.90	84,539,404	43,752,230	6,817,704
16.00	3.00	87,600,388	49,759,870	9,090,270
16.00	3.10	91,504,200	55,767,510	17,131,653

* Quantity weighted Lake States price.

Appendix table 6. Corn purchases or sales in optimum farm plans (with varying prices for milk and hogs)

Price of hogs	Price of all milk	Minnesota Corn purchases(+) or sales(—)	Michigan Corn purchases(+) or sales(—)	Iowa Corn purchases(+) or sales(—)	Illinois Corn purchases(+) or sales(—)	Wisconsin Corn purchases(+) or sales(—)	Lake States Corn purchases(+) or sales(—)
U. S. average		bushels					
$11.50	$3.20	+ 9,995,545	— 6,762,878	—70,488,830	+18,876,418	+189,464,550	+141,084,805
11.50	3.60	+ 7,886,889	— 5,453,950	+ 2,956,464	+18,876,418	+188,588,120	+212,853,941
11.50	4.00	+ 8,367,226	— 6,043,061	+ 5,471,138	+18,164,609	+213,779,785	+239,739,697
11.50	4.40	+ 5,662,877	— 5,334,845	+ 5,471,138	+13,150,809	+223,778,269	+242,728,248
11.50	4.80	+ 6,641,486	— 3,671,370	+47,007,254	— 5,513,836	+231,020,429	+275,483,963
11.50	5.20	+ 6,602,491	+ 236,988	+44,959,668	—19,754,948	+212,018,617	+244,062,816
13.00	3.20	+ 12,336,979	— 7,364,633	—70,488,830	+18,876,418	+214,631,447	+167,991,381
13.00	3.60	+ 10,593,422	— 5,453,950	+ 2,956,464	+18,876,418	+218,160,733	+248,882,369
13.00	4.00	+ 11,071,853	— 6,043,061	+ 5,471,138	+18,164,609	+240,851,959	+241,342,051
13.00	4.40	+ 8,342,578	— 5,334,845	+ 5,471,138	+13,150,809	+250,767,546	+272,397,226
13.00	4.80	+ 9,346,315	— 3,671,370	+47,007,254	— 5,432,652	+255,650,046	+301,879,475
13.00	5.20	+ 9,306,392	+ 236,988	+44,959,668	—17,049,781	+234,394,964	+305,473,817
14.50	3.20	+ 13,150,364	— 6,657,998	—42,132,656	+20,144,646	+216,007,976	+200,512,350
14.50	3.60	+ 11,060,240	— 5,176,975	+ 3,578,624	+20,144,646	+216,381,509	+245,988,044
14.50	4.00	+ 11,551,219	— 5,766,086	+ 8,136,226	+19,432,837	+239,557,581	+272,911,777
14.50	4.40	+ 8,495,900	— 4,627,870	+ 6,093,298	+12,918,998	+259,816,189	+282,696,515
14.50	4.80	+ 9,477,852	— 3,394,395	+47,007,254	— 3,475,488	+239,105,010	+288,720,233
14.50	5.20	+ 9,437,478	+ 513,963	+44,959,668	—18,311,305	+237,483,317	+274,083,121

Appendix table 6 (continued)

Price of hogs	Price of all milk	Minnesota Corn purchases(+) or sales(—)	Michigan Corn purchases(+) or sales(—)	Iowa Corn purchases(+) or sales(—)	Illinois Corn purchases(+) or sales(—)	Wisconsin Corn purchases(+) or sales(—)	Lake States Corn purchases(+) or sales(—)
...U. S. average...		...bushels...					
$16.00	$3.20	+ 13,726,996	— 3,731,881	+33,458,808	+19,339,204	+274,687,247	+337,480,374
16.00	3.60	+179,909,282	— 2,523,473	+34,111,065	+19,339,204	+270,390,725	+501,226,803
16.00	4.00	+180,620,461	— 4,084,370	+35,231,606	+18,703,748	+273,807,793	+504,279,238
16.00	4.40	+139,082,258	— 4,242,810	+45,165,650	+11,809,554	+258,203,354	+450,018,006
16.00	4.80	+ 99,801,853	— 3,077,317	+50,062,810	+ 4,653,772	+244,356,476	+395,797,594
16.00	5.20	+ 56,037,078	+ 1,241,762	+49,647,400	—13,206,457	+211,008,544	+304,728,327
17.50	3.20	+ 26,132,181	+18,719,846	+38,585,205	+22,280,469	+303,640,765	+409,358,466
17.50	3.60	+216,881,852	+20,229,839	+41,844,482	+22,280,469	+301,338,880	+602,575,522
17.50	4.00	+225,269,063	+ 3,236,845	+43,650,470	+22,280,469	+308,571,515	+603,008,362
17.50	4.40	+218,928,254	+ 2,519,399	+44,401,745	+22,280,469	+312,218,361	+600,348,228
17.50	4.80	+205,880,086	+ 3,057,051	+56,004,032	+ 1,625,576	+286,945,639	+553,512,384
17.50	5.20	+125,653,148	+ 4,238,890	+61,653,474	—15,170,446	+263,226,025	+439,601,091
19.00	3.20	+ 28,462,664	+64,994,038	+43,382,975	+24,374,256	+347,706,035	+508,919,968
19.00	3.60	+253,782,399	+27,902,062	+43,460,243	+24,374,256	+357,490,603	+707,009,563
19.00	4.00	+256,314,804	+27,222,699	+46,627,356	+24,374,256	+360,209,616	+714,748,731
19.00	4.40	+257,672,275	+ 3,654,553	+47,748,684	+24,374,256	+356,031,877	+689,481,627
19.00	4.80	+249,456,097	+ 3,666,103	+49,511,563	+24,374,256	+359,057,659	+686,065,678
19.00	5.20	+239,927,907	+ 7,184,082	+56,773,312	+ 2,281,754	+359,877,023	+666,044,078

