RESOURCE PRODUCTIVITY IN KANSAS-NEBRASKA AND NORTHERN CREAMERIES

by

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INTRODUCTION

During the past three decades there has been an increase in the consumption of non-fat milk solids and a downturn in the use of fat milk solids per person. The uptrend in non-fat consumption has resulted in an expanded use of dairy products containing non-fat solids, such as cheese, ice milk products, and packaged non-fat milk powders.

The decrease in consumption of milk fat is primarily due to the lower consumption of butter per person. During the period between World War I and World War II, per capita consumption of butter, relative to disposable income, slowly declined. In the World War II period, consumption declined more rapidly as point rationing and physical shortages caused many consumers to use oleomargarine. Consumers did not shift back to the higher-priced butter after the War. Moreover, vegetable fat replaced milk fat in numerous other products and fluid milk sales changed to a lower fat content (Plate I).

The shift in consumer preferences resulted in a greater proportion of the nation's milk supply being marketed off farms in the form of whole milk rather than cream (Table 1). In the year immediately preceding the War (1941), approximately 37 percent of the total United States milk supply was marketed as farm-separated cream. In 1956, the proportion marketed in this form was only 12.4 percent.[1]

Decreased demand for butter and a change in farm output from cream to whole milk are of special concern to the dairy industry of Kansas and Nebraska. These two states supplied 117,000,000 pounds or over eight percent of the total butter manufactured in the United States in 1956.[2]

Between 1941 and 1956, butter manufacturing decreased 25 percent in the United States. In the same period, Kansas reduced production 50 percent and Nebraska reduced production sixteen percent (Appendix Table 7).[3]

This study involves the adjustment problems faced by management of creamery enterprises in Kansas and Nebraska as a result of the changes in farm output of milk.

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1 U.S. Department of Agriculture, Agricultural Marketing Service, Milk: Farm Production, Disposition, and Income, April 1957, p. 6.

2 U.S. Department of Agriculture, Agricultural Marketing Service, Production of Manufactured Dairy Products, October 1955.

3 U.S. Department of Agriculture, Agricultural Marketing Service, Production of Manufactured Dairy Products, October 1951 and October 1955 issues.

Table 1. Forms in which milk, or its equivalent in other dairy products, was sold off farms in the United States, 1940-56.

Year	Sold to plants and dealers: As whole milk	Sold to plants and dealers: As farm-skimmed cream	Retailed by farmers as milk and cream*	Total	Percent marketed as cream
	Millions of pounds				
1940	47,152	32,965	6,109	86,226	38.23
1941	52,062	33,967	5,948	91,977	36.92
1942	59,076	31,080	5,862	96,018	32.36
1943	59,656	29,871	5,739	95,266	31.35
1944	63,680	26,026	5,750	95,456	27.26
1945	68,929	23,868	5,576	98,373	24.26
1946	69,619	21,379	5,352	96,350	22.18
1947	70,559	20,952	4,907	96,418	21.73
1948	69,010	19,712	4,572	93,294	21.12
1949	73,290	19,949	4,234	97,473	20.46
1950	74,205	20,208	3,935	98,348	20.54
1951	74,480	18,530	3,738	96,748	19.15
1952	77,301	16,853	3,518	97,672	17.25
1953	84,567	16,334	3,208	104,109	15.68
1954	87,874	15,910	2,930	106,714	14.90
1955	90,801	14,815	2,677	108,293	13.68
1956**	95,083	13,816	2,436	111,335	12.40

Source: Milk: Farm Production, Disposition, and Income, United States Department of Agriculture, Agricultural Marketing Service, April 1957, p. 6.

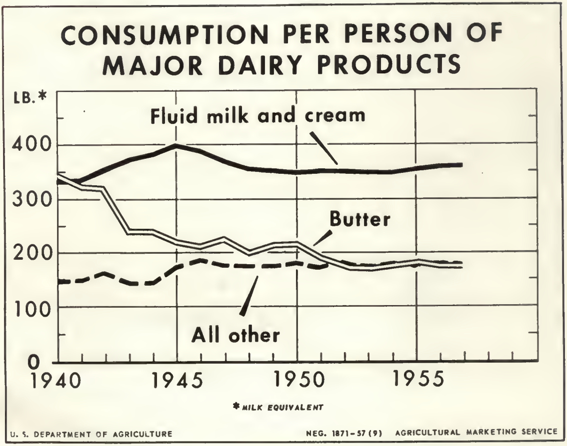
* Approximations based on information on sales by producer-distributors and other farmers on own routes or at farm.

** Preliminary.

EXPLANATION OF PLATE I

Annual consumption per person of the major dairy products on a milk equivalent basis, in the United States, 1940 through 1956.

PLATE I


CONSUMPTION PER PERSON OF
MAJOR DAIRY PRODUCTS
LB.*
Fluid milk and cream
Butter
All other
400
300
200
100
0
1940
1945
1950
1955
* MILK EQUIVALENT
U. S. DEPARTMENT OF AGRICULTURE
NEG. 1871-57 (9)
AGRICULTURAL MARKETING SERVICE

HISTORICAL PERSPECTIVE

The historical setting of the dairy industry in the Central Plains provides a contrasting background to its present position. Back in 1940, there were 708,000 dairy cows on farms in Kansas, and 605,000 in Nebraska. By 1956, dairy cow numbers were 443,000 and 422,000 in these two states, respectively -- a decline of 39 percent and 30 percent in sixteen years.[1] A decline of this extent would lead one to expect a comparable reduction in the milk output-off farms. However, in this same period, production of milk did not decrease as greatly because milk production per cow was increasing. Improved production techniques and careful selection in breeding resulted in a 26.5 percent increase in production efficiency during the span of 16 years (1940-56) in Kansas and Nebraska. This was roughly equivalent to an increase of 1100 pounds of milk per cow in these two states. Despite the increased production per cow, total milk production decreased 583 million pounds in Kansas, a decline from 2860 to 2277 million pounds of milk or twenty percent. The trend was quite similar in Nebraska, where production dropped from 2589 million to 2283 million pounds of milk--a fall of 12 percent.[2] There

1 U.S. Department of Agriculture, BAE, Farm Production, Disposition, and Income from Milk, April 1952, p. 2; and Milk: Farm Production, Disposition, and Income, April 1957, p. 8.

2 Loc. cit..

have been some recent indications of a possible leveling off in the trend towards lower production of milk. Since 1953, production has remained near the two billion pounds level in both Kansas and Nebraska.[1]

Accompanying the trend towards lower milk production was an important change in the form in which milk was marketed. For several decades, farmers in Kansas and Nebraska sold their milk off farms primarily in the form of farm-separated cream. As the demand for butter declined and consumption of fluid milk and non-fat milk solids increased, farmers felt encouraged to market a larger proportion in the form of whole milk in expectation of higher returns. This shift was much more rapid in Kansas than in Nebraska. For example, during most of the World War II years (1940-44), Kansas farmers marketed nearly 69 percent of their milk output as cream. But by 1956, this proportion had declined to only 30.6 percent. During the same years, Nebraska farmers lowered the proportion from 83 percent to 71.6 percent. The contrast between Kansas and Nebraska in this respect is more striking when examined on an absolute basis. In a recent six-year period (1950-56), both states had higher marketings of whole milk. In Kansas this was accompanied by a decline in cream marketings from 1180 million

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1 U.S. Department of Agriculture, Agricultural Marketing Service, Milk: Farm Production, Disposition, and Income, April 1954, and following issues.

pounds of milk equivalent down to 600 million pounds in 1956, a decrease of nearly 50 percent. However, during this same period, Nebraska actually increased cream output from 1401 to 1420 millions pounds--an increase of slightly over one percent (Appendix Tables 8 and 9).[1]

The changing structure of the dairy industry with regard to the volume and composition of farm output of milk materially affected the operations of creamery enterprises. In some areas, it meant a reduced source of cream supplies which caused a number of plants to cease operations entirely. In Kansas, there were 123 creameries in 1940 and only 38 in 1956, a decrease of 69 percent. Nebraska creameries decreased from 119 to 56, or 53 percent in the same period.[2] The fewer number of creameries is partly accounted for by consolidations or mergers of some of the smaller plants. Average production per creamery rose from 616,309 pounds of butter in 1940 to 1,071,895 pounds in 1956 in Kansas, and from 700,227 pounds to 1,362,232 pounds of butter in Nebraska. This was an increase in average plant volume of over 50 percent in both states in 16 years.[3]

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1 A peak of 1504 million pounds of farm-separated cream was sold in 1954 in Nebraska.

2 North Central Regional Committee, "Great Plains Dairy Data", a statistical supplement to Dairy Marketing in the Northern Great Plains - Its Patterns and Prospects, p. 50; and U.S. Department of Agriculture, Agricultural Marketing Service, Production of Manufactured Dairy Products, October 1957, p.38.

3 Loc. cit.

Thus, creamery operations were adjusted for a larger volume of production per plant as well as for receiving a larger proportion of butterfat supplies in the form of whole milk.

To meet the increased demand for more dairy products consisting of nonfat milk solids, creameries shifted to a greater production of manufactured dairy products other than butter. During 1949, Kansas converted 299,601,000 pounds of whole milk to manufactured dairy products, in addition to butter. By 1956, the amount had risen to 377,148,000 pounds--an increase from 23 to 30 percent of the total whole milk used for all manufacturing purposes. Nebraska diverted 100,111,000 pounds of whole milk to manufactured purposes other than butter in 1956, compared to 85,338,000 in 1949. This represented an increase from 5 to 6 percent.[1] The greatest expansion in manufactured dairy products was for the production of condensed milk (skim, unsweetened, bulk) which increased 920 percent in Nebraska from 1949 to 1955. Ice cream production in that state also increased 6 percent in the same period. Meanwhile, Kansas increased production of non-fat dry milk solids (spray process), 14 percent and ice cream, 18 percent (Table 2). On a nationwide basis, in 1940 only 55 percent of non-fat milk solids were utilized for human consumption. This figure increased to

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[1] U.S. Department of Agriculture, Agricultural Marketing Service, Production of Manufactured Dairy Products, November 1950 and October 1957 issues.

80 percent in 1956.[1]

Although dairying is considered an important source of income for those who are primarily engaged in dairy enterprises, the proportion which it contributes to the total cash receipts from all farm marketings has been of declining importance in Kansas and Nebraska since the 1930's. During the five-year period of 1935-39, cash receipts from dairy products amounted to 11 percent of the total in Kansas and 10 percent of the total in Nebraska (Appendix Table 11). The high prices during and following World War II for cash grain and other farm commodities caused many producers to either abandon the dairy enterprise or reduce its importance relative to other farming enterprises. Thus, by 1956, dairy income accounted for only 8 percent of the total cash income from marketings in Kansas and for only 6 percent of the total in Nebraska. This may be compared with dairying in a more typical dairy state such as Minnesota where 21 percent of the cash receipts were accounted for by dairy products in 1956.[2]

THE PROBLEM

Having made certain adjustments in plant operations to meet the shift in farm output of milk and changes in consumer preferences, creamery operators are interested in knowing whether

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1 Anthony S. Rojko, "The Demand and Price Structure for Dairy Products, p. 27.

2 U.S. Department of Agriculture, Agricultural Marketing Service, Production of Manufactured Dairy Products, November 1956, p. 44-45.

