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# STRUCTURAL CHANGES

In The North Dakota

# DAIRY INDUSTRY

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# STRUCTURAL CHANGES IN THE NORTH DAKOTA DAIRY INDUSTRY

Jerome W. Hammond and Rex W. Cox

North Dakota's dairy industry has experienced rapid and significant changes in recent years. Farm separated cream as a proportion of total milk marketings has dropped very substantially. Cream stations, which numbered well over 1,000 at one time, are now down to slightly over 200. The total number of dairy processing plants and firms declined from 111 in 1940 to 88 in 1962. Butter centralizers are doing one of two things, changing their methods of assembly or ceasing operations.

A dozen cheese plants have started operations since 1960. Prior to that time no cheese production was recorded in North Dakota. Total production of natural cheese, cottage cheese and frozen products has shown large growth. Production per plant for each of these products has increased.

These developments have significant implications for the type of competitive behavior and performance of the industry. Also, they may indicate future adjustments in the industry. This study is designed to investigate these developments and to make some projections for the kind of dairy industry which may be expected in the future.

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The authors are indebted to managers of North Dakota dairy plants who cooperated in providing data used in this study.

## Nature of the Study

The foregoing attributes of an industry are often studied under the method referred to as industrial organization. The student of industrial organization considers them because of the asserted casual relationships which exist between industry structure, market conduct and market performance. The causal relationship is asserted to run from structure to conduct to performance, although there may be feedbacks which will be noted.

The findings and conclusions of market structure analysis are most useful with respect to broad industry problems. For industry personnel, such analysis might determine what programs the industry should undertake to alter competitive conditions or eliminate general problems. The information is useful to legislative groups in deciding on programs to facilitate needed structural change in the industry. Regulatory agencies find the data useful in defining market areas and in deciding what important competitive abuses might need controls.

Although primarily policy oriented, the findings and conclusions of market structure analysis are not limited to this area. Management of the individual firms may find the results of significant value. They may be of use in long-run planning. For example, management may decide on the basis of current changes

in structure of the dairy processing industry that a plant of a size and type which will maximize long-run returns of the firm is needed rather than a plant which will maximize short-run returns.

This study was undertaken to point out some of the major organizational changes that the industry is undergoing and is likely to face. Another purpose was to determine what a continuation of these changes means for the industry and for the economy of the state.

The specific objectives of this study are:

1. To describe briefly the historical development of the dairy industry in this state.
2. To measure some of the recent changes in the industry structure.
3. To determine some of the major causes for these structural changes.
4. To make some projections as to future characteristics of the state's industry.

## HISTORICAL PERSPECTIVE

The development of the North Dakota dairy industry has been well documented.<sup>1</sup> This section is a brief review of the historical development which can be divided into three periods. The first was the period of farm produced butter and the marketing of excess butter

## Sources of Data

North Dakota Crop and Livestock Reporting Service, Fargo, North Dakota, provided much of the statistical data for this study. Some were from its periodic reports and publications. Other data were obtained through special efforts of the Reporting Service.

Data on number of dairy plants, plant production and changes in plant numbers were provided by the Office of the State Dairy Commissioner.

The field survey method was used to obtain data on the individual firms. Managers or owners of 10 cheese firms in operation in the summer of 1963 were interviewed, and a questionnaire was completed on each. A random sample of cream stations licensed for cream receiving in 1963 was selected for study. Managers or cream testers for 33 of these stations were interviewed. Discussions with many other industry personnel provided much information on the dairy industry in the state.

through the local store.

The second period extending from about 1910 to 1950 was characterized by a shift from farm produced to creamery butter; the development of cream stations, creameries and butter centralizers. The shift received impetus from the introduction of the cream separator.

The low density of milk production in North Dakota was undoubtedly one of the main causal factors for the type of dairy industry that developed during the second

<sup>1</sup>Benton, Alva H., **Marketing Dairy Products**, Bulletin 182, Agricultural Experiment Station, North Dakota Agricultural College, Fargo, North Dakota, October, 1924; Anderson, Harry G., and Alva H. Benton, **Cooperative Marketing of Dairy Products**, Bulletin 238, Agricultural Experiment Station, North Dakota Agricultural College, Fargo, North Dakota, September, 1930; and Fourn, L. A., and G. A. Kristjanson, **North Dakota's Dairy Marketing Problems in Historical Perspective**, Bulletin 393, Agricultural Experiment Station, North Dakota Agricultural College, Fargo, North Dakota, June, 1954.

period. It meant that creameries with only local assembly were not able to assemble volumes of cream sufficient for economic operations. The result was the large centralizer creamery which assembled cream through cream stations. Some of the latter were independent, but many were owned by Swift, Fairmont, Beatrice, or Armour.

The type of dairy industry that developed in North Dakota can be contrasted with that which developed in Minnesota. The centralizer did not gain such a dominant position in the industry as in North Dakota. Milk production in that state at the beginning of the period was sufficient within a five to six mile radius to support a creamery. The development of the motor car and truck enabled creameries to serve areas with a radius of 15 to 20 miles. This led to a downtrend in creamery numbers as early as 1920.<sup>2</sup> This downtrend still continues.

The development of the motor truck and car did not cause a decrease in creamery numbers in North Dakota. On the contrary, it expanded assembly areas for a creamery to the extent that more local creameries were able to operate where only centralizer cream stations could operate previously. Thus, the number of North Dakota creameries continued to increase until the late 1940's (Table 1).

According to the state's Dairy Commissioner Report, the number of creameries reached a high of 111 in 1948 and 1950. Centralizers had begun to decrease in importance in terms of number at a much earlier date. There were 27 in 1934,

and their number, which has been decreasing since that time, dropped to 8 in 1963.

**Table 1. Number of Cream Stations and Creameries in North Dakota, 1934-1963\*.**

Date	Cream stations	Independent creameries	Co-operative creameries	Centralizer creameries	Total creameries
1934	—	50	23	27	100
1936	—	57	26	23	106
1938	1,025	59	26	23	108
1940	989	66	26	19	111
1942	865	66	27	16	109
1944	802	60	31	14	105
1946	650	57	30	14	101
1948	642	65	32	14	111
1950	596	65	32	14	111
1952	478	63	30	14	107
1954	393	58	30	12	100
1956	374	58	30	12	100
1958	306	59	32	12	103
1960	—	—	—	—	—
1961	—	—	—	—	—
1962	234	55	22	8	85
1963	227	67	25	8	100

\* All dairy processing plants in North Dakota are reported as creameries by the Dairy Division whether butter or another product is manufactured. Several cheese factories are included with the creameries. Most of the plants included make some butter although another product may be considered primary.

Although local creamery numbers increased in the state until after World War II, many creameries were at a disadvantage compared with the centralizer in the marketing of butter. Some attempted to overcome this difficulty by joining cooperative marketing organizations such as Land O' Lakes. Others sold directly to the centralizers. In fact, this increase in direct sales to centralizers has been proposed as the reason for the decline in the ratio of centralizer output to total output and the increase in the number of local creameries.<sup>3</sup> Apparently, the superior bargaining position of the centralizer enabled it to purchase butter from local creameries at a price equal

<sup>2</sup> Fourt, L. A., and G. A. Kristjanson, op. cit., pp. 10-15.

<sup>3</sup> Vatter, Harold G., *Small Enterprise and Oligopoly*, Oregon State College, Oregon State College Press, Corvallis, 1955, p. 29.



to or lower than its own costs of production.

The establishment of multi-product dairy plants occurred during the second period. It was found that production of byproducts from whole milk, in addition to the butter, could substantially increase returns from milk.<sup>4</sup> Multi-product plants were quickly developed in the high milk producing states of Minnesota and Wisconsin. The national dairy concerns in the 30's had made the shift to other products because of the decreased earnings from butter. This was another factor which contributed to the decreasing importance of the centralizer beginning in the 30's. The companies themselves were de-emphasizing butter production, buying butter from local creameries, and concentrating on higher value products.

## MILK PRODUCTION AND UTILIZATION IN NORTH DAKOTA

### Characteristics of Farm Production

The characteristics of milk production and utilization in North Dakota are useful in explaining certain characteristics of the processing industry. Total milk production has decreased since the early 1940's (Appendix II, table 1). It reached a high of 2.3 billion pounds of milk in 1942 and decreased to about 1.7 billion pounds in 1950. Total production remained near 1.7 billion pounds from 1950 through 1962. National milk production increased from 109 billion pounds in 1940 to 126 billion pounds in 1962, a change of 20 per cent. North Dakota milk production has not kept pace with production throughout the nation.

Total quantity of milk marketed has remained relatively stable. It

The second period may be summarized thusly: The industry operated on the edge of the intensive manufacturing milk and fluid milk areas. The centralizers decreased in importance as handlers of butter and concentrated in the area of whole milk processing. The local creameries assumed a more important role in butter making in North Dakota in contrast to their disappearing role in other states.

The third period (approximately 1950 to the present) in the development of the North Dakota dairy industry has been characterized by the exit of many dairy plants, particularly those processing butter; the decline in number of cream stations, and the increase in whole milk processing plants. An analysis of some of the more important aspects of the third period is the main topic of this study.

reached a high of 1.8 billion pounds of milk equivalent in 1942, but remained generally at the 1.4 to 1.6 billion pound level throughout the 40's and 50's.

The number of milk cows decreased from 484,000 in 1940 to 289,000 in 1959, a drop of 40 per cent (Appendix II, table 2). Total milk production, however, decreased only 10 per cent because of increased milk production per cow. Annual production per cow averaged 4,300 pounds in 1940, and 6,580 pounds in 1962. During World War II milk production per cow decreased some, but this was likely the result of high milk prices and subsidies which brought a large number of nondairy type cows into milk production.

The total number of farms reporting milk cows has decreased

<sup>4</sup> Ibid. p. 30.

(Appendix II, table 3). In 1940, 84 per cent of all farms in the state reported dairy cows compared with only 55 per cent in 1959. Average milk production per reporting farm increased from 33,513 pounds annually in 1940 to 57,639 pounds in 1959. These changes are similar to the developments in most other states.

As late as 1955 more than 90 per cent of all milk marketed by farmers in North Dakota was in the form of farm separated cream (Appendix II, table 4). The preliminary estimate for 1963 is 67 per cent.