Appendix table 7. Percent change in population of Lake States and United States: 1959-65*

Year	Michigan	Minnesota	Wisconsin	Chicago metropolitan area	Iowa	Lake States study area†	United States
	in thousands						
1950	6,421	2,995	3,449	5,184	2,621	19,360	152,271
1955	7,248	3,118	3,666	5,703	2,684	21,077	165,931
1959	7,753	3,378	3,915	6,118	2,745	22,537	177,830
1965 Lake States	8,400	3,700	4,250	6,740	2,830	24,505	
1965 United States (Series II)							196,217
	percent change 1959-65						
Lake States	+8.3	+9.5	+8.6	+10.2	+3.1	+8.73	
United States							+10.34

* The 1950-59 data for the Lake States is from *The Statistical Abstract of the United States, 1961*, Department of Commerce, Washington, D.C., 1962, p. 10. U. S. data for 1950-59 is found in *Current Population Reports, Series P-25*, Bureau of Census, Washington, D.C., 1962, No. 256. The U. S. 1965 projection may be found in *Current Population Reports, Series P-25*, Bureau of Census, Washington, D.C., 1962, No. 251. This is the series II projection which assumes 1955-57 fertility levels. This presently appears to be about the fertility level most probable to prevail over the 1959-65 period. The individual state projections were constructed by the author. Hawaii and Alaska are included in all U. S. figures.

† This Lakes States aggregate is composed of Michigan, Minnesota, Wisconsin, and the Chicago metropolitan area populations, plus one-half of the Iowa population. This index of the Lake States study area population was arrived at after considerable experimentation with various approaches, including a selected county aggregate for Iowa and Illinois where either small portions of the market or the state milk supply were involved in the study area.

Appendix table 8. Data for estimation of change in tastes: 1959-65*

Item		Per capita disposable income X_1	Retail price fluid milk X_2	Per capita fluid milk consumption X_3	Retail price manufacturing milk X_4	Per capita manufacturing milk consumption X_5	Elasticities†
1956	a)	$1,890 (trend)	24.2¢/qt.	350 pounds	....	353 pounds	
1961	b)	$2,010 (trend)	26.2¢/qt.	314 pounds	....	326 pounds	
1956-61 change	c)	$ 120	+2¢	—36 pounds	....	—27 pounds	
Percent change	d)	+6.35	+8.26	—10.29	+5.08‡	—7.65	
Fluid milk							
Price (e_F)							—0.285
Income (η_F)							+0.06
Manufacturing milk							
Price (e_M)							—0.713
Income (η_M)							+0.26

* Source: *Economic Report of the President,* Council of Economic Advisers, Washington, D.C., 1963, p. 191. *Dairy Situation,* DS 292, USDA, November 1962. *Dairy Statistics Through 1960,* Stat. Bull. 303, USDA, pp. 319-22.

† George E. Brandow, *Interrelations Among Demands for Farm Products and Implications for Control of Market Supply,* Agr. Expt. Sta. Bull. 680, Pennsylvania State University, August 1961, pp. 17, 24.

‡ Estimated from USDA published retail prices of butter, cheese, evaporated milk, and ice cream. For the quantity weights used in aggregating see Brandow, *op. cit.,* p. 117.