Table 2. Number of plants and volume of production of specified types of dairy products in Kansas, Nebraska, Minnesota, and the United States, for selected years.[1]

	Butter		American cheese		Condensed milk (skim, bulk)		Dry milk solids (non-fat, spray)		Ice cream	
	1949	1955	1949	1955	1949	1955	1949	1955	1949	1955
Kansas										
No.of plants	70	43	23	15	12	10	6	8	95	59
Production[a]	47,490	42,929	9,121	13,324	30,287	34,526	10,257	17,372	5,245	6,164
Nebraska										
No.of plants	103	62	3 or 4	----	3 or 4	3 or 4	----	3 or 4	56	35
Production[a]	73,607	75,071	1,383	----	1,409	14,506	----	3,727	5,714	6,075
Minnesota										
No.of plants	679	575	53	37	9	10	32	51	89	101
Production[a]	252,621	281,176	54,309	53,340	9,036	10,795	127,775	280,107	13,298	15,988
United States										
No.of plants	3,140	2,342	1,682	1,356	385	348	209	306	3,308	3,008
Production[a]	1,412,101	1,386,158	935,018	1,002,754	535,844	639,300	629,341	1,212,404	506,803	574,387

a All productions are in thousands of pounds except ice cream, which is in thousands of gallons.

Source: U.S. Department of Agriculture, Agricultural Marketing Service, Production of Manufactured Dairy Products, Statistical Bulletin No. 93, November 1950, and Statistical Bulletin No. 199, November 1956.

1 Production omitted for states having less than 3 plants reporting.

they have achieved optimum use of the resources. Managers, directors, lenders of credit, and farmers would also like to compare Kansas-Nebraska returns from dairying with returns from more typical dairy regions. Policy makers are interested from the standpoint of transferring resources from one area to another for optimum use, or in allocating new resources if such become available. Management would also like to know whether greater plant efficiency could be obtained by a rearranging of resources--such as substituting capital for labor inputs, or by expanding or contracting the volume of operations. Further adjustments may be needed to obtain the goal of maximum efficiency in the use of input resources.

This study will apply economic choice criteria to help solve some of the problems existing today in the dairy manufacturing industry of Kansas-Nebraska.

OBJECTIVES

The general objective was to determine whether the goal of economic efficiency in resource use was attained by the Kansas-Nebraska creameries.

Specific objectives were: (1) to compare resource productivities of Kansas-Nebraska creameries with those of Northern creameries; (2) to determine whether plants were of optimum size; (3) to determine the efficiency of factor markets; and (4) to observe the statistical results obtained from varying the definition of capital service inputs. These objectives were formulated and analyzed in terms of an analytical model to be developed in the following section.

THE ECONOMIC MODEL

Basic estimates needed for making resource efficiency comparisons are the values of marginal products of various resources. These indicate the added return expected from the addition of another dollar of investment in the resource being considered. The estimates are useful for comparing returns from the same resource in different areas as well as for comparing returns to different resources in a single area. If the marginal product of a resource in one area (Area A) differs significantly from the marginal product of the same resource in another area (Area B), an adjustment or shift of resources from one area to another is indicated. The logical shift would be to transfer resource from the area of the smaller marginal product to the area of the larger marginal product.[1] Optimum resource use is achieved when the value marginal products are equal in both areas.

Certain conditions must hold if maximization of a given end or attainment of a specific goal is to be achieved. With a given

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[1] The assumption being that diminishing returns exist for the resource in both areas.

amount of composite resource (X), the production possibilities for a product-product model are shown in Fig. 1, Plate II. A transformation or opportunity curve is constructed from a table which gives all the amounts of products A and B that are produced when resource X is employed for production of various combinations of products A and B. The curve indicates that if the entire amount of resource X is used to produce product A, the quantity OA will be obtained but none of product B. Or, if all of resource X is used to produce product B, the quantity OB can be obtained but no amount of product A. Between these two extremes, the transformation curve also indicates the maximum quantity of one product that can be produced when the amount of the other product is specified.

The relevance of the model to this study is further illustrated by Plate II, Fig. 2. Products A and B may be considered as representing production of butter in two different areas, A and B. This model shows how the maximization of a product or of a specified goal is achieved.[1] The lines R_1, R_2, and R_3 represent constant revenue amounts. At any point on an iso-revenue line, revenue may be defined as $P_a \cdot Q_a$ plus $P_b \cdot Q_b$

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[1] An initial objective of this study was to make a comparison of resources used for butter-making to alternative uses, such as for producing grade A milk. In this case product A could be butter and product B grade A milk. Such a study would have involved considerable more data and analysis. With limited funds and data on hand, it was possible to make an inter-industry study of this type.

where P_a and P_b represent the prices of butter in areas A and B, and Q_a and Q_b represent quantities of butter output in each area as determined from a point such as P on the transformation curve.

All points on the same constant revenue line represent equal amounts of revenue. The ratio of butter prices for areas A and B, expressed in algebraic terms, is $-\frac{P_a}{P_b}$, which is also the slope of the iso-revenue lines. Movements from R_1 to R_2 to R_3 describe successively larger amounts of revenue. It is readily apparent that points on R_1 and R_2 that are not enclosed by the curve are irrelevant since such combinations cannot be made with the composite resource X. Nor is there any point on R_3 which is relevant because the curve does not even touch it. A combination of products causing point P to be on R_1 would also be irrational since a more desirable combination of products could be chosen so that P is on the R_2 iso-revenue line.[1] At the point of tangency of R_2 and the transformation curve, point P, the most profitable combination of products exists.

Some fundamental allocation criteria can be derived from the above product- product model. If P_a and P_b are the product prices of A and B, and P_x is the price of composite resource X, the production possibilities of transforming resource X into A and B products are given by the equation: $X = f(B, A)$. This is to say, the division of resource X as inputs to produce products A and B depends upon the combination of outputs of A and B.

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1 The combined quantities of products A and B can be determined by drawing a vertical line from point P to the horizontal axis, giving Q_a, and a horizontal line from point P to the vertical axis, giving Q_b.

EXPLANATION OF PLATE II

Fig. 1. The relationship of output A to output B, given a quantity of iso-resource X.

Fig. 2. The relationship of the transformation curve to iso-revenue curve R_2 at the optimum product combination point P.

PLATE II

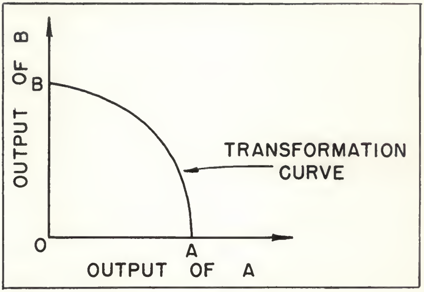

Fig. 1

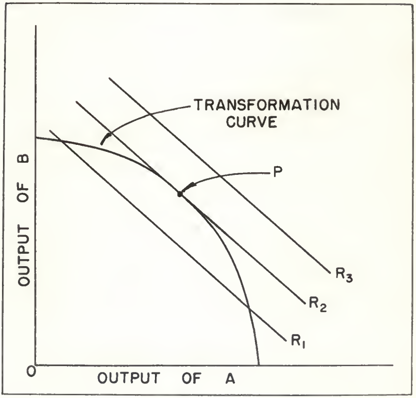

Fig. 2

An equation of ratios of marginal products to product prices is essentially an equation of slopes since lines and curves at their point of tangency have the same slopes.[1]

By calculus, the slope of a line or curve is obtained by taking the derivative of the equation which describes it. The total derivative of the function $X = f(B,A)$ with respect to A, equated to zero, is:

(1) $\frac{\partial X}{\partial B} \cdot \frac{dB}{dA} + \frac{\partial X}{\partial A} = 0$

(2) $\frac{\partial X}{\partial B} \cdot \frac{dB}{dA} = - \frac{\partial X}{\partial A}$ or $\frac{dB}{dA} = - \frac{\frac{\partial X}{\partial A}}{\frac{\partial X}{\partial B}}$

(3) At point P $\frac{dB}{dA}$ is equal to the slope of the iso-revenue line R_2.

(4) Therefore, at point P, $- \frac{\frac{\partial X}{\partial A}}{\frac{\partial X}{\partial B}} = - \frac{P_a}{P_b}$

(5) Multiplying both numerator and denominator of the left-hand side of (4) by the price of resource P_x gives

$$- \frac{\frac{\partial X}{\partial A} \cdot P_x}{\frac{\partial X}{\partial B} \cdot P_x} = - \frac{P_a}{P_b}$$

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[1] The concept of marginal products as it relates to the production function will be further discussed in the section Methods of Analysis.

(6) But $\frac{\partial X}{\partial A} \cdot P_x$ is the marginal unit cost (MUC_a) of A, and

$\frac{\partial X}{\partial B} \cdot P_x$ is the marginal unit cost (MUC_b) of B.

(7) Therefore $\frac{MUC_a}{MUC_b} = \frac{P_a}{P_b}$

(8) Rearranging (7) gives $\frac{P_a}{MUC_a} = \frac{P_b}{MUC_b}$

From (8) we can conclude when a single resource is used to produce two products and the price of the resource is the same for both uses, optimum resource allocation is attained when the product prices are proportional to marginal unit costs.

(9) When the prices of the resource used to produce A and B are different but constant, the following condition must be met:

$$\frac{P_a}{\frac{P_{xa}}{MPP_{r_a}}} = \frac{P_b}{\frac{P_{xb}}{MPP_{r_b}}}$$

when P_{xa} and P_{xb} are prices of the resource used for A and B, respectively, and MPP_{r_a} is the marginal physical product of A and MPP_{r_b} is the marginal physical product of B.

(10) Rearranging (9) gives

$$\frac{P_a \cdot MPP_{r_a}}{P_{x_a}} = \frac{P_b \cdot MPP_{r_b}}{P_{x_b}} \text{ or } \frac{VMPP_{r_a}}{P_{x_a}} = \frac{VMPP_{r_b}}{P_{x_b}}$$

The condition in (10) means that, for optimum resource allocation, the value of the marginal physical products ($VMPP_r$) of A and B must be proportional to the prices of the resources used to produce A and B when the prices of the resource are different but constant.

In comparing the resource productivity of Kansas-Nebraska creameries to those of Northern creameries, it was assumed that the prices of resources were the same for each area. The hypothesis which stipulated equal resource productivity of creameries between areas was thus stated as $VMPP_{r_a} = VMPP_{r_b}$. If this hypothesis could be rejected, the results would indicate a need for readjustment of resource use between Kansas-Nebraska and Northern creameries.[1]

After formulating the problem and hypothesis, the next step of research consisted of designing empirical procedures to be used in the analysis.

THE SAMPLE

Preliminary Population of Kansas-Nebraska Creameries

All plants producing only butter, or butter and other manufactured dairy products, were defined to be the preliminary

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[1] A secondary objective of this study was to determine whether plants were operating at the optimum volume of operations for maximum profits. The discussion on economics of size or returns to scale is set forth in the section entitled Analysis.

population of interest at the outset of the study. This definition was essential since a substantial number of plants, particularly in Kansas, were diversified manufacturing operations.

The State Agricultural Statistician's office in each state furnished information on the number of plants by type and volume categories (Table 3). The most recent data available at the time the sampling plan was designed were for the year 1951 for Nebraska and for 1952 for Kansas.

Table 3. Distribution of the number of dairy manufacturing plants producing butter, by size groups and type of ownership in Kansas and Nebraska.[a]

Annual butter production (1000 lbs.)	Number								Kansas and Nebraska
	Kansas				Nebraska				
	Coop.	Ind.	Line	Total	Coop.	Ind.	Line	Total	
Less than 500	0	32	5	37	17	17	0	34	71
500-999	0	1	3	4	3	5	2	10	14
1,000 and more	8	2	6	16	8	4	12	24	40
Total	8	35	14	57	28	26	14	68	125

[a] Figures are for calendar year 1951 in Nebraska and for 1952 in Kansas.