### Characteristics of Milk Processing

Production of specified dairy products is listed in Appendix II, table 10. Butter is the most important dairy product manufactured in the state; however, it has decreased in importance. In 1962 butter production dropped although total milk production and total milk sold increased over previous years. It appears that cheese plants which started producing in the state expanded at the expense of creameries.

The increase in ice cream production has been similar to that observed throughout the nation. In 1940 North Dakota ice cream production was 1,086,000 gallons annually. Production more than doubled by 1962, amounting to 2,622,000 gallons; however, this upward trend has not been steady. Ice cream production reached a peak of 3,079,000 gallons in 1946, fell to about 2,000,000 gallons in 1950, and rose to more than 2,600,000 gallons in 1961 and 1962.

Cottage cheese production, both curd and cream, has expanded sub-

stantially since 1940.<sup>5</sup> Production of cottage cheese curd and creamed cottage cheese in 1962 was about five and six times, respectively, that in 1946 (Appendix II, table 5). This expanded production was in response to increased demand resulting from both increased population and increased per capita consumption of cottage cheese from 2.5 pounds in 1946 to 4.6 pounds in 1962.<sup>6</sup> During the same period natural production of cottage cheese curd increased about two and one half times, and creamed cottage cheese, about three and one half times. It is evident that North Dakota firms have more than maintained their share of an expanding cottage cheese market.

American cheese production has made the largest gains in production in recent years. Prior to 1960 there was no reported American cheese production in North Dakota. The first cheese plant was built in 1959. Since then 12 cheese plants have begun operations. Of this number, 10 were dairy firms new to the industry. Two had been in the production of butter and other dairy products prior to their beginning of cheese production. Four cheese plants produced 813,000 pounds of cheese in 1960. Ten plants produced 10,437,000 pounds in 1962.

### Innovation and Technological Environment

Although market performance is determined by market structure and conduct, there may be certain limitations to the relations which

<sup>5</sup> Curd and creamed cottage cheese production cannot be added together to get total production because some curd may be creamed in the same plant, while some is sold to another plant which does the creaming.

<sup>6</sup> U. S. Department of Agriculture, "Dairy Statistics Through 1960" and Supplement, op. cit., p. 380.

might be expected. These limitations are considered as industry environment.<sup>7</sup> They are classified as physical, technological and institutional environment. In market studies where these environmental characteristics remain unchanged, only limited consideration of them is necessary. For example, physical environment involves a consideration of the geographical characteristics of a market area such as terrain and resources (natural and human). These characteristics are relatively constant for most industry or market studies.

Technological environment is not static. On the contrary, it is one of the more dynamic aspects of the economy. Thus, a change in this aspect of environment may be a very important factor affecting change in market structure and behavior and ultimately in industry performance. Described in this section are some of the major technological changes or innovations in dairy processing and marketing. No doubt, some of these changes can be related to changes in the structure of the North Dakota industry.

The adoption of the paper carton for fluid milk products was one of the most significant developments during the 1950's. It was developed prior to the 50's, but a large part of its introduction into the industry occurred during the 50's.

One of the significant results of the paper milk carton has been its role in expanding fluid milk distribution areas for fluid milk plants. One investigation concluded that the main overall effects of the innovation are increased competi-

tion geographically during a period of decreasing number of firms and centralization of the bottling and distribution function.<sup>8</sup> Another study arrived at the same conclusion.<sup>9</sup> It stated that paper containers have increased overlapping of fluid milk markets.

Separate and distinct milk markets which once existed for bottled milk in many areas are the exception. In 1950, three plants, Dutch Maid, Knerr Dairy and Cass-Clay Cooperative confined their distribution to the Fargo, North Dakota, market only. Since that time Dutch Maid was purchased by the Fergus Dairy in Fergus Falls, Minnesota. Milk is now packaged at Fergus Falls for distribution to Fargo-Moorhead and other locations. Land O' Lakes purchased Knerr Dairy and packages milk at Grand Forks, Crookston and Thief River Falls. These plants not only serve the local territory but also Devils Lake and several other North Dakota markets.

The paper package for milk has been a major factor altering the structure of the market. It has broken down the local nature of milk production. It has decreased the need for large numbers of bottling operations and, thus, enabled firms to attain significant economies in the packaging of milk. Merger and exit of firms are methods by which these changes are brought about.

Bulk gathering of milk is an innovation which has affected milk

<sup>8</sup> Cook, Hugh L., *Paper Packaged Milk in Wisconsin, Its Part in Expanding Distribution Areas*, Research Bulletin 179, University of Wisconsin, Madison, Wisconsin, June, 1953, p. 46.

<sup>9</sup> *Outer Market Distribution of Milk in Paper Containers in the North Central Region*, North Central Regional Publication No. 39, Purdue University, Agricultural Experiment Station, Lafayette, Indiana, October, 1953.

<sup>7</sup> Bain, J. S., *Industrial Organization*, John Wiley and Sons, Incorporated, New York, New York, 1959, pp. 44-84.

assembly patterns as the paper carton has affected milk distribution. It has allowed processing plants to expand assembly areas. Thus, a decrease in dairy plants has not always meant a decrease in competition for milk supplies.

Talks with industry personnel indicate that bulk milk assembly has had an impact on the organization of North Dakota processing. One of the major limitations on plant size is milk supplies. Anything that can extend the radius of the area which a dairy plant can reach will enlarge plant size if in-plant economies of scale exist.

Bulk tank assembly of milk made large gains in the intensive dairy producing areas in the early 50's. In the past five to six years it also has made significant gains in North Dakota. Whole milk receivers have expressed their desire to switch

completely to bulk milk assembly.

Changing techniques of in-plant processing have been a factor stimulating structural and behavioral change in the industry. Among them are in-place cleaning of equipment, continuous process ice cream making, improved butter manufacturing equipment, stainless steel equipment, etc. The development and availability of this equipment have stimulated change in two different ways: (1) Much of it is very high cost and can be installed only at plants with very large volumes of product so that the fixed cost can be spread over more units. Thus, it can be said that new techniques are output increasing. (2) Some of this equipment is required for meeting quality requirements for dairy products. Those plants not intending to adopt the new equipment are eventually forced from the industry.

## STRUCTURAL CHANGE IN THE NORTH DAKOTA DAIRY INDUSTRY

### Changes in Number of Dairy Plants

The total number of dairy processing plants in North Dakota has not decreased as significantly as in other states or in the nation. For example, census reports show that the number of creameries in the United States has dropped from 1,482 in 1947 to 997 in 1958, a 33-per cent decrease.<sup>10</sup> In Wisconsin, licensed butter factories dropped from 350 to 194 during the same period, a 45-per cent decrease.<sup>11</sup> The number of North Dakota dairy processing plants changed from 105

to 90 from 1944 to 1958, a decrease of only 14.3 per cent.

Changes for the various types of plants within the total were more significant than the aggregate figures represent. The number of centralizer creameries in North Dakota decreased from 14 in 1948 to 8 in 1958 (table 1). These figures are not indicative of their real decrease in importance; Bridgeman Creameries in Grand Forks and Minot and Foremost in Mandan are listed as centralizer creameries when, in fact, they are multi-product firms with more emphasis on fluid milk and ice cream business than butter manufacture.

Several reasons have accounted for the decrease in centralizer creamery numbers: (1) The in-

<sup>10</sup> U. S. Government, *Concentration Ration in Manufacturing Industry, 1958*, report by Bureau of the Census for Subcommittee on Antitrust and Monopoly of the Committee on the Judiciary, U. S. Senate, Part I, Washington, 1962, p. 10.

<sup>11</sup> Hammond, J. W., *Financial and Market Causes for Margin in the Wisconsin Dairy Industry*, Ph.D. thesis, Department of Agricultural Economics, University of Wisconsin, 1963, p. 4.

Table 2. Proportion of the Production of Various Dairy Products Manufactured by Specified Number of Firms, North Dakota, 1940-1962.

Year	BUTTER					AMERICAN CHEESE				
	No. of Firms	Proportion of total production produced by the largest:				No. of Firms	Proportion of total production produced by the largest:			
		4	8	20	All		4	8	20	All
		per cent					per cent			
1940	105	31.0	44.4	65.3	100.0	1	100.0			
1945	103	29.1	42.6	63.1	100.0	2	100.0			
1950	104	28.6	43.7	64.0	100.0	1	100.0			
1955	95	30.8	43.7	57.5	100.0	None				
1960	82	42.8	54.6	68.0	100.0	4	100.0			
1962	77	43.9	53.2	68.9	100.0	10	63.1	97.9	100.0	
		ALL COTTAGE CHEESE					DRIED BUTTERMILK			
1940	13	68.8	92.9	100.0		10	63.3	94.2	100.0	
1945	7	94.7	100.0			15	55.8	81.2	100.0	
1950	6	93.2	100.0			15	60.2	83.3	100.0	
1955	9	94.5	99.9	100.0		14	58.3	87.1	100.0	
1960	10	94.6	99.7	100.0		13	70.2	88.6	100.0	
1962	9	93.2	99.6	100.0		14	73.7	88.8	100.0	
		ICE CREAM					SHERBET			
1940	40	42.5	64.2	90.3	100.0	33	53.6	77.9	95.6	100.0
1945	45	45.7	71.5	94.7	100.0	15	73.0	92.9	100.0	
1950	33	48.8	75.1	96.2	100.0	8	73.5	100.0		
1955	27	55.8	77.1	98.0	100.0	16	66.5	94.0	100.0	
1960	20	64.3	87.1	100.0		12	89.2	98.1	100.0	
1962	15	72.3	90.7	100.0		12	81.1	96.6	100.0	
		ICE MILK					WATER ICES			
1940	None					None				
1945	1	100.0				None				
1950	2	100.0				3	100.0			
1955	8	75.9	100.0			3	100.0			
1960	18	60.0	91.4	100.0		3	100.0			
1962	15	82.4	96.1	100.0		3	100.0			

Source: Data compiled from reports of the North Dakota Crop and Livestock Reporting Service, Fargo, North Dakota.

crease in whole milk sales by farmers and the rise in the relative importance of local creameries caused centralizer volume to drop to levels below those needed for efficient operation. (2) The large dairy companies needed more butter than their centralizers were producing. To avoid more competition for butterfat with creameries from which they purchased butter, these companies closed their centralizers. (3) The national dairy firms which operated centralizers shifted to the type of dairy processing and merchandising which had greater profit potential. Butter is a low profit item compared with fluid milk and frozen desserts. The national concerns began diversification into other lines in the late 1920's and during the 30's, and the importance

of butter in contributing to their earnings decreased.<sup>12</sup> When a centralizer plant became obsolete, instead of replacement it was often closed. Armour and Fairmont, for example, closed their North Dakota centralizers within the last decade.