Appendix table 9. Estimation of change in tastes: 1959-65*

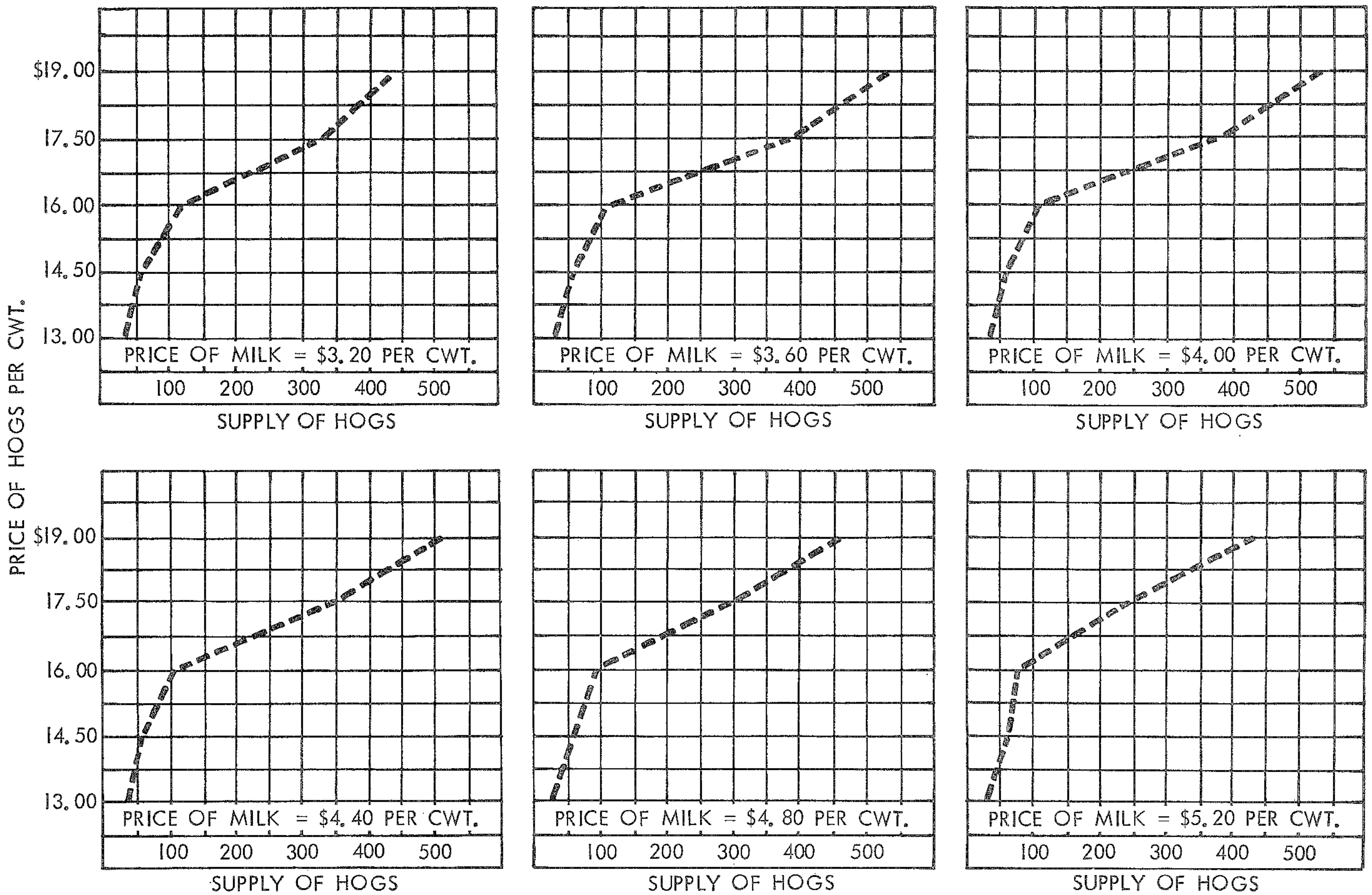
1) Fluid milk consumption trend adjusted for price and income effects

Total fluid consumption change, 1956-61 = X_{3c} =	−36.00	pounds
Income effect = (X_{1d}) (η_F) (X_{3a}) = (6.35) (0.06) (350) =	1.33	pounds
Price effect = (X_{2d}) (e_F) (X_{3a}) = (8.26) (−0.285) (350) =	− 8.24	pounds
Net taste trend =	−29.09	pounds
Annual taste trend 1956-61 = 29.09 ÷ 5 years =	− 5.82	pounds
Annual percentage taste trend = 5.82 ÷ 350 =	− 1.66	percent
Thus, 1959-65 taste shifter = $1-(100 - 1.66)^6$ =	− 9.56	percent

2) Manufacturing milk consumption trend adjusted for price and income effects

Total manufacturing milk consumption change, 1956-61 = X_{5c} =	−27.00	pounds
Income effect = (X_{1d}) (η_M) (X_{5a}) = (6.35) (0.26) (353) =	5.83	pounds
Price effect = (X_{4d}) (e_M) (X_{5a}) = (5.08) (−0.713) (353) =	−12.79	pounds
Net taste trend =	−20.04	pounds
Annual taste trend 1956-61 = 20.04 ÷ 5 =	− 4.00	pounds
Annual percentage taste trend = 4.00 ÷ 353 =	− 1.135	percent
Thus, 1959-65 taste shifter = $1-(100 - 1.135)^6$ =	− 6.62	percent

* Notations and data used are from appendix table 8.



Appendix figure 1. Normative supply of hogs with milk at alternative prices, million cwt.

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