Sub-population of Kansas-Nebraska Creameries

Data for the 28 line plants in Kansas and Nebraska were not readily available so these plants were excluded, leaving 97 creameries in the sub-population of interest.

Sample Design for Kansas Creameries

Availability of useable data was a major consideration in this analysis. The fourteen line plants were excluded because data were not readily available from these. A modified stratified random sampling plan was used for the remaining 43 plants. Since detailed audit data were available from all eight Kansas cooperative creameries, these were included in the sample. There were only two high-volume and one medium-volume independent plants so all three of these were chosen to be sampled. Of the 32 low-volume independents, sixteen were chosen at random. One alternate plant was also selected for this stratum. In all, 27 of the 43 plants in the sub-population of Kansas were included in the sample.

Sample Design for Nebraska Creameries

The fourteen line plants were excluded from the preliminary population of Nebraska creameries leaving 54 cooperative and independent plants in the sub-population of interest. Of these, twenty-seven, or approximately one-half in each of the six-volume type stratums, were selected at random. One alternate plant was also chosen for each stratum.

Sample Design for Northern Creameries

The sample of 168 Northern creameries was obtained from audit records of a cooperative auditing firm in Minnesota. Four plants were located in Wisconsin, one in Iowa, 22 in North Dakota, and 141 in Minnesota. They ranged in type from those highly-specialized for butter production to widely-diversified units. For comparative purposes, the 168 Northern creameries were stratified as follows:

Group	No. of plants	Percent of butterfat supplies received in the form of milk
		%
Low diversification	49	0
Medium diversification	67	0.08 to 39.41
High diversification	52	42.3 to 100.0

The low-diversification stratum appeared to be more nearly comparable to Kansas-Nebraska creameries which also received a large proportion of their butterfat supplies in the form of cream in 1953. The Northern aggregate sample could serve for an interindustry study as a considerable proportion of the plants in the aggregate received a substantial amount of their butterfat supplies in the form of whole milk. The geographical location of the 168 Northern creameries is shown on Plate III.

Collection and Adjustment of Data

Wherever possible, data for the creameries were obtained from annual audit records. All observations for the Northern plants were secured by this method and eight Kansas creameries and seven Nebraska creameries had audit records. Personal interviews were also held with creamery managers of plants comprising the Kansas-Nebraska sub-population.

Several check ratios were employed to check accounting data for reliability and consistency. The ratios were: output value per pound of butter sales, expenses per pound of butter sales, gross profit per pound of butter sales, labor costs compared to total costs, and pounds of butter manufactured compared to pounds of butterfat used. These check ratios resulted in rejection of eighteen Kansas creameries and eight Nebraska creameries.[1] The geographical distribution of the remaining 28 Kansas-Nebraska creameries is shown on Plate IV. The distribution by size group and type of ownership is given in Table 4.

Table 4. Distribution of the final sample of 28 Kansas and Nebraska dairy manufacturing plants (by size group and type of ownership).

Annual butter production (1000 lbs.)	Number				Total for Kansas and Nebraska
	Kansas		Nebraska		
	Coop.	Ind.	Coop.	Ind.	
Less than 500	0	1	6	2	9
500-999	0	0	4	3	7
1,000 and more	8	0	3	1	12
Total	8	1	13	6	28

1 It should be noted that many of the Kansas-Nebraska creameries had extremely poor accounting systems. This situation had been noticed on previous surveys of other types of processing plants in the area.

PLATE III

EXPLANATION OF PLATE III

Geographical distribution of the 168 Northern Creameries comprising the aggregate sample, located in North Dakota, Minnesota, Wisconsin, and Iowa.

The majority of audits of Kansas-Nebraska creameries contained data for the calendar year 1953. In a few instances, the audit period varied from the calendar year by several months but the variation was not considered sufficiently important to involve an adjustment of data. For two Kansas creameries and one Nebraska creamery, the audit period necessitated an adjustment of their data. The adjustment was made by using indices of average weekly earnings of dairy products workers in Kansas, cost of general purpose machinery, and Chicago 92 score butter prices (Appendix Tables 12 - 15). Audit records for Northern creameries were for the period May 1, 1952 to April 30, 1953. Data of the 49 creameries in the Northern low-division stratum were not adjusted for the Northern low-division function A but were adjusted in Northern low-division function B, using indices of average weekly earnings of production workers of food and kindred products in Minnesota, cost of general purpose machinery, and Chicago 92 score butter prices (Appendix Tables 14-18).

Accounting firm audits usually show information on gross sales, net sales, operating expenses, and net profit or operating margin. Operating statements, although useful, do not provide creamery managers with information on productivity of individual resources or economies of size for plant operations. This analysis is intended to furnish such information which is vital for policy decisions.

EXPLANATION OF PLATE IV

Fig. 1. The geographical location of the nineteen creameries in Nebraska included in the final Kansas-Nebraska sample.

Fig. 2. The geographical location of the nine creameries in Kansas included in the final Kansas-Nebraska sample.

PLATE IV

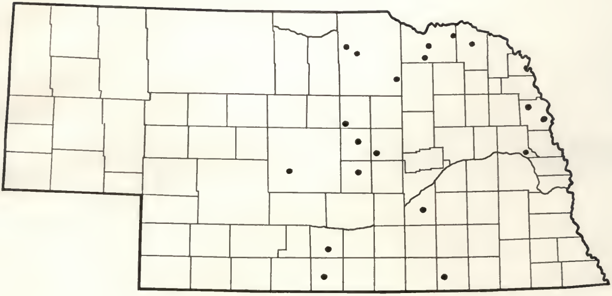

Fig. 1

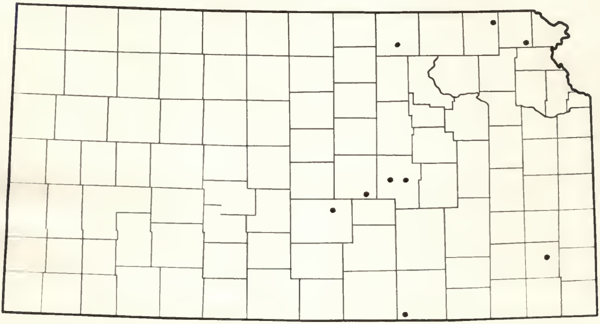

Fig. 2

METHODS OF ANALYSIS

Procedure of Analysis

The environment of the model assumed an economic system in which consumer sovereignity, the prevailing distribution of national income, existing organization of industry, and primary production were all given. Profit maximization was assumed to be the sole objective of the firms operating in a pure competitive market, with prices of factors and products as given.[1]

A Cobb-Douglas type of production function was used to estimate productivity of resource use of Kansas-Nebraska and Northern creameries. The general form of the production function was $Y = f\,(a\,X_1^{b_1}\,X_2^{b_2}\text{----}X_n^{b_n})$. The Y represented the monetary value of output. Inputs (X_i's) consisted of physical quantities of butterfat and monetary expenditures for labor, operating expenses, and capital services.

The Cobb-Douglas function becomes linear when the data is transformed into logarithmic values. The linear form is then, $\log Y = \log a + b_1 \log X_1 + b_2 \log X_2 \text{-----} b_n \log X_n$. By converting the exponential equation to the logarithmic form, the function can be readily fitted to the data by the method of least squares. Elasticities of production (b_i's) are solved for as

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[1] This hypothesis seems reasonable for butter-manufacturing plants although it would not be applicable for fluid milk plants.

regression coefficients. The value of a coefficient indicates the percentage change in output expected for a one percent change in input of a particular resource, when the other resources are held constant.

Values for marginal products are computed from the production function as partial derivatives with respect to a particular resource input (X_1):[1]

$$Y = a X_1^{b_1} X_2^{b_2}$$

$$\frac{\partial Y}{\partial X_1} = b_1 \cdot \frac{Y}{X_1}$$

The advantages of the Cobb-Douglas function were summarized by Tintner as follows:[2]

> "(1) It gives immediately elasticities of product with respect to the factors of production. That is, we get answers to the question: by how many percent will the product increase on the average if the given factor increases by one percent. Elasticities are dimensionless numbers and are independent of the units of measurement.
>
> (2) Our form of production function permits the phenomenon of decreasing marginal returns to come into evidence without using too many degrees of freedom. This would not be possible if we should fit a linear function to our data as such, without using the logarithms. If we should use, on the other hand,

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1 The X_1 and Y being computed at the geometric means of variables.

2 Gerhard Tintner, "A Note on the Derivation of Production Functions from Farm Records", Econometrica, January 1944, 12:26-27.

> a quadratic function, we could get decreasing returns. But such a function would necessitate more than twice as many regression coefficients and hence substantially diminish the number of degrees of freedom".[a]
>
> . . . .
>
> [a] If n is large, the loss of degrees of freedom is of little consequence when the quadratic function is used but computational effort is greatly increased.

A Cobb-Douglas function, permits some interaction between variables. It also lumps resources together into categories of inputs rather than expressing the specific production resources employed. It has been termed a distributive function in contrast to a general function.[1]

Since elasticities of production are assumed to remain constant, inferences regarding returns to scale are made for the entire range of the data. The function curve becomes asymptotic to a production limit, and does not allow a change to a decreasing total product. Marginal product ratios of the various resources change so that inferences about these are most valid at the mean.[2] Slopes of successive contour or

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[1] M. Bronfenbrenner and Paul A. Douglas, "Cross-Section Studies in the Cobb-Douglas Function", The Journal of Political Economy, December 1939, 47:761-785.

[2] In a recent unpublished study, H.O. Carter and H.O. Hartley, of Iowa State College, made a study to compare the usual method of computing variance of marginal productivity estimates with a more refined method. They concluded that the error for the usual method was probably small if the estimate of variance was made at the geometric mean, but it increased rapidly as the estimates were made further away from the mean.

iso-product lines are assumed the same at each point where they are intersected by a given scale line. In other words, the same rate of resource substitution is assumed to exist for all contour lines if the proportions of various resources remain unchanged. The least cost combination of resources for one level of output also gives the least cost combination for all other levels of output.

Returns to individual resources are indicated by the values of elasticity coefficients. An elasticity value of less than one indicates diminishing returns, a value of one indicates constant returns, and a value greater than one gives indications of increasing returns to a specific resource. Inputs of other resources are assumed to be held fixed when inference is made about a specific resource's returns. The sum of elasticity values indicates the expected percentage change in output when all inputs are increased by one percent. If the sum of elasticities is one, constant returns to scale exist. If the sum is less than one, diminishing returns exist, or if the sum is greater than one, increasing returns to scale are evidenced. When decreasing returns exist, claims of the factors are less than the total product while under increasing returns claims are greater than the total product.

The production function in this analysis was applied to the data of a group of firms. It is therefore more appropriate for interfirm comparisons than for intrafirm applications.

Classification of Data and Characteristics of Variables

In classifying resources for a production function, it is essential that inputs are grouped in their proper categories. For each separate classification or category, inputs should consist of groups of complements or substitutes. The several categories should be neither good complements nor good substitutes for each other. Only two of the broad economic categories of land, labor, and capital were included in this study. Land was excluded as it was a relatively minor input.

The initial function (hereafter referred to as Kansas-Nebraska function A) consisted of four resource inputs. These were: butterfat, labor, operating expenses, and capital services. Usually, creameries engage in some sideline activities, such as handling feed, produce, manufacturing ice cream, or bottling milk. This was true of all the Nebraska firms and of all but two of the Kansas creameries. Joint costs of the butter enterprise and various sidelines were allocated on the basis of gross sales in each department except where the manager or the auditor made allocation on some other basis.