Cream stations have shown the greatest decrease in numbers (table 1). It was stated earlier that there were 1,235 cream stations in North Dakota at one time. Eleven hundred of them had been established and equipped by centralizers. Armour Creameries at one time received cream from more than 300

<sup>12</sup> Nicholls, W. H., *Post-War Developments in the Marketing of Butter*, Research Bulletin 250, Agricultural Experiment Station, Iowa State College, Ames, Iowa, February, 1959, pp. 345-355.

cream stations. At present Armour has no dairy operations in the state. It is not difficult to understand why many cream stations have ceased operation. Although they may provide a service desired by some farmers and butter manufacturers, many dairy farmers no longer need the services of the cream stations.

### **Concentration in Processing**

Changes in the concentration or control of processing by a specified number of firms also should be considered in analyzing trends in market structure. The identification of these changes is provided by the concentration ratios presented in table 2. These ratios represent the proportion of the total output produced by a specified number of firms. In addition, this table lists the number of plants actually producing the products. Because of the multi-product characteristic of many dairies, the figures do not indicate the number of dairy firms in the state.

The data in table 2 are useful in three respects. They are descriptive of the industry. They indicate changes in the structure of the industry and the kinds of competitive behavior which may be expected. All three will be considered in the following discussion.

Five of the products listed in table 2 show increasing concentration for the period 1940-1962. Concentration in butter production has increased. For example, eight firms accounted for 53 per cent of North Dakota's output of butter in 1962 compared with 44 per cent in 1940. Butter is sold in a national market; thus, increased concentration within North Dakota has no significant effect regarding competitive power in selling markets. Because butter production has remained relatively

constant for the period involved, the ratios do mean that some firms and some plants have increased size for greater efficiency.

Cottage cheese production in the state shows high concentration, and the only significant change occurred between 1940 and 1945. The relevant market for cottage cheese is, however, more restricted than the boundaries of the state. Therefore, increasing concentration may have very important competitive effects on the relevant market. For example, the Minot area can be considered a market for cottage cheese. One dairy plant produces cottage cheese in Minot. Two outside firms distribute or sell to distributors in the city. The number is so small that prices are not likely to be determined in a purely competitive manner. Entry or exit of a single firm can change the competitive relations among sellers.

Not only have a few firms controlled production of cottage cheese in North Dakota, but also it appears they have managed to foreclose any potential competition which may have entered because of an expanding cottage cheese market. A dominant position held by a firm or firms in a market is conducive to maintaining that position even when demand increases rapidly.

Concentration of ice cream production has increased steadily since 1940. The largest four firms controlled about 42 per cent of total production in 1940 and 72 per cent in 1962. Here also the market has enlarged. Total production increased two and one half times since 1940 (Appendix II, table 5). Fifteen firms produced ice cream in 1962 compared with 40 in 1940. Not only are fewer firms controlling production, but some firms are controlling

a much larger total market in terms of volume.

Concentration in the relevant market for ice cream likely is greater than ratios indicate. The increasing ratios for the state indicate that concentration in those relevant markets has been increasing. The markets for ice cream are local although they may overlap to some extent. Fairmont, for example, produces ice cream in Moorhead, Minnesota. Its distribution area for ice cream from this plant is Minnesota, North Dakota and parts of South Dakota. Bridgman's plant at Minot produces for the Minot and Williston areas.

Concentration ratios for the production of American cheese indicate little about the structure of the industry. This is a developing industry in the state. Only four firms were producing cheese in 1960. The number in 1963 was 11. The change in ratio from 100 in 1960 to 63.1 for the largest four firms merely represents the growth of the industry.

Like much of new manufacturing in the past, three periods of development in the cheese industry might be expected. The first is characterized by the establishment of new firms with their manufacturing operations located throughout the area. The second is one of retrenchment of established firms and a weeding out of the inefficient and weak firms. This may be done by a process of exit of facilities and personnel of some firms or by a process of merger and consolidation. The third period is that of a mature industry in which exit and entry may be occurring in response to factors such as new techniques, expanded demands, etc. The development of the cheese industry in North Dakota is in the first phase.

At least the purchase of milk and manufacture of cheese fit this phase. It is likely that additional cheese manufacturing firms will begin business in the state, and some probably will not succeed. Others may consolidate and merge operations.

Concentration ratios for dried buttermilk, sherbet and water ices are very high. The milk drying industry in North Dakota, however, is very small. Although a few firms produce all the powder produced in the state, their output is relatively unimportant in terms of the national market in which they sell. High concentration in the production of sherbet and water ices is difficult to evaluate. These are usually produced in conjunction and with the same equipment as ice cream. They are such close substitutes that in considering concentration they should be included with ice cream in a frozen desserts category.

Concentration ratios for ice milk also are difficult to evaluate. Total production was zero in 1940, and only two firms reported production in 1950. Production in 1962 was more than three times that in 1951. The four largest firms accounted for a large proportion of the increase. Also the four largest producers increased their percentage of total production from 60 per cent in 1960 to 82 per cent in 1962. At the same time three firms ceased producing ice milk.

The concentration ratios imply several things about the behavior and the resultant industry performance of North Dakota dairy firms. The ratios for cheese and dried buttermilk are quite high. Considering that these firms sell these products in national markets and their output is small relative to the

national market, it is to be expected that they would not be a dominant force in determining market price. High and increasing concentration for ice cream and cottage cheese implies that the firms are able to set prices higher than purely competitive conditions would warrant.

### Entry of Cheese Factories

Exit and entry of dairy firms have been the main features in the changing structure of North Dakota's dairy industry since 1960. Ten firms began manufacturing cheese from 1960 to the summer of 1963. Approximately 100 cream stations went out of business during the same period. More than 50 of these ceased operations between May, 1963, and May, 1964.

The amount of entry and exit which is observed in an industry is determined by the conditions of entry and exit. The condition of entry is defined as the extent to which existing firms in the industry can raise price above the minimum average cost of production without attracting new entry.<sup>13</sup> In an analogous manner the condition of exit is defined as the amount by which price can fall below minimum average costs of production without causing exit.<sup>14</sup> Both of these definitions are subject to the restriction that new entry or exit be that of both productive capacity and a control or management unit. Therefore, when Foremost purchased the Bridgeman-Russell operations in North Dakota, no entry occurred, nor was there an exit according to the textbook definition. For pur-

poses of this study, departures from this rigid definition will be made. Any new firm or an old dairy firm that begins making cheese or a cheese firm in another state that expands by opening a new plant in North Dakota will be considered entry into this state's cheese industry.

There are several reasons for the economic importance of the conditions of entry and exit: (1) they indicate the ease by which the industry can make adjustments when new capacity is warranted, (2) they indicate the ease of adjustments when exit may be required because of the development of excess capacity and (3) they may explain the economic behavior of the firms in the market.

The cheese industry in North Dakota provides useful insights into the problems of entry. The industry is expanding in North Dakota by new entry at the same time the industry in other parts of the nation is experiencing exit. These developments seem to warrant the conclusion that barriers to entry in this state are low. Barriers hypothesized as important to the potential entrant in the cheese industry are (1) size requirements to achieve necessary economies of scale, (2) capital requirements in relation to capital availability, (3) the lack of a good market for the final product that can result in a price disadvantage for new entrants, (4) competition for available milk supplies that make acquisition of an adequate milk supply impossible and (5) absolute cost disadvantages, especially in the assembly of milk supplies. To identify the important factors bearing on entry, management of all cheese firms in the state were personally interviewed in the summer of 1963.

<sup>13</sup> Bain, J. S., *Barriers to New Competition*, Harvard University Press, Cambridge, Massachusetts, 1956, p. 5.

<sup>14</sup> Clodius, R. L., "Operational Criteria for Public Programs Affecting Firm Entry and Exit," *Market Structure Research*, edited by Paul L. Farris, Iowa State University Press, Ames, Iowa, 1964, pp. 54-67.



Results of these interviews indicate the nature of specific barriers to entry.

### Growth of the Cheese Industry.

The growth of cheese production in North Dakota is part of a development taking place in cheese production elsewhere in the nation. This partly explains why cheese production is increasing here. For example, between 1956 and 1960 the number of cheese plants in Wisconsin decreased from 988 to 783.<sup>15</sup> Several reasons accounted for this decrease. Lack of adequate milk supplies for efficient operation was an important cause. This resulted from broadening of the fluid milk supply areas and the high prices that large, highly efficient manufacturing plants were able to pay. Some of the owners closed all their Wisconsin operations and looked elsewhere for areas of less expensive milk supplies. Other Wisconsin firms, when considering expansion or new operations, looked to new areas.

The ownership or management of 7 of the 10 cheese factories had or formerly had some connection with the cheese industry in Wisconsin (table 3). These owners or operators were asked why they left the cheese business in Wisconsin or why they chose to expand cheese production in a new area. Six indi-

cated that obtaining adequate milk supplies in Wisconsin at manufacturing milk prices was too difficult. Large parts of the dairy production areas in Wisconsin are under Federal Order pricing. To enter a Federal Order market many producers change to Grade A milk production. Cheese factories cannot afford the higher prices paid for Grade A milk, and as a result many went out of business.

**Table 3. Background of Owners or Cheese Makers of North Dakota Cheese Factories.**

North Dakota cheese factories	Number
Owned by Wisconsin firm or personnel of Wisconsin cheese firm	3
Owned by former owners of Wisconsin cheese firms	3
Cheese maker a former Wisconsin cheese maker or owner of cheese factory	1
Owned and operated by native North Dakotans	2
Other	1
Total	10

**Factors Encouraging Entry.** Volume of milk handled, total sales, number of employees, and investment required to begin cheese production were recorded for the 10 North Dakota cheese factories. The averages and ranges for these size characteristics are listed in table 4. These indices of size are useful in measuring the relative height of barriers to entry into the cheese industry.

<sup>15</sup> Hammond, J. W., *Financial and Market Causes for Merger in the Wisconsin Dairy Industry*, Ph. D. thesis, University of Wisconsin, Madison, 1963, p. 4.

**Table 4. Size Characteristics of 10 North Dakota Cheese Factories, 1962.**

	Average	Range
Volume of milk handled (pounds) (cheese only)	13,141,000	7,000,000-18,250,000
Annual sales (dollars)	455,671	250,000-650,000
Required investment to begin operations (dollars)	98,779	60,000-200,000
Employees (number)	12	8-20

Annual sales or annual volume of milk processed can be used to determine if the firms are operating at the low point or near the low point on the long-run planning curve. A conversion ratio of 10 pounds of whole milk per pound of cheese shows that all cheese plants were producing from 700,000 to 1,800,000 pounds of cheese per year. The annual volume of cheese production necessary to realize economies of size was achieved by all North Dakota plants in 1963.<sup>16</sup>

The average size plant, according to the data in table 5, could not decrease its per pound cost of manufacture significantly by increasing volume. Only one plant in the summer of 1963 could have lowered its average cost by increased volume. Cheese plants in North Dakota are in a much better position regarding volume than are the plants in Wisconsin, the leading cheese state. For example, almost 40 per cent of the plants in Wisconsin produced less than 500,000 pounds in 1955.

Adequate volume necessary to realize economies of size in cheese processing has been attained by the new entrants in the state's dairy industry. The data in table 5 may not

be truly representative of present day economies of size, but a quick review of technological advances in cheese manufacturing indicates no major change which would affect optimum size volume since these figures were published. The comparisons warrant the conclusion that economies of size in cheese manufacturing have been a very low barrier to entry in North Dakota.

The capital requirement for cheese plants of optimum size is a relatively low barrier to entry. The average investment for seven firms which provided data on investment was about \$100,000, and previous data on size indicate that these plants are optimum sized. When this investment is compared with investment requirements in other industries, it appears to be an exceedingly low barrier to entry. Three industries considered to have low capital requirements are flour milling, shoes and canned goods. The capital requirements for these three industries ranged from \$500,000 to \$3,000,000.<sup>17</sup> Apparently, the capital requirement should not be a significant problem for potential entrants in cheese manufacture.

<sup>16</sup> Governor's Dairy Marketing Committee, *Improving the Efficiency of Dairy Cooperatives in Wisconsin*. The University of Wisconsin, Madison, Wisconsin, September, 1960, pp. 14-15.

<sup>17</sup> Bain, J. S., "Economies of Scale, Concentration, Entry," in *Readings in Industrial Organization and Public Policy*, ed. R. B. Heflebower and G. W. Stocking, Richard D. Irwin, Incorporated, Homewood, Illinois, 1958, pp. 65-67.

**Table 5. Cost Differences Between High and Lower Volume Cheddar Cheese Plants.**

Annual production	Probable amount by which processing costs per pound are higher than for a large volume plant*
(thousand pounds)	(cents per pound)
Under 500	1.4
500 - 999	0.4
1,000 - 1,499	0.0
1,500 and over	n.a

\*A large volume plant is one defined as producing between one and one half million pounds of cheese per year.  
Source: Governor's Dairy Marketing Committee, *Improving the Efficiency of Dairy Cooperatives in Wisconsin*, Report to Governor Gaylord Nelson, University of Wisconsin, Madison, Wisconsin, September, 1960, p. 15.

Managers and owners of cheese factories were queried on the sources and availability of capital. Five sources of capital were used by the 10 cheese factories beginning operations in North Dakota between 1960 and 1963. Two were completely financed by the owners. In one case the owner had sold his operations in Wisconsin and reinvested in his plant here. The other was opened as another factory of a cheese firm in Wisconsin.

Other sources of capital were banks, city economic development commissions, the Small Business Administration and equipment companies. In some instances the city built the building and leased it to the cheese factory operators on rather favorable terms. The leasing of a building limits the total capital requirement. The number of firms using each source of financing is listed in table 6.

**Table 6. Sources of Capital for Nine Cheese Factories Beginning Operations in North Dakota Between 1960 and 1963.**

Source of capital	Number of firms using the specified source
Owner financed	7
Local banks	4
Local economic development commission or cities	3
Small Business Administration	1
Equipment companies	2
Leasing of buildings in place of owning	1

Capital availability cannot be evaluated completely by studying only firms which have obtained financing. However, the number of sources and the relatively low requirement suggest this has been a low barrier to entry in North Dakota's cheese industry.

The small number of employees, including milk haulers, per cheese plant implies obtaining labor

should not be a problem to entry (table 4). The operators of the six cheese factories, however, stated that obtaining experienced or qualified personnel was one of their main problems. Adequate numbers of people were willing to work, but many aspects of cheese making require experienced personnel who were not available. In addition, many of the people hired were not willing to learn. Some operators said that the situation was gradually improving.

Five operators of cheese factories had experienced difficulty in obtaining milk of desired quality. There were two facets of the quality problem: (1) The factory has to be sure that its producers meet state requirements for milk used in manufactured dairy products. If it is lax in this respect, the factory runs the risk of being closed by health authorities. (2) Operators have to be sure that milk meets requirements necessary for making quality cheese. They were unanimous in their opinion that to continuously produce good cheese a high quality milk is needed. The quality milk problem is compounded by the dual production standards for milk used in manufactured products in the state. Regulations on milk separated and sold as cream from the farm are very limited. Essentially, they require the cowyards, premises and buildings to be kept reasonably clean, and utensils and equipment to be kept clean.

Standards for production of whole milk used for manufacturing are more strict. They require a milkhouse, facilities to cool milk to 50° F. two hours after milking, washing equipment and hot water. Producers have been given time to make the improvements, but in

many instances they have been cut off from selling whole milk, or they have voluntarily decided not to invest in the required equipment and facilities. Thus, as far as sanitary requirements are concerned, the cream buyers have a substantial advantage in competing for milk supplies. In this respect the sanitary requirements act as a barrier to the entry of manufacturing milk firms.

Another important problem for cheese factories is the cost associated with assembly of milk supplies. At the beginning of this report the low density of milk production was discussed. This means that assembly areas for an optimum sized processing plant will be much larger than in more intensive milk production areas. For the 10 cheese plants in this study, the minimum radius of the plants' assembly areas was 20 miles, and the maximum, 110 miles. These assembly areas are exceptionally large for the volumes of milk received by the plants.

Data on charges for milk hauling are presented in table 7. Five of the 10 plants reported the charges for can hauling of milk were not covering the average cost of hauling. Only two of the plants reported costs in excess of charges for bulk hauling of milk. Nearly all operators indicated that the size of the assembly area was much greater for bulk assembly than can pick-

up for any given hauling cost per hundredweight.

The question arises as to whether high hauling costs and large assembly areas are significant problems to the entering cheese firm. In competition with cream buyers the cheese factory should have an advantage regarding price. Whole milk sales, even with hauling charges as high as 60 cents, can return more to the farmer in sales revenue than cream sales. This has been a traditional relationship. For example, the highest hauling charge made by any of the cheese factories was 60 cents per hundredweight. It paid \$2.95 per hundredweight for whole milk, which resulted in a net to producers of \$2.35. Cream buyers in the same area were paying 61 cents per pound for butterfat. For 3.5 per cent butterfat milk this returned \$2.14 per hundredweight to the producer. Selling whole milk would have increased receipts by 21 cents per hundredweight. Many producers would show a larger gain than this.

**Competition for Milk Supplies.**

The amount of competition for whole milk between cheese processors and other whole milk processors is illustrated by the data in table 8. The average number of competitors for whole milk was 4.4 They were divided into major and minor competitors. Major competitors were those which manufactured dairy products or were large fluid milk and ice cream distributors. The average number of major competitors per cheese factory was 3.1, which is not a large number when size of assembly areas is considered. Minor competitors were small local milk distributors. They may have paid higher prices for milk than the cheese factory, but their volume was limited

**Table 7. Charges for Hauling Milk by North Dakota Cheese Factories, 1963.**

Method of assembly	Charge		Number of cheese plants not covering costs of assembly
	average (cents per 100 pounds)	range	
Can	34.0	25-60	5
Bulk	30.8	10-60	2

because of the small size of the market for bottled products. Also considered as minor competitors were several butter factories which roller dried skim milk.

**Table 8. Number of Whole Milk Competitors in Assembly Area for 10 North Dakota Cheese Plants, 1963.**

Firm	Minor competitors (number)	Major competitors (number)	Total (number)
No. 1	0	1	1
No. 2	6	3	9
No. 3	1	3	4
No. 4	1	2	3
No. 5	0	3	3
No. 6	4	3	7
No. 7	0	4	4
No. 8	0	6	6
No. 9	0	5	5
No. 10	1	1	2
Average	1.3	3.1	4.4

It appears that milk assembly is not a significant problem for the entering cheese firms. Assembly costs are high, but they are no higher than for other manufacturing milk plants with which they compete. The producers can sell to the cheese factory, pay the hauling cost and increase their returns from milk sales. Competition for whole milk supplies is not so vigorous as to make obtaining adequate volume for efficient operation an impediment to entry.

Marketing problems were not impediments to entry of cheese firms into North Dakota. In some of the dairy sub-industries the development of a market can be very difficult. Fluid milk, for example, involves merchandising and the development of retail outlets. Cheese also can be marketed this way. It can be aged, cut and packaged, and sold directly to retail outlets. But this involves a great deal of money tied up in inventory and additional equipment. Most factories are not large enough to realize economies

of scale in merchandising, and competition in retail outlets would be with some of the nation's largest cheese wholesalers. Except for a small amount of local sales direct to consumers, none of the plants merchandised cheese at the retail level. All sold to large cheese wholesalers or through cheese brokers. The product was sold as green cheese in the 40-pound block or in the curd form in 400-pound barrels. Half the factories sold to Kraft. The remainder sold to Wisconsin cheese wholesalers and to West Coast cheese handlers.

In summary, the aggregate effect of all these factors has not been a major restraint on the development of new cheese factories in the state. Capital requirements do not appear to be in a serious restriction. Volume requirements for efficient operations have been met by all the existing cheese factories. Competition for whole milk supplies has not appeared to be vigorous. Costs of milk assembly are high, but they have been borne equally by all milk processors. In the sale of cheese these firms are not in competition with other sellers who have any advantage over them. Thus, barriers to entry of new cheese factories have been low.

### The Demise of Cream Stations

The number of cream assembly stations declined from 478 in 1952 to 234 in 1962, a drop of more than 50 per cent (table 1). This marked decline was in part due to the decreasing importance of the centralizer. To determine other possible causes and to determine if cream stations are exiting as quickly as economic conditions warrant, a 15 per cent random sample of cream stations in operation in April, 1963, was selected for special study. The owners or operators of

these stations were interviewed during the latter part of 1963.