Butterfat inputs consisted of physical quantities of cream used in manufacturing butter. Labor inputs grouped together ordinary labor wages and salaries for managerial services. In some instances, the salaries of management may also have included an entrepreneurial reward, but this could not be eliminated because a satisfactory method of measuring entrepreneurial inputs has not yet been devised. However it is known that for many agricultural marketing firms there is little to distinguish the services of the manager from the remainder of the working force.[1] This condition was believed to hold true for many of the smaller creameries in the sample. Current operating expenses which contributed directly to the production process constituted the operating expense input. Office supplies and telephone expenses were included in this category on the belief that these expenses were necessary in any modern operational system.

The capital input was defined in several different ways in order to compare the statistical results obtained from using various accepted capital measurements. Capital inputs are usually regarded as primarily capital goods such as buildings and equipment. The most widely-accepted measure of the service flow from capital goods is the accountant's term for depreciation. In addition to depreciation, economists include expenditures for repairs and maintenance of capital assets, and other expenditures which are directly related to the use of capital, such as utilities and rents. Some employ a combination of all of these while others choose only one or several to represent capital use. Admittedly, these measurements are rough approximations of the true contribution of capital to the production process.[2] The functions developed in this study

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1 Paul Leo Kelley, "Resource Productivity in Agricultural Marketing Firms of the Midwest", an unpublished project report, p.103.

2 A detailed discussion of this problem is presented in a later section entitled Methodology of Capital Measurements.

were designed to observe the appropriateness of employing various known measures of capital services, as well as to provide information about capital productivity of the Kansas-Nebraska creameries.

Kansas-Nebraska Function A. In this function Y or output was defined as the gross value (in dollars) resulting from butter manufacturing.[1] Inputs consisted of butterfat, in physical quantities, represented by X_1; expenditures for labor services, X_2; expenditures for operating expenses, X_3; and capital services (in dollars), X_4. Miscellaneous sales of surplus cream or by-products such as buttermilk were excluded from the gross product. Purchases of cream and sales of butter were confined to a F.O.B. plant basis. Selling costs such as freight and drayage out, sales route, transport and delivering expenses were excluded.

The pounds of butterfat input for one Kansas creamery were estimated by dividing the plant's total butter sales by the prevailing price for butter in the area. An overrun ratio of 1 to 1.25 was used to convert pounds of butter to pounds of butterfat.

The capital service input included depreciation reserve for buildings and plant equipment, depreciation of office equipment, rent and lease expenditures, maintenance and repairs,

1 See Appendix Table 19 for a more complete description of the variables used in this function.

and expenditures for electricity, fuel, gas, and water. One creamery's statement included an expense for sewage which was not separable. However, the amount was believed to be negligible.

<u>Kansas-Nebraska Function B</u>. Output or Y was defined as the added increment to total product, in contrast to function A in which Y was defined as the gross value of output (Appendix Table 20). A variable for butterfat inputs was omitted in this function and capital service inputs were measured in terms of the monetary value of electrical power consumed during the manufacturing process. The data, for three creameries were omitted from this function because their expenditures for electricity appeared to be confounded with fuel.

<u>Kansas-Nebraska Function C.</u> Output or Y was here defined as the added increment to total product (Appendix Table 21). Capital service inputs were represented by expenditures for all utilities (electricity, gas, fuel, and water).

<u>Kansas-Nebraska Function D</u>. The output, Y, represented the added increment to the total product. Labor and operating expense inputs were defined the same as for Kansas-Nebraska functions A, B, and C. Capital service inputs were defined as for function A, that is, monetary values for depreciation reserve for buildings and plant equipment, depreciation of office equipment, rent and lease expenditures, maintenance and repairs,

and expenditures for electricity, fuel, gas, and water. This function differed from A in the definition of Y and the butterfat input was omitted (Appendix Table 22).

Northern Low-Division Function A. The low-division stratum of 49 Northern creameries which received all of their butterfat supplies in the form of cream was considered the most comparable for resource efficiency comparisons with Kansas-Nebraska creameries. Approximately one-half of the creameries in this stratum were located in Minnesota. The output variable (Y) was defined as the gross amount of butter sales. Input variables were X_1, butterfat; X_2, value of labor services; X_3, the value of operating expenses; and X_4, the value of capital services. A few plants in the stratum utilized some butterfat for other than buttermaking purposes but these amounts were considered negligible (Appendix Table 23).

Northern Low-Division Function B. The function differed from Northern low-division function A in that the output variable (Y) was defined as the added increment to total product rather then the gross output. Results of this function were compared with Kansas-Nebraska function C. The butterfat input therefore was excluded, and capital service inputs were defined as the value of all utilities consumed (Appendix Table 24). Data for the 49 creameries in this function were adjusted to the 1953 calendar year basis.

Northern Aggregate Function. The Northern aggregate function contained a sample size of 168 creameries located in four states as follows: 141 plants in Minnesota, 22 plants in North Dakota, four plants in Wisconsin, and one plant in Iowa. In the function Y was defined as the gross value of output, X_1, butterfat inputs; X_2, inputs of labor services; X_3, inputs of operating expenses; and X_4, the value of inputs of capital services. The results of this function could be compared to results of Kansas-Nebraska function A and Northern low-division function A since the variables for those functions were similarly defined (Appendix Table 25).

Some expenses incurred by creameries were not included in any of the resource inputs of the production function. Indirect expenses such as taxes, insurance, bonds, interest payments and advertising were not included as these items did not contribute directly to the production process, and were not considered essential in the short-run.[1] For example, an insurance expense is generally not carried with the objective of increasing the gross income by at least the amount of the insurance premium but rather for protection against insurable losses. The payment of taxes does not result in a direct value product either. The

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1 These expense items were not included: auditing, taxes, payroll taxes, insurance, interest on loans, advertising, bank charges, bonds, licenses, tax and legal services, corporation fees, documentary stamps, bad debts and other losses, procurement costs, selling costs, and other miscellaneous expenses.

relative importance of input components which were included in the functions is discussed in the next section dealing with economic organization of creameries.

ECONOMIC ORGANIZATION OF THE CREAMERIES[2]

Statistical results obtained from Kansas-Nebraska function A provided a significant elasticity coefficient for only the butterfat input. This input was then omitted from the succeeding Kansas-Nebraska functions. In function B, capital service inputs were measured in terms of expenditures for electrical power. Elasticity coefficients for both labor and operating expense inputs were statistically significant for this function, but it was not directly comparable with the Northern low-division data since capital service inputs for Northern low-division function A were not defined in the same way. Kansas-Nebraska function C and Northern low-division function B were computed in which capital service inputs were defined as expenditures for all utilities (electricity, gas, fuel, refrigeration, and water). The data for Kansas-Nebraska function D again defined capital service inputs in terms of all the usual methods of measurement, as in function A, but it differed from function A in the definition of Y which was here defined as the added increment to total product.

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2 This discussion relates to the creameries included in Kansas-Nebraska function C and Northern-low division function B.

Values of outputs varied considerably more for the samples of Kansas-Nebraska than in the Northern low-division creameries. Product value ranged from a low of $3,780 to a high of $386,023, for the Kansas-Nebraska plants, and from a low of $5,471 to a high of $90,621, for the Northern low-division plants. The maximum value product was thus over 100 times larger than the minimum value product in the Kansas-Nebraska sample while the maximum in the Northern stratum was approximately seventeen times larger than its minimum (Table 5). Kansas-Nebraska input values also ranged more widely than the values of Northern low-division creameries.

Table 5. Minimum and maximum values of range of variables and proportion of productive inputs for Northern low-division function B and Kansas-Nebraska function C creameries, 1953.

Strata	No. of plants	Minimum and maximum values	Product	Labor	Oper. exp.	Capital
			(In dollars)			
Northern Low-division (B)	49	Minimum	5,471	2,200	997	751
		Maximum	90,621	28,852	9,447	6,246
(Percent of total)				(63)	(21)	(16)
Kansas-Nebraska (C)	28	Minimum	3,780	361	13	346
		Maximum	386,023	102,308	57,264	17,266
(Percent of total)				(58)	(32)	(10)

In both regions, values of labor inputs made up more than one-half of the total productive input values, averaging nearly three-fifths when computed at the arithmetic mean. Operating expenses comprised 32 percent of total input values in Kansas-Nebraska but this input averaged only 21 percent in the Northern division.

Kansas-Nebraska also had a higher labor-capital service input ratio. The ratio for Kansas-Nebraska function C was 5.83:1 compared to 3.88:1 for the Northern low-division function B. This means that the value of labor services exceeded the value of capital service charges by these proportions. The Northern creameries apparently used capital to a greater extent than the Kansas-Nebraska creameries.

The large variation in outputs and inputs could be attributed to the various sizes of operations, and to some extent to the degree of diversification and efficiency of plant operations. The 49 Northern creameries operated on a smaller volume scale and one would expect less variation for this group since the plants were chosen from one stratum of the Northern aggregate sample.

THE ANALYSIS

Elasticity Coefficients and Marginal Products

A preliminary analysis to determine whether resource inputs and output were linear in logarithms was made by plotting the data on scatter diagrams. The resulting patterns were sufficient to meet the requirements for using a Cobb-Douglas function. The method of least squares and abbreviated Doolittle system of matrix inversion was then used to fit functions to the data.

Kansas-Nebraska Function A. This function gave the following results: $Y = .9531\ X_1^{.9608}\ X_2^{.0166}\ X_3^{.0072}\ X_4^{.0131}$. Elasticity coefficients for each separate category of resources indicated diminishing returns although the coefficient for butterfat input was much larger than the others, and came near to being one. This coefficient was significant at the one percent level. The sum of coefficients was .9978, indicating diminishing returns to scale. However, the F test indicated that there was no significant difference from constant returns at the five percent level. Coefficients for inputs of labor, operating expenses, and capital were non-significant at the twenty percent level. The computed multiple correlation coefficient (R) was .999 indicating successful estimation of the equation as a whole. Marginal product for butterfat was 77 cents per pound (Table 6).

Kansas-Nebraska Function B. The results of this function were: $Y = 37.5481\ X_1^{.4743}\ X_2^{.2261}\ X_3^{.1318}$. Elasticity coefficients again indicated diminishing returns to each category of inputs since the coefficient for each was less than one.

Coefficients for inputs of labor and operating expenses were significant at the five percent level but the coefficient for capital services was non-significant at the 40 percent level. The sum of coefficients was .8322, indicating diminishing returns. The F test supported this observation at the five percent level. Multiple correlation coefficient, R, was computed as .965. The marginal product for labor was $1.87 and for operating funds, $2.82 (Table 6).

Kansas-Nebraska Function C. The computed function was: $Y = 35.9861\ X_1^{.6032}\ X_2^{.2115}\ X_3^{-.0190}$. The coefficient for capital was negative but the t-test indicated that it was not significantly different from zero at the twenty percent level. Labor and operating expense inputs were significant at the one percent and 5 percent levels, respectively. The sum of the coefficients was .7957 and the F test supported the evidence of diminishing returns to scale at the 1 percent level. The results of this function will be compared with results of Northern low-division function B and discussed under the heading "Productivity Comparisons and Factor Pricing".

Kansas-Nebraska Function D. The computed function was: $Y = 32.5344\ X_1^{.5257}\ X_2^{.2124}\ X_3^{.0788}$. All elasticity coefficients were less than one indicating diminishing returns to individual categories of inputs. The coefficient for labor inputs was significant at the one percent level and for operating expenses at the 5 percent level. Elasticity coefficient for capital services remained non-significant at the 40 percent level. The sum of the exponents was .8170 which was significant at the one percent level. Correlation coefficient, R, was .968 and significant at the one percent level of significance.

Northern-Low-Division Function A. $Y = .8768\ X_1^{.8499}\ X_2^{.1674}\ X_3^{-.0306}\ X_4^{.0821}$. Elasticity coefficient for operating expenses was negative but it was not significantly different from zero at the twenty percent level. The coefficient for butterfat inputs was relatively high, and indicated that a large share of the total product could be attributed to this factor. A similar observation was made for butterfat when it was included as an input in the Kansas-Nebraska function A. Labor was significant at the 5 percent level but inputs of operating expenses and capital were not significant at any acceptable level. The sum of elasticity coefficients was greater than one (1.06780), but the F value for testing returns to scale was not large enough to reject the hypothesis of constant returns to scale at the five percent level. The multiple correlation coefficient, R, was computed as .983. Marginal products were 78 cents per pound for butterfat and $4.82 for labor inputs.

Northern Low-Division Function B. The function computed by least-squares analysis was: $Y = .7491\ X_1^{.6522}\ X_2^{.5111}$

Table 6. Regression coefficients and associated statistics of analytical interest, Northern and Kansas-Nebraska creameries, 1952-53.

Statistic	Kans. Nebr. A (n =28)	Kans. Nebr. B (n =25)	Kans. Nebr. C (n =28)	Kans. Nebr. D (n=28)	Northern low-div. A (n= 49)	Northern low-div. B (n = 49)	Northern aggregate (n=168)
Value of "a" (in log.)	-.0209	1.5746	1.5561	1.5123	-.0571	-.1255	-.1025
Value of "a"	.9531	37.5481	35.9861	32.5344	.8768	.7491	.7898
Elasticities of production (b_i)							
Butterfat	.9608				.8489		.8954
Labor	.0166	.4743	.6032	.5257	.1674	.6522	.0541
Operating expense	.0072	.2261	.2115	.2124	-.0306	.5110	-.0024
Capital	.0131	.1318	-.0190	.0788	.0821	.0160	.1203
Standard errors							
Butterfat	.0336				.0912		.0216
Labor	.0350	.1761	.1448	.1612	.0804	.1222	.0319
Operating expense	.0157	.0927	.0859	.0854	.1196	.1497	.0268
Capital	.0233	.1329	.1152	.1299	.0837	.1347	.0269
Sum of elasticities	.9978	.8322	.7957	.8170	1.0678	1.1792	1.0674
"F" value, returns to scale	.05	5.50[b]	9.69[a]	9.64[a]	2.31	6.64[b]	33.90[a]
Calculated "t" value							
Butterfat	28.620[a]				9.309[a]		41.384[a]
Labor	.476	2.694[b]	4.165[a]	3.261[a]	2.081[b]	5.337[a]	1.696[c]
Operating expense	.461	2.439[b]	2.461[b]	2.489[b]	-.256	3.414[a]	-.088
Capital	.561	.992	-.165	.607	.981	.118	4.474[a]
"R", Multiple correlation Coefficient	.999[a]	.965[a]	.968[a]	.968[a]	.983[a]	.901[a]	.982[a]

a Significant at 1 % level
b Significant at 5 % level
c Significant at 10 % level
d Significant at 20 % level

Table 6 (concl.)

Statistic	Kans. Nebr. A (n=28)	Kans. Nebr. B (n=25)	Kans. Nebr. C (n=28)	Kans. Nebr. D (n=28)	Northern low-div. A (n= 49)	Northern low-div. B (n=49)	Northern aggregate (n=168)
Geometric mean							
Gross income	495,714	69,658	80,100	80,100	185,495	14,392	289,935
Butterfat	619,885				201,021		290,589
Labor	20,855	17,660	20,855	20,855	6,447	6,130	11,340
Operating expense	6,639	5,592	6,639	6,639	3,023	2,809	5,518
Capital	8,228	1,218	3,028	8,228	3,664	1,591	7,029
Geometric marginal product							
Butterfat	.77[a]				.78[a]		.89[a]
Labor	.40	1.87[b]	2.32[a]	2.02[a]	4.82[b]	1.53[a]	1.38[c]
Operating expense	.54	2.82[b]	2.55[b]	2.56[b]	-1.88	2.62[a]	-.12
Capital	.79	7.54	-.50	.77	4.16	.14	4.96[a]
Analysis of variance							
Regression							
Degrees of freedom	4	3	3	3	4	3	4
Sum-of-squares	8.728072	5.173119	6.017365	6.023107	4.821570	4.214580	17.721392
Mean square	2.182018	1.724373	2.005788	2.007702	1.205392	1.404860	4.430348
Deviations from regression							
Degrees of freedom	23	21	24	24	44	45	163
Sum of squares	.011365	.382829	.410295	.404553	.168183	.462125	.315865
Mean square	.000494	.018230	.017095	.016856	.003822	.010269	.001938
F-Value	4416[a]	95[a]	117[a]	119[a]	315[a]	137[a]	2286[a]

a Significant at the 1 % level
b Significant at the 5 % level
c Significant at the 10 % level
d Significant at the 20 % level

$X_3^{.0160}$. All exponents were less than one and indicated diminishing returns to each separate category of inputs. The sum of elasticities was 1.1792, suggesting that increasing returns existed to the factors as a whole. The F test supported this observation at the probability of a one in 20 chance of error. Labor and operating expense coefficients were significant at the one percent level but capital was non-significant at the 40 percent level. The value of R was computed to be .901. Results of this function will be discussed in greater detail in the succeeding section dealing with "Productivity Comparisons and Factor Pricing".

Northern Aggregate Function. The aggregate function included all three substratums of Northern creameries. The following results were obtained: $Y = .7898\ X_1^{.8954}\ X_2^{.0541}\ X_3^{-.0024}\ X_4^{.1203}$. From Table 6 it may be observed that, as in the two previous functions where it was included, butterfat accounted for a large share of the total product. In this function it was significant at the one percent level. A negative coefficient was obtained for operating expenses but it was not significant at the 20 percent level.

Capital service inputs were significant at the 1 percent level. Since this was the only function in which the input became significant, it may suggest that a large-size sample tends to smooth out some of the irregularities of capital measurements. Or perhaps the more diversified creameries of the Northern regions had more refined bookkeeping methods relating to capital service charges.

For labor, the regression coefficient was significant at the 10 percent level, and butterfat at the 1 percent level. The sum of elasticity coefficients was 1.0674. Evidence of increasing returns to scale was significant at the 1 percent level. It should be noted that for each of the three Northern functions the sums of their elasticity coefficients totaled more than one (Table 6). This suggests that Northern creameries may be operating in an area of increasing returns to scale. For the aggregate sample, a 1 percent increase in inputs would result in a 1.06 percent increase in output while for the Northern low-division B function it would effect a 1.18 percent increase. The R for the aggregate function was .982 at the 1 percent level of significance.

Marginal product of butterfat for the aggregate function was 89 cents per pound. This was nearly 15 percent greater than the marginal product of butterfat for either Kansas-Nebraska or the Northern low-division group. A distinguishing characteristic of the aggregate sample was the large number of creameries receiving a substantial proportion of butterfat supplies in the form of whole milk. A proportionately large supply of whole milk generally results in a higher quality product than is obtained from supplies consisting mostly of farm-separated cream. The aggregate also included a large number of creameries which had diversified operations in contrast to creameries of Kansas-Nebraska and the Northern low-division which were specializing primarily in butter production. A marginal product of 89 cents per pound for butterfat allowed a considerable margin above factor cost as the price paid to farmers in Minnesota averaged 73 cents per pound during this period.[1] The price paid to Kansas-Nebraska farmers during this same period was 61 cents per pound of butterfat for a marginal product of 77 cents per pound. Creameries in the aggregate sample thus paid producers a slightly higher proportion of the marginal product for butterfat than did creameries of the Kansas-Nebraska sample (82 percent compared to 79 percent).

Productivity Comparisons and Factor Pricing

Marginal products were of primary interest in this study as the analytical model specified equal value marginal products between areas. To test whether a difference between two marginal products was statistically significant, a hypothetical coefficient was computed and tested. By letting subscript 'a' represent the marginal product of Kansas-Nebraska creameries and subscript 'b' represent the marginal product for Northern low-division

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[1] U.S. Department of Agriculture, Agricultural Marketing Service, Milk: Farm Production, Disposition, and Income, April 1955, p. 14

creameries, the hypothetical elasticity coefficient (b'_a) necessary to equate the marginal product of Kansas-Nebraska with the marginal product of Northern low-division was computed as:[1]

$$b'_a = b_b\left(\frac{\bar{Y}_b}{\bar{X}_b} \cdot \frac{\bar{X}_a}{\bar{Y}_a}\right)$$

Hypothetical elasticity coefficients are shown in Appendix Table 26. Differences between observed coefficients and hypothetical coefficients were tested by computing t-values as followed:

$$t = \frac{b_a - b'_a}{\sqrt{s^2_{b_a} + \left(\frac{\bar{Y}_b}{\bar{Y}_a} \cdot \frac{\bar{X}_a}{\bar{X}_b}\right)^2 s^2_{b_b}}}$$

The significance level was determined at $n_1 + n_2 - 4$ degrees of freedom (Appendix Table 27).

There was only a one cent difference between the marginal products of butterfat of the Kansas-Nebraska creameries and the Northern low-division creameries (Table 6), Kansas-Nebraska function A and Northern low-division function A. Apparently, creameries in the Kansas-Nebraska area were producing a product that was very nearly equal to the product of Northern creameries. The t-test revealed that the one cent was not significantly

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1 Earl O. Heady and Schalk Du Toit, "Marginal Resource Productivity for Agriculture in South Africa and the United States", The Journal of Political Economy, LXII:1954, p. 501.

different from zero at the 20 percent level.

Both groups received a marginal product which was above the cost of the resource. For Kansas-Nebraska, the marginal product exceeded the cost of a pound of butterfat by 16 cents, or approximately 26 percent. In the Northern substratum, the cost was exceeded by five cents, or about seven percent. Northern producers were receiving a return for cream more nearly equal to its marginal product than were Kansas-Nebraska farmers.

The t-test was used to test the hypothesis that the difference between the cost of a factor (K) and its marginal product was zero:

$$t = \frac{b_1\left(\frac{\bar{Y}}{\bar{X}_1}\right) - K}{\sqrt{s^2_{b_1}\left(\frac{\bar{Y}}{\bar{X}_1}\right)^2}}$$

The difference between factor cost and factor productivity of the butterfat input was significant at the one percent level for the Kansas-Nebraska function A group. No significant difference was found for the Northern low-division function A group at the twenty percent level (Appendix Table 27). There was a substantial margin between the price paid to farmers for cream and the return from the marginal unit of butterfat for Kansas-Nebraska creameries.

To compare differences in productivities of labor and operating expense inputs between the two areas results of

Kansas-Nebraska function C and Northern low-division function B were compared since significant elasticities were obtained for these inputs in both functions. Labor's marginal product was $2.32 in the Kansas-Nebraska area compared to $1.53 in the Northern region. Upon testing the hypothetical regression coefficient for labor against the observed coefficient, it was found that there was no significant difference between the two coefficients at the twenty percent level (Appendix Table 27). It could thus be concluded that creamery labor was equally productive in both areas. The hypothesis of no difference between productivity and cost for labor resources was rejected at five percent level for Kansas-Nebraska creameries, and at the 10 percent level for Northern low-division creameries. A difference of 79 cents in returns for the last one dollar invested in labor in Kansas-Nebraska compared to the Northern substratum was perhaps largely due to variations in sampling. Evidence of significant differences between labor's productivities and the cost of a marginal unit of labor (one dollar) meant that both groups could compete with other industries for labor by bidding up its price, if necessary. Marginal productivity of labor exceeded marginal cost by 132 percent in the Kansas-Nebraska region, and by 53 percent in the Northern region. The feasibility of substituting capital for labor inputs was not measured since a significant coefficient for capital inputs was not obtained.