**Ownership.** Various types of ownership characterized cream stations (table 9). Twenty-four per cent were owned by the creamery or centralizer which received their cream. The cream station operator was an employee of the company. Twenty-four per cent were owned and operated independently. More than half were owned and operated in conjunction with some other business operation. The most common of these was the grocery store. Several other types of businesses were operated in conjunction with the cream station. Some operators were distributors of fluid milk products for some of the larger dairies in the state. One operated a laundromat, several sold feed and seed, and one operated a locker plant and had meat processing facilities. There were several other miscellaneous joint enterprises.

**Table 9. Ownership Characteristics of a Sample of 33 North Dakota Cream Stations, 1963.**

Ownership characteristic	Number	Per cent
Owned by creamery	8	24.2
Independently owned	8	24.2
Owned and operated in conjunction with another business	17	51.6
Total	33	100.0

**Size Characteristics.** Size of cream stations was measured by volume of butterfat handled and net income to the operator. The 1962 volume of butterfat received by most stations was relatively small. For example, 60 per cent of the stations handled less than 50,000 pounds annually. According to a former study, only 20 per cent of the stations had a volume less than this amount in 1928<sup>18</sup>

<sup>18</sup> Anderson, H. G., and A. H. Benton, *op. cit.*, pp. 39-42.

**Table 10. Annual Volume of Butterfat purchased by 33 North Dakota Cream Stations, 1962.**

Volume of butterfat	Number of cream stations	Per cent of cream stations
pounds		
0-9,999	4	12.1
10,000-24,999	10	30.3
25,000-49,999	5	15.2
50,000-74,999	6	18.2
75,000-99,999	4	12.1
100,000 and over	4	12.1
Total	33	100.0
Average volume of butterfat per cream station, 49,126 pounds.		

Twelve per cent of the stations included in the 1962 survey handled less than 10,000 pounds of butterfat, which is less than could be produced by one medium size dairy herd during a year. It is evident that the volume of butterfat received by a significant proportion of the stations was much too low to permit efficient operation.

The declining trend in number of cream stations and in volume of butterfat handled by most of them implies that their importance as a segment of North Dakota's dairy industry is becoming less and less.

**Factors Accounting for Declining Volume.** According to the replies received from cream station operators, three factors stand out as the causes of declining volume of cream stations. One is the increase in direct movement of cream from the farm to the creamery. This has resulted in part from the development of creamery truck routes and the higher prices the creamery is able to pay for butterfat. Formerly, prices received by the farmer were the same whether he sold to the cream station or to the creamery.

A second major factor contributing to the decreasing volumes for cream stations was the accelerated

shift to whole milk sales by producers which has taken place in the last five years. The amount of this shift has been discussed in earlier parts of this report. Seventeen, or more than 50 per cent, of the 33 sampled cream stations specified this as a major cause of the decline of their volume.

Whole milk shipment to cheese factories was reported as having an important effect on cream station volume in the west and central parts of the state. One cream station operator reported that nearly his entire group of producers was taken over by the cheese factory. Several reported losing from 20 to 50 per cent of their cream supplies with the establishment of a cheese factory in their supply areas. Strasburg had three cream stations before the cheese factory began operation. It had one in the summer of 1963.

Several cream station operators stated that both cheese factories and other whole milk plants had had a significant impact on their volumes. The older whole milk receivers seemed to be the main shifters of producers in the eastern part of the state. Processors such as Cass-Clay and Bridgeman were reported as expanding and increasing the number of routes in this area. These reports are from cream stations still in business. No doubt the exit of many stations may be attributed to the shift to whole milk

An additional factor bringing about decreased cream sales although very closely related to the above is the change taking place in milk production. The data in Appendix II table 3 illustrate the trend toward fewer milk producers with larger average herd size. The larger the herd, the greater is the likelihood that the producer is selling

whole milk. A trend toward larger and fewer herds means more milk sold to whole milk processing plants and less farm separated cream sales. Eighteen per cent of the responses from cream station operators specified this development as a cause of decreased cream station volume. They stated that many of the farmers with a few milk cows were going out of dairying completely. If these dairy cows were sold to another producer to increase the size of his herd, the chances increased that the purchaser would attempt to shift to whole milk sales. The cream buyer not only loses the producer who sold his milk cows, but he may lose the cream producer who buys the cows. Six interviewees were not sure of the causes for decreased volume.

**Income of Operators of Cream Stations.** The main economic effects of small volume of cream stations are reflected in efficiency of operation and income of the cream station operator. Only a limited amount of information was available for estimating the level of operator income for the sample of cream stations. This was determined in one of several ways.

If the cream station was merely managed by the operator but owned by others, the net income to the operator was his salary. If the owner managed and operated the cream station and maintained expense records, the difference between the gross margin and expenses represented his net income. Some owner-operated and managed cream stations had no records other than volume of cream and margins received. For these operators net income was assumed to be equal to 90 per cent of the gross margin.<sup>10</sup>

<sup>10</sup> Net income of the creameries which had accurate records averaged about 90 per cent of the gross margin.

Net returns to cream station operators for butterfat were very low in 1962. The average net return for all operators in the sample was \$1,632 (table 11). More than 40 per cent of the operators earned less than \$1,000 per year. Less than 10 per cent had net returns of \$4,000 or more per year from cream operations. About half of their stations were operated in conjunction with some other type of business, but the total net income figures for the joint businesses were not available. Therefore, the incomes of these operators are not strictly comparable with those received by other operators.

**Table 11. Estimated Net Income of Operators of 33 North Dakota Cream Stations, 1962\*.**

Net income to operator	Number of operators	Per cent of operators
(dollars)		
0-499.99	7	21.2
500.00-999.99	7	21.2
1,000.00-1,499.99	6	18.2
1,500.00-1,999.99	1	3.0
2,000.00-2,999.99	7	21.2
3,000.00-3,999.99	2	6.1
4,000.00 and over	3	9.1
Total	33	100.0
Average net income per operator — \$1,632.		

\*For method of estimation see text.

To overcome this obstacle, net returns for 16 operators who received all their income from the cream station were determined. The results are presented in table 12. Median net return for these 16 operators was \$2,378.07. This compares with a median income of \$3,110 for all males in North Dakota in 1962 and a median income of \$2,618 for all rural males.<sup>20</sup> Over 37 per cent of these cream station operators received less than \$2,000 in annual income, compared with

about 17 per cent of all North Dakota families receiving less than this amount.<sup>21</sup> If the sample is representative of all cream stations in the state, operators of cream stations are doing worse than other income recipients in the state. And, with volume of business per cream station on the decrease, the income outlook is poor.

**Table 12. Estimated Net Income of Operators of 16 North Dakota Cream Stations Receiving Entire Income from Cream Stations, 1962.**

Net income to operator	Number of operators	Per cent of operators
(dollars)		
0-999.99	2	12.5
1,000.00-1,999.99	4	25.0
2,000.00-2,999.99	5	31.2
3,000.00-3,999.99	2	12.5
4,000.00 and over	3	18.8
Total	16	100.0
Average net returns per operator — \$2,378.		
Median net returns per operator — \$2,385.		

**Factors Mitigating Small Volume of Cream Stations.** The results of the preceding sections indicate many cream stations are too small to operate at a minimum level of efficiency or to return a satisfactory income to the operator. It seems logical to consider an income of less than \$2,000 per year to the operator as unsatisfactory when this is his only source of income. However, two major considerations tend to prevent more rapid exit of cream stations than is now occurring. One is the complementary and supplementary relationships that exist between the cream station and the business with which it is jointly operated. The second is the age and lack of more profitable alternatives for the operators of cream stations.

The supplementary relationship between the cream station and other business has prevented sta-

<sup>20</sup> United States Department of Commerce, *Statistical Abstract of the United States, 1962*, U. S. Printing Office, Washington, D. C., 1963, p. 335.

<sup>21</sup> *Ibid.*, p. 333.



tions from going out of business more rapidly than volume of cream and income would warrant. The income from several miscellaneous types of businesses supplemented the income received from the cream station operations. At the same time that income is supplemented, there are complementary relationships. Complementary relations existed in the use of labor. Many of the grocery stores and miscellaneous businesses were small and located in small rural communities not likely to make very intensive use of available labor. Receiving of cream more fully utilized labor and made some contribution to income.

The jointly operated cream station and grocery store aids in maintaining and generating grocery sales by providing the service of receiving cream. Eleven, or one-third of the sample of 33 stations, were jointly operated with grocery stores. One store and cream station owner said 90 per cent of all checks he wrote for cream were spent on groceries in his store. This meant roughly \$7,000 worth of groceries sales were purchased by farmers with proceeds from cream checks. Another store operator paid out \$27,000 for cream purchases in 1963. He estimated that \$25,000 of this was spent in the store on groceries.

Several of the grocery store cream station combinations were

located in small inland towns. The operators said that the main reason they were able to stay in the grocery business was the service they provided farmers. The farmers, in turn, spent their cream checks on groceries. One stated he would not buy cream if it were not for the fact that the service drew farmers into the store to buy groceries.

#### **Evaluation of Barriers to Exit.**

Barriers to exit of cream stations can be characterized as low, simply because a great deal of exit has been and is taking place. The preceding discussion indicates why they are low. Very few fixed assets are required for operating a cream station; thus, there is no problem of disposing of assets. Returns to operators are so low that if any alternative employment arises promising higher returns, they are likely to close their stations.

The decline in number of cream stations is accelerated by the higher prices creameries with truck routes can pay for butterfat resulting in loss of volume. The drop in volume is accompanied by a cost disadvantage in cream station operation.

The only factors tending to restrict the rate of exit are the supplementary and complementary relationships when the cream station is operated jointly with some other type of business.

### **FUTURE DEVELOPMENTS IN THE DAIRY INDUSTRY OF NORTH DAKOTA**

The most recent developments in the North Dakota dairy industry suggest strongly that current trends and developments will continue for some time to come. The rapid decrease in the number of cream stations and volume of cream

handled by them shows no indication of moderating. Establishment of new and growth of existing cheese factories can reasonably be expected to continue. In contrast, evidence points to a continued downward trend in number of creameries.

## Cheese Production

Since surveying the 10 cheese factories in operation in North Dakota in the summer of 1963, two new factories have begun manufacturing cheese, one at Wishek and the other at Garrison. It is unlikely, however, that there will be a marked increase in numbers. Emphasis today is on plants and firms of large size in order to obtain needed efficiency in processing. Growth of the industry will largely result from growth of existing plants rather than a continual increase in cheese plant numbers.