The difference in values of marginal products of operating expenses between Kansas-Nebraska and the Northern group was only seven cents. This productivity differential was not significantly different from zero at the twenty percent level. Marginal productivity of operating funds was \$1.55 more than the marginal input of one dollar invested in the Kansas-Nebraska group and \$1.62 above the last \$1.00 input in the Northern stratum. Differences between productivities and costs for Kansas-Nebraska and Northern low-division creameries were significant at the 20 and the 5 percent levels, respectively. Funds used for operating purposes apparently returned a very substantial amount, and creameries could profitably afford to borrow for operating expenses at existing interest rates. Lenders in these areas may be assured that loans to creameries for operating purposes were productive.

From the above analysis, it was concluded that a shift or reallocation of butterfat, labor, or operating fund resources between the areas studied was not indicated for the period of the analysis. Any recommendation about reallocations of these resources would have to be made independent of the tests of productivity differences for Kansas-Nebraska and the Northern low-division stratum. The values obtained from the functions were believed to be statistically acceptable as estimates of the true population parameters. A factor which probably contributed to the disequilibrium between marginal productivity and factor cost was the lack of knowledge concerning marginal products on the part of management. Management may also have been influenced to use criteria based on other than profit maximinization. Some differences between marginal productivities and costs are to be expected under the conditions of uncertainity which prevailed. This study could well serve as a basis for a broader study of these aspects of the problem.

Returns to Scale

The sums of elasticities indicated decreasing returns for all four Kansas-Nebraska functions (Kansas-Nebraska functions A, B, C, and D). To test returns to scale, the hypothesis was adopted that constant returns prevailed. That is, the difference between the sum of observed elasticities and one was hypothesized as being equal to zero. The F test provided evidence for rejecting this hypothesis at the one percent level for the Kansas-Nebraska function C.[1] Decreasing returns to scale was plainly evident for Kansas-Nebraska creameries. This is important information for policy decisions. It can be used by managers and directors in their deliberations concerning possible plant extensions. Planners should realize that overall operations are in the range of decreasing returns.

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[1] The F test for returns to scale provided evidence to reject the hypothesis of constant returns to all Kansas-Nebraska functions except function A (Table 6).

A conclusion would be that a proportionate increase in all inputs would not increase the total product by an equal proportion for Kansas-Nebraska creameries. The sum of elasticities for Northern low-division creameries suggested increasing returns to scale (Table 6). For Northern low-division function B, a one percent increase in all inputs should result in a 1.18 percent increase in output. The F value for level of significance was computed at the five percent level. Northern creameries of the lower stratum had a much lower mean output and inputs than Kansas-Nebraska creameries.[1] The inference of increasing returns to scale would apply to the range of the data to which the function was fitted. There are probably limiting factors, such as availability of additional resources and management capabilities, which would not permit expansion to be profitable beyond a certain point. In the final analysis, management may determine to a large extent the most efficient size for an individual plant.

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1 A recent study of manufacturing costs of Minnesota creameries by Arvid C. Knudtson and Fred E. Koller of the University of Minnesota pointed out the need for low-volume creameries to reorganize their plants for more efficient operations. They concluded that in some cases it may mean closing the least needed plants and concentrating available butterfat in the larger and more efficient firms (Arvid C. Knudtson and E. Fred Koller, <u>Manufacturing Costs in Minnesota Creameries</u>, Agricultural Experiment Station, University of Minnesota).

METHODOLOGY OF CAPITAL MEASUREMENTS

Considerable attention was given in this study to various techniques of measuring capital inputs. Samuelson suggested that the term "inputs" as it relates to a production function should be "confined to denote measurable quantitative economic goods and services".[1] Capital inputs are generally conceived as being a stock or flow of services from capital goods. If the entire stock of capital assets is allowed to represent the measure of capital input, it is assumed that the flow of services is in constant proportion to the amount invested. For it is the flow of services which really contributes to the process of production. Both concepts of capital inputs are used in production functions.

Precise measurements of capital inputs are difficult, if not impossible, due to the heterogeneity of capital in its physical forms, and the existance of imperfect markets for most capital assets when measured in monetary terms. Numerous physical units of measurement are used for capital. A few examples are square feet or cubic feet of operational or storage space of buildings, and various capacity rating of equipment, such as horsepower, gallons per minute, etc. In order for physical measurements of buildings to serve as an index of capital use, it must be assumed that each plant utilizes its

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1 Paul Anthony Samuelson, Foundations of Economic Analysis, p. 84.

available space to the same degree of intensity. This assumption is often unrealistic. Furthermore, physical measurements often fail to reflect variations in efficiency due to differences in design, technological advancements, and arrangement of capital assets. This is especially true when applied to equipment which is subject to frequent innovations. Some butter-making churns are said to be as much as 50 percent more efficient in the time required for churning than other makes. Due to variations in efficiency alone, a physical measurement of equipment such as a churn would very likely either overestimate or underestimate the input of this resource unless one undertook the tedious task of determining the efficiency of each individual plant's equipment and then converted these to some common denominator before aggregating.

Capital inputs are commonly expressed in terms of monetary values, such as values of capital accounts; or depreciation charges, including costs of repairs and maintenance. One can only estimate the value of a capital asset for which an imperfect market exists. In some cases, there may be only one or two prospective buyers from whom an estimate can be obtained of the present market value.

Various accounting terms attempt to describe the rate of capital depletion; such as the straight-line method of depreciation, diminishing balance, rapid write-off, or the annual revaluation method. A difficulty encountered in these methods is that a depreciation rate established in a previous period may not accurately state the current value of a capital asset due to external factors such as movements of price levels or extra-ordinary obsolescence. This difficulty becomes more complex for highly durable assets. Moreover, if demand for a product is declining, a capital valuation rate established in an earlier period may continue to be carried on the books although a part of the asset may no longer be utilized and cannot be sold except for scrap in the present period. An excessive depreciation charge can be an overcharge in much the same way that idle labor can be overcharged to a production process.[1] Accounting techniques are often selected from the viewpoint of tax advantages and not for the purpose which the econometrician desires to measure.

Repairs and maintenance expenditures are properly classed as capital inputs. These expenditures either maintain the present condition of assets or restore their efficiency and usefulness. It is believed that quite often expenditures for these purposes are not allocated over the entire period for which they serve. For example, to be realistic, the expense of small minor repairs should be allocated over the years during which they have an effect instead of the whole amount being charged in the year in which these repairs are made.

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1 Paul Leo Kelley, op. cit., p. 268-269.

Some attempts have been made to measure the productivity of capital in terms of units of power consumed.[1] This method appears to be most applicable for measuring productivity of equipment using substantial amounts of power. Ernst[2] collected data on output, manhours, and kilowatt hours for eight industries (all heavy users of electricity except the leather industry) over a period of five years. He assumed that kilowatt-hours per manhour could be used as a basis for measuring changes in the use of machinery and equipment. He compiled ratios for output per manhour and kilowatt-hours per manhour. These ratios were compared and the significance of the technological factor computed by squaring the correlation coefficient for the two ratios. From the results obtained, Ernst concluded that technological changes in machinery and equipment accounted for much of the change in output per manhour.

The difficulties encountered in attempting to measure inputs when capital is aggregated point out the need for more refined methods of measuring this important resource. It is too often "plugged" into the production function without much thought being given to how accurately it represents the real contribution of capital. Until a common denominator is developed

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1 In this study, it will be recalled that Kansas-Nebraska function C and Northern low-division function B defined capital inputs in terms of expenditures for utilities.

2 Harry Ernst, "Accounting for Productivity Changes", Harvard Business Review, May-June, 1956.

which will precisely measure capital inputs, it will be necessary to work with rough measurements if economic theory is to have a tool for estimating marginal products and applying choice criteria.

In this analysis, it was assumed that equal degrees of durability and intensity of capital use existed for all creameries. All units were also assumed to have developed over time at similar rates, thus employing similar techniques. Working capital was not included as an input as the functions were of a static nature. The production process was assumed to begin and end in the period of the functions.

LIMITATIONS OF THE ANALYSIS AND RECOMMENDATIONS FOR FUTURE STUDIES

Static conditions were assumed for the production functions whereas the real problem actually related to a dynamic world where risk, uncertainty, and imperfect knowledge existed. In future studies, it would be desirable to include these factors in a dynamic model.

Limitations of the Cobb-Douglas function should be kept in mind. The function forces certain phenomena on the analysis, such as constant elasticity throughout the range of the data, a rigid expansion path for least-cost or maximum profit combinations, and marginal product ratios which are most meaningful at the geometric mean.[1]

Simultaneous equations or linear programming could be useful techniques in further studies. Simultaneous equations could reflect the dynamic aspects, including lag relationships such as the influence of capital service flow in a previous period on current production. Linear programming techniques would be valuable in computing estimates of returns for various specific kinds of resource inputs rather than the more general categories presented in this analysis.

It would also be desirable to have future studies account for each of the several kinds of products of creameries. The efficiency with which resources are employed for manufacturing dairy products other than butter is of interest as consumption of these is increasing. The influence of government buying programs on operations of creameries should also be investigated.

Studies are needed to determine the technical limits of resources used by creameries; especially, the extent to which capital could be substituted for labor in determining least-cost combinations under varying conditions. The need for more

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[1] The influence, limitations, and relationship of this type of function to other possible algebraic functions are discussed by Paul Leo Kelley in "Resource Productivity in Agricultural Marketing Firms of the Midwest", an unpublished project report.

precise measurements of capital inputs was pointed out by the fact that only one out of seven functions contained a statistically significant regression coefficient for this resource. Larger samples may help to overcome the deficiency in measurement, provided the error does not increase proportionally with the size of samples.

Although there was a considerable margin between the marginal products and factor prices for labor and operating expenses, the feasibility of increasing these expenditures should be investigated further. Directors may wish to consider higher salaries for managers as a means of attracting more capable persons to these positions.

It was assumed that the cost of resources was identical for Kansas-Nebraska and Northern creameries. There may have been some differences in factor costs between these areas. The differences, if any exist, should be taken into account in future studies.

Kansas creameries received a considerably larger proportion of butterfat supplies in the form of whole milk than did Nebraska creameries during the period tested. The trend towards marketing of butterfat in whole milk form seems to have been slower in developing in Nebraska. A separate study of Kansas and Nebraska creameries would furnish more relevant information to plants in each state.

Analyses of this type would have greater applicability if the input-output data were defined in terms of physical units.

Techniques of production change less rapidly than prices, and inferences based on such data could be used throughout a wide range of prices.

SUMMARY

Butter consumption per capita declined from 15.8 pounds per capita in 1941 to 8.6 pounds in 1956, a decrease of nearly 46 percent in 15 years.[1] Meanwhile consumption of fluid milk and non-fat milk solids increased over prewar levels.

The trends in consumer preference were largely responsible for farmers shifting to a larger proportion of sales off farms in the form of whole milk instead of cream. As a result of these changes in consumption and farm output, creameries were forced to reorganize their operations. Some plants began manufacturing a variety of dairy products, while others continued to specialize in butter after streamlining their operations. A considerable number of creameries merged with larger plants.