If the development of the cheese industry is, in large part, a matter of growth of existing firms, what might be expected in the way of growth or what is the potential for growth? To answer this question a simple procedure was used. The supply areas from which each of the 10 surveyed cheese plants assemble milk were determined. The product of the number of milk cows in their supply areas and the average milk production per cow in North Dakota for 1962 was taken as the estimate of milk supplies in the area.<sup>22</sup> For those cheese factories which assembled milk from outside the state the estimate of outside milk was based on the proportion of the procurement area lying outside the state. Results of this procedure are presented in table 13.

None of the cheese factories received more than 25 per cent of the milk in its supply area. Six were receiving less than 20 per cent of the total milk supplies. Poten-

**Table 13. Per Cent of Total Milk in Each of 10 Cheese Factory Supply Areas Which Was Received by the Cheese Factory, North Dakota, 1962.**

Cheese factory	Per cent of total milk received by cheese factory
No. 1	24.5
No. 2	15.5
No. 3	11.8
No. 4	15.6
No. 5	14.9
No. 6	5.3
No. 7	20.6
No. 8	21.0
No. 9	24.4
No. 10	9.0
Per cent of all milk in North Dakota received by cheese factories, 5.9%.	

tial in terms of possible raw milk supplies appears extremely favorable. There is some overlapping of whole milk supply areas between cheese factories and between cheese factories and other whole milk processors, but it is not extensive. Some overlapping occurs where local fluid milk distributors assemble milk. These distributors usually are not large, and their potential for expansion is very limited. The cheese factories generally are well distributed throughout the state thus avoiding duplication of milk procurement operations.

Another factor makes the outlook bright for existing factories. Nearly all factories are assembling milk in some areas where no other whole milk is being marketed. Thus, as producers shift to whole milk sales, the cheese factories will very often be the most likely outlet.

## Cream Stations

The outlook for survival of the cream station is poor. Several developments lead to this conclusion. First, the nation as a whole has moved away from farm separated cream. Only 5 per cent of all milk marketed by farmers in the United States in 1962 was marketed as

<sup>22</sup> Milk cows per county were reported in *State of North Dakota Biennial Report of the Department of Agriculture and Labor*, Bismarck, North Dakota, and milk production per cow in North Dakota, from United States Department of Agriculture supplement for 1962 to *Dairy Statistics Through 1960*, Statistical Bulletin No. 303, Economic Research Service, Washington, D. C., 1963, p. 3.

farm separated cream (Appendix II, table 4). In 1940 this percentage was 38 and in 1950, 20 per cent. Comparable figures for North Dakota for 1940 and 1962 were 94 and 70 per cent, respectively.<sup>23</sup> The proportion dropped to 67 per cent in 1963. If the North Dakota dairy industry continues to make the same adjustment as the industry has throughout the nation, the cream station is likely to become an institution of the past.

A projection of the current decrease in cream station numbers leads to the same conclusion. The annual decline in number of cream stations averaged 24 for the 10-year period 1952-1962 and 20 for the 8-year period 1954-1962. A projection of the smaller annual change suggests the exit of all cream stations by 1974. The complement<sup>24</sup> and supplementary relations between some cream stations and a jointly operated business will retard the rate of exit. The number in 1970, however, probably will be less than 100.

### Creameries

The procedure used in projecting future changes in number and distribution by size of North Dakota creameries is described in Appendix I.<sup>24</sup>

The projections discussed here are concerned with butter producing plants, not dairy firms. Al-

though a dairy plant may cease production of butter, the firm may continue producing other products at that plant or some other plant. For example, Bridgeman's in Grand Forks ceased butter production subsequent to 1954, but it continues to bottle milk and manufacture ice cream.

The development of the cheese industry, the rapid shift to whole milk sales by producers during the past four or five years and the necessity for creameries to grow in order to achieve certain economies of size in production of butter have influenced the number and size distribution of creameries.

It is reasonable to conclude that a continuation of the expansion in cheese manufacture and shift to whole milk will be accompanied by a decline in the number of creameries. Even with the decline in number, this continuation is likely to increase the proportion of creameries operating with low volume of butter output. It will be difficult for many creameries to achieve that volume adequate for efficient operation. These conclusions are confirmed by the results obtained from the application of the method used in deriving the projected number of creameries and their distribution by size.

North Dakota creameries numbered 77 in 1964.<sup>25</sup> The projected numbers in 1974 and 1990 are 57 and 44, respectively (table 14).

**Table 14. Projected Number of Creameries in Specified Years, North Dakota.**

Year	Number
1964	77
1966	68
1970	61
1974	57
1990	44

<sup>25</sup> One firm was omitted from the analysis because data were not available prior to 1959.

<sup>23</sup> Figures based on data from United States Department of Agriculture, *Dairy Statistics Through 1960 and Supplement Through 1962*, Statistical Bulletin No. 303, Economic Research Service, Washington, D. C. 1962 and 1963.

<sup>24</sup> The Markov process was utilized in deriving the projections. This method uses probabilities as a basis of projection. A basic premise is that changes in plant size can be classified in a probability distribution. The probabilities are generated by underlying economic and noneconomic factors that determine the growth and development of firms and markets. If these underlying forces do not change, the projections may be considered valid. It should be emphasized that the projections are not forecasts.

**Table 15. Projected Proportion of Creameries in Different Size Classes For Specified Years, North Dakota.**

Year	Size classification*						Total
	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	S <sub>4</sub>	S <sub>5</sub>	S <sub>6</sub>	
1964	32.5	33.2	28.0	2.8	0	3.5	100.0
1970	33.7	31.5	29.7	2.8	0	2.3	100.0
1974	34.9	30.2	30.4	2.9	0	1.6	100.0
1990	43.2	27.5	26.7	2.6	0	0	100.0

\*Annual production of butter in pounds:

S <sub>1</sub>	Less than 250,000	S <sub>4</sub>	1,000,000-1,499,999
S <sub>2</sub>	250,000-499,000	S <sub>5</sub>	1,500,000-1,999,999
S <sub>3</sub>	500,000-999,999	S <sub>6</sub>	2,000,000 and over

Little change is expected in the proportionate distribution of creameries by size or volume of butter manufactured during the next 10 years. The projections suggest that by 1974 about 65 per cent of the 57 creameries will be producing less than 500,000 pounds of butter annually (table 15). This proportion is approximately the same as in 1964. The probability is that the proportion will increase to about 71 per cent in 1990. Less than 3 per cent of the 44 creameries projected for the latter year will be producing as much as 1,000,000 or more pounds.

**Implications of Projections**

The projections which have been discussed suggest significant adjustments yet to take place in the North Dakota dairy industry.

Cream stations will become a very minor part of the marketing industry. Thus, many communities will lose a business. This is serious not only because of the income and purchasing power of the owner of the cream station that will be lost, but because of the loss of persons who do business in the community as a result of delivering cream to the station.

The projections for creameries are even more significant. The trends in the size distribution of North Dakota creameries indicate

serious efficiency problems. At present a majority of creameries are too small to realize minimum unit cost of butter manufacturing. Yet projections indicate the problems will become more acute.

The data in table 15 suggest that the annual volume of butter production will be less than 1,000,000 pounds for about 95 per cent of the creameries in 1974 and less than 500,000 pounds for 65 per cent of the creameries. Efficiency studies indicate a butter output of from 750,000 pounds to 1,000,000 pounds to be necessary for efficient operation.<sup>26</sup>

These projections are not at all inconsistent with what is happening in butter manufacturing in the state. Creamery numbers are becoming fewer, and some consolidations of creameries have taken place. However, the decrease in the amount of cream sold to creameries is more than offsetting volume increases of each plant which would result from creamery consolidation. The proportion of all milk sold as cream for the four-year interval 1958-1962 decreased from about 89 per cent to 71 per-

<sup>26</sup> Knudtson, A. C., and E. F. Koller, **Manufacturing Costs in Minnesota Creameries**, Station Bulletin 442, Agricultural Experiment Station, University of Minnesota, St. Paul, June, 1957, pp. 19-21; and Governor's Dairy Marketing Committee, **Improving the Efficiency of Dairy Cooperatives in Wisconsin**, op. cit., pp. 11-12.

cent (Appendix II table 4). Evidence points to a continuation of this decline; consequently, a large proportion of creameries is likely to find greater difficulty in maintaining adequate cream volume for plant efficiency in the future.

Creameries in many communities will cease operation. Some will have no alternative. The loss of a creamery by a community has more serious consequences than a loss of a cream station. Creameries have more employees and more potential for bringing money into the community than the cream station.

There are two policies which might alleviate the problem. One is increased emphasis on merger and consolidation of existing creameries. This may enable resulting firms to attain some economies of large scale operations. Another may be programs designed to accelerate the shift to whole milk

operations that can operate with relatively low volumes of milk. The development of large butter-powder operations may be a solution in some parts of the state. Thus, as the firms lose volume in cream assembly and churning, offsetting growth can be made in whole milk processing. These solutions are not open to all firms. No doubt, many will have to leave the industry.

The cheese industry is the brightest area of the dairy industry for North Dakota communities. Increasing size of existing cheese factories means additional income and potential business for these communities. Cheese making is a relatively labor intensive type of dairy operation; thus, employment opportunities may be increased above those which are lost through the egress of a creamery. If additional cheese factories are built in North Dakota, other communities will benefit in the same way.

## SUMMARY AND CONCLUSIONS

The major findings of this study fall into four major areas: (1) The general trends in industry concentration and the reduced number of dairy firms in North Dakota, (2) the developing cheese industry, (3) the demise of cream station assembly of cream, and (4) projections of plant numbers for cheese factories, cream stations, and creameries.

The total number of dairy processing plants in North Dakota has not exhibited the same trends observed elsewhere in the nation. For example, butter plants in Wisconsin declined from 350 in 1947 to 194 in 1958, a drop of 45 per cent. During about the same period the number in North Dakota declined from 105 to 90, a decrease of 14 per cent.

Cream station numbers have de-

creased more rapidly than butter processing plants in North Dakota. The decline from 478 in 1952 to 234 in 1962 represented a drop of more than 50 per cent in 10 years.

For most dairy products, production has become more and more concentrated in firms of larger size. The main exception is in the production of American cheese.

The changes in concentration were considered in terms of their effect on competition. Increased concentration for butter and dried buttermilk has had little effect on the selling of these products. In the purchase of cream the creameries may have been placed in a somewhat stronger competitive position.

Decreased concentration for

American cheese is merely representative of the development of the industry in the state. The entry of these new plants means increased competition for whole milk supplies. This could result in higher prices paid for whole milk.

The establishment of cheese firms was one of the most significant developments in the state's dairy industry. Twelve cheese plants have been established since 1959. This development appears to be part of a shift of the cheese production areas taking place throughout the nation. Large numbers of cheese factories have ceased operations in Wisconsin. Owners or cheese makers of these factories have in several instances established new or additional factories in North Dakota. Seven of the 10 cheese factories visited in the summer of 1963 were owned by former owners of Wisconsin cheese firms, presently owned by a Wisconsin cheese firm, or had a cheese maker who was a former Wisconsin cheese maker or owner of a cheese factory.

Entry barriers for these new cheese factories were found to be low. Because there was not a large number of whole milk assemblers in the state, these factories were able to obtain volumes of milk necessary to achieve economies of size. Only one cheese factory was producing at a volume not sufficient to realize lowest per unit costs. In Wisconsin, about 40 per cent of all cooperative cheese factories were below optimum size in 1958.

The cream assembly segment of North Dakota's dairy industry has shown the greatest change in numbers in recent years. The main factors bringing about the exit of cream stations were increased vol-

umes of cream moving on truck routes direct from producer to creamery, a large proportion of milk sold as whole milk, and the tendency of producers to increase the size of the dairy herd and shift from cream sales to whole milk sales.

Decreasing volume has resulted in reduced income for cream station operators and increased per unit costs of assembly. Average income to cream station operators was \$1,633 in 1962. More than 42 per cent of cream stations were operating at a volume too low for desired efficiency.

Cream stations will continue to exit from the industry. Their investment in facilities and equipment is low; therefore, assets do not pose a major restriction on exit. The only serious impediment seems to be lack of alternatives for the operators. It is estimated there will be fewer than 100 cream stations in the state by 1970.

The number of cheese factories is not likely to get very large, but the outlook for the existing factories is very favorable. None of the 10 cheese factories in 1963 was receiving more than 25 per cent of the milk produced in its assembly area. Thus, factories have high potential for growth.

Past trends and projections of numbers of dairy plants indicate growth of whole milk manufacturing plants, particularly cheese. It appears that cheese plants can acquire milk volumes sufficient to realize necessary economies of size. Thus, the activities of the Economic Development Commission to establish cheese factories have had and are likely to have a favorable effect on North Dakota dairying. Firms owning the plants may expect a reasonable return on in-

vestment. Farmers may expect increased prices and returns from milk sales.

The number of creameries probably will not exceed 57 by 1974 compared with 77 in 1964. It is estimated that about two-thirds of this number will have an output of butter below 500,000 pounds annually. This amount is below that required for efficient operation. The probability is that only one or two creameries of the 44 projected for 1990 will be producing as much

as 1,000,000 pounds.

The demise of cream stations, the decreasing importance of creameries and the projected future decrease imply efficiency problems. Consolidation and merger of many creameries now in existence may be part of the solution. Perhaps creameries should be considering the development of drying facilities so they can handle whole milk. Merger of plants and/or expansion into milk drying might ease the process of adjustment.

## APPENDIX I

### Method of Projecting Creamery Numbers <sup>27</sup>

This appendix describes the method used in projecting creamery numbers in North Dakota. The base period for the projections discussed in the text was the time interval 1958-1962. Another base period was also considered in this study, that of 1944-1959. This period consisted of three subintervals (1944-1949, 1949-1954 and 1954-1959). Changes that occurred during each of these subintervals were averaged to provide data for the 1944-1959 base period. It is this base period which will be used here to illustrate the Markov method of projection.

The first step in the Markov process is to establish size categories and record the movement of creameries from one size category to another during the specified time periods. The size classifica-

tions used for the projections are repeated in Appendix I, table 1.

**Table 1. Size Classification of Creameries in North Dakota.**

Class notation	Annual butter production (pounds)
$S_0$	0
$S_1$	1- 249,999
$S_2$	250,000- 499,999
$S_3$	500,000- 999,999
$S_4$	1,000,000-1,499,499
$S_5$	1,500,000-1,999,999
$S_6$	2,000,000 and over

The data in Appendix I, table 2 represent a matrix of the plant movements from one size category to another for the period 1944-1949.<sup>28</sup> Each element of this matrix represents movements of firms during the time period. For example, the element in the  $S_0$  row and the  $S_1$  column (symbolically denoted as  $S_{01}$ ) states that six new firms entered the industry in the size category  $S_1$ . The item in the  $S_2$  row and  $S_1$  column represents 11 plants which were in size category  $S_2$  at the beginning of the period as moving to a smaller size  $S_1$ .

<sup>27</sup> This section is based on: Kemeny, J. G. and J. L. Snell, *Finite Markov Chains*, D. Von Nostrand Company, Incorporated, Princeton, New Jersey, 1960; Padberg, D. I., "The Use of Markov Processes in Measuring Changes in Market Structure," *Journal of Farm Economics*, American Farm Economics Association, Volume XLIV, No. 1, February, 1962, pp. 189-199; Alexander, W. H., and D. C. Williams, *op. cit.*

Appreciation is extended to Thor A. Herts-gaard, assistant professor of Agricultural Economics, North Dakota State University, and Ronald D. Krenz, agricultural economist, Economic Research Service, U. S. Department of Agriculture, for their suggestions regarding the organization of this section.

<sup>28</sup> This matrix may be referred to as a flow chart. A flow chart was calculated for each time period included in the base period. The base period used for one projection here, 1944-1959, contained three time periods. The flow chart for the entire base period is constructed simply by summing corresponding elements of each of the flow charts for the respective time periods contained in the entire base period.

**Table 2. Movements of North Dakota Creameries From Various Size Categories for the Period 1944-1949.**

Size group in 1944	Size group in 1949							Total
	S <sub>0</sub>	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	S <sub>4</sub>	S <sub>5</sub>	S <sub>6</sub>	
S <sub>0</sub>	22	6	2	0	0	0	0	30
S <sub>1</sub>	8	37	2	0	0	0	0	47
S <sub>2</sub>	2	11	19	2	0	0	0	34
S <sub>3</sub>	0	2	5	4	0	0	0	11
S <sub>4</sub>	0	0	0	3	1	1	0	5
S <sub>5</sub>	0	0	0	1	1	0	0	2
S <sub>6</sub>	0	0	0	0	1	3	2	6
Total	32	56	28	10	3	4	2	135

The 22 in the S<sub>0</sub> row and S<sub>0</sub> column was an artificial value that was arbitrarily inserted for computational purposes. This value has no meaning for interpretation of Appendix I, table 2, but it does result in the S<sub>0</sub> row total, the S<sub>0</sub> column total, and the matrix total (extreme lower right-hand corner) exceeding their true value by 22 units. The sum of all columns except S<sub>0</sub> is the total number of creameries (103) in operation at the end of the period. Likewise, the sum of all row totals except S<sub>0</sub> is the total number of creameries (105) in business at the beginning of the period.

The next step is to calculate the transition probability matrix from the flow chart for the entire base period. This is done by computing each element in a row as a fraction of the row total for all rows. This is the transition probability matrix for the 1944-1959 base. This matrix, denoted by the letter P, is

presented in Appendix I, table 3. Because like elements were added from the flow charts for the time periods 1944-1949, 1949-1954 and 1954-1959, this matrix represents the average movement for a five year period on the 1944-1959 base. Row totals for any P matrix will always equal one. Each element is the probability that a firm will move from one size category to another during any five-year period. Element S<sub>23</sub> (.1720) is the probability that a creamery will move from size S<sub>2</sub> to S<sub>3</sub> during any five-year period. Element S<sub>11</sub> (.6803) is the probability that a firm in size S<sub>1</sub> at the beginning of the period will stay in that classification during the time period. All the elements in the main diagonal are the probabilities that the creamery will stay in the class during that time period.

Another transition probability matrix was constructed for the 1958-1962 period (Appendix I, table 4). This was a period during which the underlying forces generating these probabilities were considerably different from the preceding periods. Cheese factories had begun operating in the state. The shift to whole milk shipment by farmers was taking place at an accelerated rate. Several of the large centralizers had ceased operations. These developments did not get started until about 1959; therefore, to obtain probabilities representative of the conditions, the time interval was shortened to four years, because the last year for which

**Table 3. Transition Probability Matrix for Creameries in North Dakota (1944-1959 Base Period).**

		S <sub>0</sub>	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	S <sub>4</sub>	S <sub>5</sub>	S <sub>6</sub>
P =	S <sub>0</sub>	.8812	.0891	.0297	0	0	0	0
	S <sub>1</sub>	.1496	.6803	.1701	0	0	0	0
	S <sub>2</sub>	.0430	.1613	.6239	.1720	0	0	0
	S <sub>3</sub>	0	.0690	.3448	.4827	.0690	.0345	0
	S <sub>4</sub>	.2000	0	0	.4000	.1000	.2000	.1000
	S <sub>5</sub>	.1111	0	0	.2222	.1111	.2222	.3334
	S <sub>6</sub>	.0769	.0769	0	0	.0769	.2308	.5385



**Table 4. Transition Probability Matrix for Creameries in North Dakota (1958-1962 Base Period).**

		$S_0$	$S_1$	$S_2$	$S_3$	$S_4$	$S_5$	$S_6$
P =	$S_0$	.9333	.0667	0	0	0	0	0
	$S_1$	.2759	.5862	.1379	0	0	0	0
	$S_2$	.1081	.1351	.5676	.1622	.0270	0	0
	$S_3$	0	0	.1765	.7647	.0588	0	0
	$S_4$	1.0000	0	0	0	0	0	0
	$S_5$	0	0	0	0	0	0	1.0000
	$S_6$	.4000	0	0	0	0	0	.6000

plant data were available was 1962.