Since these adjustments have been made, creamery operators have been wondering how efficiently resources are being employed. Some people have maintained that creameries in the Kansas-Nebraska area are less productive than creameries in more typical dairy regions such as the Northern dairy states. It is common knowledge that Northern creameries manufacture high

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1 Rojko, op. cit., p. 30.

quality butter from sweet cream and whole milk under optimum conditions. For this reason, Kansas-Nebraska creamery operators have been apprehensive over whether they were able to effectively meet this competition. Managers of creameries in Kansas-Nebraska are interested in knowing whether they are producing a value product comparable to that produced by creameries in the Northern region.

The analysis proceeded on the null hypothesis that the value of marginal products between areas was equal. The conditions for a static model were assumed. Data was obtained from audit records and surveys of a sub-population of a universe of Kansas and Nebraska creameries. A cooperative auditing firm in Minnesota provided data for Northern creameries which were stratified according to the percent of butterfat supplies received as whole milk.

Cobb-Douglas functions were fitted to the data and the statistical method of least squares used to derive estimates of elasticities of production. The dependent variable in the regression equation was alternately defined as gross value of output or added increment value of output. Independent variables consisted of butterfat, labor services, operating expenses, and capital services. Various concepts of capital service measurements were employed to observe their effects on the statistical results. A significant regression coefficient for this resource was obtained in only one of the seven Cobb-Douglas functions.

Results of the study failed to provide sufficient evidence to reject the hypothesis that marginal products were equal between the areas studied. It thus appears that Kansas-Nebraska creameries were able to compete successfully with butter plants in the Northern region. The conclusion, however, must be limited to the period tested as changing economic conditions, such as further shifts in milk output by farmers, could affect future results.

The conclusion is also limited by the accuracy of data. Considerable time was spent in assembling data where adequate bookkeeping records were not kept. Joint costs of the butter and sidelines departments had to be arbitrarily allocated on the basis of gross sales when more precise information was not available.

More research is needed to develop precise measurements of capital inputs. The productivity of this resource was not analyzed as the various techniques for defining capital service inputs failed to furnish statistically significant regression coefficients.

The evidence presented and conclusions reached in this study were only broad attempts to estimate the efficiency with which resources were used by Kansas-Nebraska creameries. The several aspects of the problem should be examined in greater detail. Inferences should be restricted to the year of the study unless factor and product prices are comparable under similar conditions.

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APPENDIX

Table 7. Production of creamery butter in Kansas, Nebraska Minnesota, and United States, 1930-1956.

Year	Kansas	Nebraska	Minnesota	United States
	1,000 Pounds			
1930	56,919	85,623	282,700	1,597,747
1931	68,997	86,084	284,270	1,667,452
1932	74,587	85,660	281,659	1,694,132
1933	81,969	93,361	299,872	1,762,688
1934	79,248	91,384	275,786	1,694,708
1935	69,548	76,400	272,585	1,632,380
1936	62,802	72,842	289,830	1,629,407
1937	68,039	63,594	276,491	1,623,971
1938	78,141	68,216	301,604	1,786,172
1939	80,108	81,236	297,325	1,781,737
1940	75,806	83,327	311,153	1,836,826
1941	81,510	91,262	326,478	1,872,183
1942	76,689	90,665	314,537	1,764,054
1943	72,977	95,718	294,359	1,673,788
1944	60,805	81,157	251,614	1,488,502
1945	52,385	75,291	233,436	1,363,717
1946	48,892	80,783	175,891	1,171,339
1947	51,001	79,003	243,874	1,329,094
1948	46,823	78,240	222,657	1,210,324
1949	47,490	73,607	252,621	1,412,111
1950	50,614	76,557	251,389	1,386,290
1951	42,759	74,566	237,237	1,202,981
1952	37,327	71,269	247,656	1,188,170
1953	44,743	76,988	267,664	1,411,814
1954	46,203	78,198	272,093	1,448,872
1955	42,929	75,071	281,176	1,386,158
1956[1]	40,732	76,285	306,108	1,409,868

Source: United States Department of Agriculture, Agricultural Marketing Service, Production of Manufactured Dairy Products, April 1946, October 1951, and following issues.

[1] Preliminary.

Table 8. Forms in which milk, or its equivalent in the form of other dairy products, was sold by farmers in Kansas, by five-year periods, 1925-49, and by years, 1950-56.

Period	Whole milk	Farm separated cream	Milk and cream retailed by farmers[1]	Total milk utilized	Percent marketed as cream
	Millions of pounds				
1925-29	278	1594	223	2095	76.09
1930-34	338	1920	233	2491	77.08
1935-39	377	1659	185	2221	74.70
1940-44	667	1762	140	2569	68.59
1945-49	868	1236	120	2224	55.58
1950	810	1180	95	2085	56.59
1951	860	1050	82	1992	52.71
1952	910	900	79	1889	47.64
1953	1060	870	70	2000	43.50
1954	1140	870	68	2078	41.87
1955	1261	680	63	2004	33.93
1956[2]	1302	600	56	1958	30.64

Source: U. S. Department of Agriculture, Agricultural Marketing Service, various issues of Milk: Farm Production, Disposition, and Income.

1 Approximations based on information on sales by producer-distributors and other farmers on own routes or at farm.

2 Preliminary.

Table 9. Forms in which milk, or its equivalent in the form of other dairy products, was sold by farmers in Nebraska, by five-year periods 1925-49, and by years, 1950-56.

Period	Whole milk	Farm separated cream	Milk and cream retailed by farmers[1]	Total milk utilized	Percent marketed as cream
	Millions of Pounds				
1925-29	154	1491	164	1809	82.42
1930-34	208	1852	160	2220	83.42
1935-39	235	1568	136	1939	80.87
1940-44	274	1866	109	2249	82.97
1945-49	356	1473	89	1918	76.80
1950	390	1401	63	1854	75.57
1951	370	1335	57	1762	75.77
1952	380	1295	55	1730	74.86
1953	420	1435	47	1902	75.45
1954	440	1504	40	1984	75.81
1955	473	1480	34	1987	74.48
1956[2]	539	1420	25	1984	71.57

Source: U. S. Department of Agriculture, Agricultural Marketing Service, various issues of <u>Milk: Farm Production, Disposition, and Income</u>.

1 Approximations based on information on sales by producer-distributors and other farmers on own routes or at farm.

2 Preliminary.

Table 10. Forms in which milk, or its equivalent in the form of other dairy products, was sold by farmers in Minnesota, by five-year periods 1925-49, and by years, 1950-56.

Periods	Whole milk	Farm separated cream	Milk and cream retailed by farmers[1]	Total milk utilized	Percent marketed as cream
	Millions of Pounds				
1925-29	597	5315	208	6120	86.85
1930-34	752	5795	212	6759	85.74
1935-39	945	5759	176	6880	83.71
1940-44	2005	5688	139	7832	72.63
1945-49	4182	3429	100	7711	44.47
1950	3760	3615	62	7437	48.61
1951	3760	3453	58	7271	47.49
1952	4290	3110	54	7454	41.72
1953	5180	2810	40	8030	34.99
1954	5410	2624	35	8069	32.52
1955	5805	2444	32	8281	29.51
1956[2]	6826	1995	30	8851	22.54

Source: U. S. Department of Agriculture, Agricultural Marketing Service, various issues of _Milk: Farm Production, Disposition, and Income_.

[1] Approximations based on information on sales by producer-distributors and other farmers on own routes or at farm.

[2] Preliminary.

Table 11. Cash receipts from dairy products and from all farm marketings in Kansas, Nebraska and Minnesota, by five year periods, 1925-49, and annually, 1950-56.[a]

Period	Kansas: All farm receipts	Kansas: Dairy products receipts	Kansas: % dairy products	Nebraska: All farm receipts	Nebraska: Dairy products receipts	Nebraska: % dairy products	Minnesota: All farm receipts	Minnesota: Dairy products receipts	Minnesota: % dairy products
	Mil. of dollars			Mil. of dollars			Mil. of dollars		
1925-29	485	37	8	454	31	7	424	112	26
1930-34	246	26	11	255	22	9	246	72	29
1935-39	259	29	11	233	24	10	329	86	26
1940-44	528	49	9	454	37	8	642	136	21
1945-49	1006	70	7	923	53	6	1157	229	20
1950	1032	63	6	992	50	5	1188	206	17
1951	1047	71	7	1154	54	5	1287	238	18
1952	1192	74	6	1165	57	5	1279	260	20
1953	960	69	7	1106	53	5	1281	253	20
1954	958	65	7	1053	52	5	1237	231	19
1955	849	66	8	1019	52	5	1237	238	19
1956[b]	838	67	8	888	55	6	1279	265	21

a Excluding government payments
b Preliminary

Source: U. S. Department of Agriculture, Agricultural Marketing Service, "Cash Receipts and Value of Home Consumption by States, 1924-51", and various issues of The Farm Income Situation.

Table 12. Computation of index for base period of average weekly earnings of dairy products workers in Kansas, 1947-49.

Month	Weekly earnings (in dollars) for years		
	1947	1948	1949
January	36.97	39.94	42.86
February	38.03	40.39	43.72
March	37.69	40.41	42.00
April	37.86	38.01	43.13
May	38.13	38.72	43.72
June	38.94	42.02	44.30
July	38.51	41.69	44.49
August	41.66	41.71	44.23
September	41.00	42.13	44.77
October	39.52	40.76	45.50
November	39.19	42.66	46.29
December	40.04	42.16	46.26
Yearly average	38.96	40.88	44.27
Three year average (1947-49)		=	41.37

Source: Monthly bulletins of the Kansas State Department of Labor.

Table 13. Computation of index for selected months of average weekly earnings of dairy products workers in Kansas, September 1953 to December 1954.

Month	Year	Average weekly earnings ($)	Average weekly earnings (1947-49)	Computed index
September	1953	63.64	41.37	153.8
October	1953	59.93	41.37	144.8
November	1953	60.13	41.37	145.3
December	1953	61.04	41.37	147.5
January	1954	63.32	41.37	153.0
February	1954	63.13	41.37	152.5
March	1954	63.46	41.37	153.3
April	1954	65.11	41.37	157.3
May	1954	66.20	41.37	160.0
June	1954	66.26	41.37	160.1
July	1954	67.19	41.37	162.4
August	1954	65.80	41.37	159.0
September	1954	66.07	41.37	159.7
October	1954	64.97	41.37	157.0
November	1954	64.27	41.37	155.3
December	1954	66.37	41.37	160.4

Source: Monthly bulletins of the Kansas State Department of Labor.

Table 14. Index of cost of general purpose machinery in United States, 1947-49 = 100.

Year	Index
1952	122.6
1953	125.4
1954	128.2
January to June, inclusive, 1953	123.0
January to June, inclusive, 1954	129.9

Source: U. S. Bureau of Labor Statistics, The Handbook of Basic Economic Statistics.

Table 15. Computation of index for selected months of Chicago 92 score butter prices, October 1953 to November 1954.

Month	Year	Average price (¢ per pound)	Average price (1947-49)	Computed index
October	1953	67.4	68.9	97.8
November	1953	66.2	68.9	96.0
December	1953	65.5	68.9	95.0
January	1954	65.3	68.9	94.7
February	1954	65.3	68.9	94.7
March	1954	64.5	68.9	93.5
April	1954	57.3	68.9	83.1
May	1954	67.1	68.9	82.8
June	1954	56.9	68.9	82.5
July	1954	56.9	68.9	82.5
August	1954	57.0	68.9	82.7
September	1954	58.4	68.9	84.7
October	1954	59.1	68.9	85.7
November	1954	58.9	68.9	85.4

Source: U.S.D.A., BAE, Dairy Situation, May 1950 and following issues.