These transition matrices are useful in determining certain characteristics about the plants in the industry. High probabilities in the main diagonals indicate a stable industry with little mobility of the firms. The probabilities in the main diagonal of this matrix are low. Probabilities for both of these base periods indicate considerable movement from one size category to another. The sum of the elements on the left side of the diagonal element on each row as compared with the sum of the elements on the right side indicate whether there is a greater tendency of a creamery growing or decreasing its volume if it does move out of that size classification. For the 1944-1959 base period (Appendix I, table 3) the probability that a firm in size category  $S_3$  will decrease in size (.0690 + .3448 = .4138) is much greater than the probability that it will increase in size (.0690 + .0345 = .1035). For the base period 1958-1962 the respective probabilities were .1765 and .0588 Appendix I (table 4). Thus, these matrices not only can be used for projections, but they also indicate something about stability within the industry.

When the initial size distributions of firms and the associated probability matrices for the specified time periods are known, projections of creamery numbers can be made. The procedure is as follows: let  $C$  be a vector representing

the initial distribution of creameries in each size classification in 1958.

$$C = (C_0, C_1, C_2, C_3, C_4, C_5, C_6) = (45, 29, 37, 1, 1, 5)$$

Then the number of creameries at the end of the four-year period in each class is the number of creameries staying in that class plus those coming from each of the other classes into that class. The probabilities are used to estimate the proportion moving from one classification to another. The expected number of creameries in the  $S_0$  class would be the row vector  $C$  times the  $S_0$  column of the  $P$  matrix for 1958-1962. Thus, the distribution of creameries at the end of the first time period can be calculated by multiplying the vector  $C$  times the matrix  $P$  or

$$C_0P = C_1.$$

Because the estimate of the probabilities is based on this same time period, this product, a row vector, is the distribution of creameries that was actually observed in 1962. The projected number in 1966 is the 1962 distribution of creameries multiplied by  $P$ .

$$C_1P = C_2 \text{ but}$$

$$C_1 = C_0P, \text{ thus, } C_2 = C_0PP = C_0P^2.$$

Similarly, the distribution for 1970 is  $C_2$  multiplied by  $P$ ,

$$C_2P = C_3 = C_0P^3,$$

and for the  $n^{\text{th}}$  four-year time period

$$C^n = C_0P^n.$$

Appendix I, table 5 gives the projected number of creameries

**Table 5. Projected Number of Creameries in Each Size Classification in North Dakota (1944-1959 Base Period).**

Year	Number in class*						Total
	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	S <sub>4</sub>	S <sub>5</sub>	S <sub>6</sub>	
	number						
1964	35	33	14	2	2	3	89
1969	35	33	13	2	2	2	87
1974	34	32	13	1	2	2	84
1989	34	31	12	1	1	2	81
Equilibrium	34	30	11	1	1	1	78

\*For size classification see table 1.

and the distribution by size using the 1944-1959 base period. Since the 1944-1959 period does not include some major shifts which occurred in the creamery industry since 1959, it is likely that

the 1958-1962 base period provides more realistic projections than does that based on the 1944 - 1959 time period.

Probability matrices such as those used in the Markov process have another useful characteristic. For example, when the matrix P is raised to some power, all rows converge to a unique vector, K. Thus  $KP = K$ .<sup>29</sup> This means that the proportion of creameries in each class is tending toward a distribution where there is no net movement of firms in or out of each class. This is known as the equilibrium position. In this case it is the equilibrium distribution of creameries.

## APPENDIX II

### Statistical Tables

**Table 1. Milk Production and Milk Equivalent Sold From Farms, North Dakota, 1940-1962.**

Year	Production total	Total amount sold
	(million pounds)	(million pounds)
1940	2081	1627
1941	2238	1789
1942	2277	1846
1943	2198	1804
1944	2099	1709
1945	1970	1574
1946	1949	1589
1947	1905	1546
1948	1725	1394
1949	1678	1393
1950	1699	1397
1951	1700	1401
1952	1723	1432
1953	1759	1483
1954	1786	1515
1955	1785	1543
1956	1791	1557
1957	1762	1547
1958	1773	1590
1959	1757	1598
1960	1700	1555
1961	1740	1603
1962	1763	1637

Source: Taylor, Fred R., R. F. Engelking, and C. J. Heltemes, **North Dakota Agricultural Statistics**, Bulletin 408, Agricultural Experiment Station, North Dakota State University, Fargo, North Dakota, pp. 35-36.

**Table 2. Milk Cows and Production Per Milk Cow, North Dakota, 1940-1962.**

Date	Number of milk cows	Production per cow
	(thousand)	(pounds)
1940	484	4300
1941	511	4380
1942	532	4280
1943	536	4100
1944	530	3960
1945	495	3980
1946	463	4210
1947	432	4410
1948	392	4400
1949	377	4450
1950	375	4530
1951	368	4620
1952	365	4720
1953	371	4740
1954	372	4800
1955	368	4850
1956	359	4990
1957	335	5260
1958	311	5700
1959	289	6080
1960	272	6250
1961	274	6420
1962	277	6580

<sup>29</sup> The method for solving for K is explained in Williams, D. C., and W. H. Alexander, *op. cit.*, pp. 15-16; and Padberg, D. I., *op. cit.*, pp. 189-191.

**Table 3. Characteristics of Milk Production on Farms in North Dakota for Selected Years.**

Year	Number cows <sup>a</sup>	Number farm <sup>b</sup>	Number reporting dairy cows <sup>b</sup>	Per cent reporting dairy cows	Prod/farm with cows	Ave. No. of cows/farm reporting dairy cows
	(number)	(number)	(number)	(per cent)	(pounds)	(number)
1940	484,000	73,962	62,096	84.0	33,513	7.8
1950	375,000	65,401	49,220	75.3	34,518	7.6
1954	372,000	61,943	42,686	68.9	41,840	8.7
1959	289,000	54,928	30,483	55.4	57,639	9.5

Source: (a)Taylor, F. R., R. F. Engelking, and C. J. Heltemes, **North Dakota Agricultural Statistics**, Bulletin 408, Agricultural Experiment Station, North Dakota State University, Fargo, North Dakota, February, 1962.

(b)United States Department of Agriculture, **Dairy Statistics Through 1960 and Supplement Through 1962**, Statistical Bulletin 303, Economic Research Service, Washington, D. C.

**Table 4. Whole Milk Equivalent of Milk Marketed as Whole Milk and as Cream in North Dakota and United States, 1940-1962.**

Year	North Dakota				United States			
	Amount sold as cream	Amount sold as milk	Total amount sold	Per cent delivered as cream	Amount sold as cream	Amount sold as milk	Total amount sold	Per cent delivered as cream
	(million pounds)			(per cent)	(million pounds)			(per cent)
1940	1519	43	1562	97.2	32965	47152	80117	41.1
1941	1681	50	1731	97.1	33967	52062	86029	39.5
1942	1732	60	1792	96.7	31080	59076	90156	34.5
1943	1687	70	1757	96.0	29871	59656	89527	33.4
1944	1601	64	1665	96.2	26026	63680	89706	29.0
1945	1468	64	1532	95.8	23868	68929	92797	25.7
1946	1474	74	1548	95.2	21379	69619	90998	23.5
1947	1427	80	1507	94.7	20952	70559	91511	22.9
1948	1274	85	1359	93.7	19712	69010	88722	22.2
1949	1250	90	1340	93.3	19949	73290	93239	21.4
1950	1272	95	1367	93.1	20208	74205	94413	21.4
1951	1277	95	1372	93.1	18530	74480	93010	19.9
1952	1311	95	1406	93.2	16853	77301	94154	17.9
1953	1348	110	1458	92.5	16334	84567	100901	16.2
1954	1370	125	1495	91.6	15910	87874	103784	15.3
1955	1369	147	1516	90.3	14688	90960	105648	13.9
1956	1385	157	1542	89.8	13264	95521	108785	12.2
1957	1360	175	1535	88.6	11669	98284	109953	10.6
1958	1400	180	1580	88.6	10280	99626	109906	9.4
1959	1360	230	1590	85.5	9073	100809	109882	8.3
1960	1310	268	1578	83.0	7942	103791	111733	7.1
1961	1210	385	1595	75.9	6910	108145	115055	6.0
1962	1150	480	1630	70.6	5973	110280	116253	5.1

**Table 5. Production of Dairy Products by North Dakota Dairy Plants, 1940-1962.**

Year	Ice cream	Creamery butter	Creamed cottage cheese	Other frozen products	Cottage cheese curd	Total sold as whole milk or farm skimmed cream	Cream sold to plants & dealers quantity bft.	Milk sold to plants & dealers
	(thousand) gallons	(thousand) pounds	(thousand) pounds	(thousand) pounds	(thousand) pounds	(million) pounds	(thousand) pounds	(million) pounds
1940	1,086	58,416	—	26	161	1,562	55,440	43
1941	1,267	64,638	—	13	167	1,731	61,360	50
1942	1,468	66,675	—	22	177	1,792	63,220	60
1943	1,231	62,597	—	140	116	1,757	61,580	70
1944	1,296	56,093	—	124	132	1,665	58,440	84
1945	1,505	51,007	—	389	175	1,532	53,580	64
1946	3,079	49,800	169	2	107	1,548	53,800	74
1947	2,677	49,525	200	7	134	1,507	52,090	80
1948	2,324	44,999	184	22	151	1,359	46,500	85
1949	2,211	43,372	194	101	Not Listed	1,340	45,620	90
1950	1,948	44,534	146	215	183	1,367	46,430	95
1951	1,947	44,636	309	371	156	1,372	46,610	95
1952	2,196	44,658	317	397	172	1,406	47,850	95
1953	1,999	50,118	419	355	239	1,458	49,200	110
1954	1,952	50,602	518	438	289	1,495	50,000	125
1955	1,980	51,726	588	543	303	1,516	49,970	147
1956	2,058	52,172	729	—	386	1,542	50,550	157
1957	2,294	56,759	869	—	578	1,535	48,960	175
1958	2,324	57,365	1,102	2,107	859	1,580	49,700	180
1959	2,562	56,134	1,084	2,309	681	1,590	47,600	230
1960	2,522	56,867	1,092	—	602	1,547	45,500	247
1961	2,679	56,498	1,085	—	494	1,595	42,960	385
1962	2,622	52,763	1,099	—	536	1,630	41,400	480

Source: Taylor, F. R., R. F. Engelking, and C. J. Heltemes, **North Dakota Agricultural Statistics**, Bulletin 408, Department of Agricultural Economics, Agricultural Experiment Station, North Dakota State University and Statistical Reporting Service, USDA, Fargo, North Dakota, February, 1962, pp. 38-39.

**Milk Production, Disposition, and Income, 1961-1962**, Statistical Reporting Service, USDA, April, 1963.

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