Table 16. Indices of average weekly earnings of production workers of food and kindred products in Minnesota. (1947-49 = 100)*

Month	Year 1952	Year 1953
January	129.4	137.5
February	125.7	134.1
March	124.1	132.4
April	124.4	127.2
May	129.8	134.4
June	133.9	136.5
July	127.6	130.8
August	123.4	128.6
September	117.7	130.2
October	133.2	146.3
November	132.0	148.3
December	136.6	147.2

* Source: Indices supplied by Research and Statistics, Department of Employment Security, St. Paul, Minnesota.

Table 17. Derivation of formula for adjusting data from accounting period May 1, 1952 - April 30, 1953 to calendar year 1953.

Problem: Find income and expenditure amounts for the 12 months of 1953

Given: Total wages from 5-1-52 to 5-1-53 $= \sum_{i=5}^{12} W_i + \sum_{i=1}^{4} X_i$

Then $\frac{\text{wages}}{\text{lbs. of butter}} = \frac{\sum_{i=5}^{12} W_i + \sum_{i=1}^{4} X_i}{\text{lbs. of butter}} = \$3.41$

where the \$3.41 is a known amount.

Problem: Find the wages/lb. of butter paid in 1953.

Given: $X_5 = \frac{\text{wage}}{\text{hr.}} \times \text{hrs.} = \overline{X}_5 \cdot h_5$

and that index is $\frac{\text{wage/hr. ('53)}}{\text{wage/hr. (base period)}}$

Given: $W_5 = \frac{\text{wage}}{\text{hr.}} \times \text{hrs.} = \overline{W}_5 \cdot h_5$

and that index is $\frac{\text{wage/hr. ('52)}}{\text{wage/hr. (base period)}}$

(Note: h_5 assumed to be a constant)

Then $\frac{X_5}{W_5} = \frac{\overline{X}_5 \cdot h_5}{\overline{W}_5 \cdot h_5} = \frac{\text{index '53}}{\text{index '52}} = P_5$

Or $X_5 = P_5 \cdot W_5$

Let $X_5, X_6, X_7, X_8, X_9, X_{10}, X_{11}, X_{12}$ = monthly indices for months of May to December, incl., 1953.

Let $W_5, W_6, W_7, W_8, W_9, W_{10}, W_{11}, W_{12}$ = monthly indices for months of May to December, incl., 1952.

Table 17 (cont.)

Let $P_5, P_6, P_7, P_8, P_9, P_{10}, P_{11}, P_{12}$ = adjustment factors

to adjust wages of May to December of 1952 to wages of May to December, 1953.

Then $\frac{X_5}{W_5} = P_5, \frac{X_6}{W_6} = P_6 \cdots\cdots\cdots \frac{X_{12}}{W_{12}} = P_{12}$

But X_1, X_2, X_3, X_4 are known; $X_5 \ldots\ldots X_{12}$ are unknown.

Let Y' = 12 months operating period adjusted to 1953 level.

Then $Y' = X_1 + X_2 + X_3 + X_4 + P_5W_5 + P_6 W_6 + \cdots\cdot + P_{12}W_{12}$

Let Y = 12 months' original data of May 1, 1952 to April 30, 1953.

Assume $W_5 = W_6 = W_{12} = W_0$, where $W_0 = \frac{1}{12} Y$

Then $Y' = \sum_{i=1}^{12} X_i = X_1 + X_2 + X_3 + X_4 + W_0 (P_5 + P_6 + \cdots + P_{12})$.

Since we assume $X_1 + X_2 + X_3 + X_4 = 1/2 \sum_{i=5}^{12} W_i = (1/2)(8W_0)$

Then $Y' = 4W_0 + W_0 (P_5 + P_6 + \cdots\cdots\cdot P_{12})$

Since Y' = adjusted 12 months period to 1953 level
and Y = original unadjusted 12 months period

The ratio of Y' to Y is $\frac{Y}{3.41} = \frac{W_0 \left[4 + (P_5 + P_6 + \cdots + P_{12})\right] \text{ /lbs.butter}}{4W_0 + 8W_0 \text{ / lbs. of butter}}$

Or $\frac{Y'}{3.41} = \frac{1}{3} + \frac{2}{3} \cdot \frac{(P_5 + P_6 + \cdots\cdot P_{12})}{8}$

Then $Y' = 3.41 \left[\frac{1}{3} + \frac{2}{3} \cdot \frac{(P_5 + P_6 + \cdots\cdot P_{12})}{8}\right]$

Table 17 (concl.)

In general, then:

if Y' = adjusted data of income and/or expenses
if Y = unadjusted data of income and/or expenses

$$\text{\# Then } Y' = Y\left[\frac{1}{3} + \frac{2}{3} \cdot \frac{(P_5 + P_6 + \ldots P_{12})}{8}\right]$$

\# The basic assumption being that income and/or expenses are equally distributed between each of 12 months of the adjusted period. This assumption may be modified as follows:

If production between the unadjusted period ($4W_0$) and the adjusted period ($8W_0$) is of the ratio of 1 to .87, a correction factor may be applied so that:

$$Y' = Y\left[(1)\frac{(1)}{(3)} + (.87)\frac{(2)}{(3)} \cdot \frac{(P_5 + P_6 + \ldots P_{12})}{8}\right]$$

Table 18. Milk production on farms in Minnesota, by months during 1953, and computation of factor for adjusting Northern creameries' data from period of May 1, 1952 to April 30, 1953 to calendar year 1953 for seasonal production.

Month	Milk production (Millions of pounds)
January	724
February	722
March	841
April	843
May	925
June	934
July	773
August	597
September	497
October	499
November	550
December	685
Total	8590

January to April, average / May to December average: $\frac{782.5}{682.5} = \frac{1}{.87}$

Source: U. S. Department of Agriculture, Agricultural Marketing Service, <u>Farm, Production, Disposition, and Income from Milk</u>, April 1954, p. 18.

Table 19. Definitions of variables for Kansas-Nebraska Function A.[a]

Variable :	Definition
Y	Value of butter output (in dollars). Defined as amounts of butter sales plus ending butter inventory plus butter in transit, less beginning butter inventory less freight and drayage out, and less sales route, transport and delivery expenses.
X_1	Pounds of butterfat input.
X_2	Inputs of labor services (in dollars). Defined as manager's salary, assistant manager's salary, employees' salaries and bonuses, executive travel expenses, directors' expenses, employees' savings, inspections, laboratory and grading service, contracted services, and maintenance and boiler labor.
X_3	Inputs of operating expenses (in dollars). Defined as postage, telephone and telegraph, general office expenses and supplies, pest control, miscellaneous administrative expenses, packing supplies, manufacturing supplies, freight in, laundry expenses, ice, engine room supplies, and miscellaneous expenses.
X_4	Inputs of capital services (in dollars). Defined as depreciation of office equipment, repairs to office equipment, depreciation of buildings and equipment, depreciation of auto, rent and lease expenditures, maintenance, repairs, engine room repairs, electric power, water, gas and fuel.

[a] All monetary charges were direct charges or were allocated charges to the butter enterprise.

Table 20. Definitions of variables for Kansas-Nebraska function B.[a]

Variable	Definition
Y	Added increment to total product (in dollars). Defined as butter sales plus ending butter inventory plus butter in transit less beginning butter inventory less purchases of butterfat and transfers from the milk department, less freight and drayage out, and less sales route, transport, and delivery expenses.
X_1	Inputs of labor services (in dollars). Defined as manager's salary, assistant manager's salary, employees' salaries and bonuses, executive travel expenses, directors' expenses, employees' savings, inspections, laboratory and grading service, contracted services, and maintenance and boiler labor.
X_2	Inputs of operating expenses (in dollars). Defined as postage, telephone and telegraph, general office expenses and supplies, pest control, miscellaneous administrative expenses, packing and manufacturing supplies, freight in, laundry, ice, engine room supplies, and miscellaneous manufacturing expenses.
X_3	Inputs of capital services (in dollars). Defined as expenditures for electrical power.

[a] All monetary charges were direct charges or were allocated charges to the butter enterprise.

Table 21. Definitions of variables for Kansas-Nebraska function C.[a]

Variable	Definition
Y	Added increment total product (in dollars). Defined as butter sales plus ending butter inventory plus butter in transit less beginning butter inventory less purchases of butterfat and transfers from the milk department, less freight and drayage out, and less sales route, transport, and delivery expenses.
X_1	Inputs of labor services (in dollars). Defined as manager's salary, assistant manager's salary, employees' salaries and bonuses, executive travel expenses, directors' expenses, employees' savings, inspections, laboratory and grading service, contracted services, and maintenance and boiler labor.
X_2	Inputs of operating expenses (in dollars). Defined as postage, telephone and telegraph, general office expenses and supplies, pest control, miscellaneous administrative expenses, packing and manufacturing supplies, freight in, laundry, ice, engine room supplies, and miscellaneous manufacturing expenses.
X_3	Inputs of capital services (in dollars). Defined as expenditures for electricity, gas, fuel, and water.

[a] All monetary charges were direct charges or were allocated charges to the butter enterprise.

Table 22. Definitions of variables for Kansas-Nebraska function D.[a]

Variable	Definition
Y	Added increment to total product (in dollars). Defined as butter sales plus ending butter inventory plus butter in transit, less beginning butter inventory less purchases of butterfat and transfers from the milk department, less freight and drayage out, and less sales route, transport, and delivery expenses.
X_1	Inputs of labor services (in dollars). Defined as manager's salary, assistant manager's salary, employees' salaries and bonuses, executive travel expenses, directors' expenses, employees' savings, inspections, laboratory and grading service, contracted services, and maintenance and boiler labor.
X_2	Inputs of operating expenses (in dollars). Defined as postage, telephone and telegraph, general office expenses and supplies, pest control, miscellaneous administrative expenses, packing and manufacturing supplies, freight in, laundry, ice, engine room supplies, and miscellaneous manufacturing expenses.
X_3	Inputs of capital services (in dollars). Defined as depreciation of office equipment, repairs to office equipment, depreciation of auto, rent and lease expenditures, depreciation of buildings and equipment, maintenance, repairs, engine room repairs, electric power, water, gas, and fuel.

[a] All monetary charges were direct charges or were allocated charges to the butter enterprise.

Table 23. Definitions of variables for Northern Low-Division function A.[a]

Variable	Definition
Y	Value of butter output (in dollars). Defined as butter sales plus ending inventory less beginning inventory.
X_1	Pounds of butterfat input.
X_2	Inputs of labor services (in dollars). Defined as creamery labor, office labor, and directors' fees.
X_3	Inputs of operating expenses (in dollars). Defined as packing supplies, general supplies, salt, unclassified plant expense, office supplies, telephone and telegraph, quality improvement, and unclassified general expense.
X_4	Inputs of capital services (in dollars). Defined as expenditures for fuel, power, light, water, refrigeration, depreciation of buildings and equipment, repairs to buildings and equipment, and rentals.

[a] All monetary charges were direct charges or were allocated charges to the butter enterprise.

Table 24. Definitions of variables for Northern Low-Division function B.[a]

Variable	Definition
Y	Value of butter output (in dollars). Defined as the audit item dairy department-gross receipts less the item total cost including Skim Milk.
X_1	Inputs of labor services (in dollars). Defined as creamery labor, directors' fees and expenses, and office salaries.
X_2	Inputs of operating expenses (in dollars). Defined as packing supplies, general supplies, salt, unclassified plant expenses, office supplies, telephone and telegraph, quality improvement and unclassified general expense.
X_3	Inputs of capital services (in dollars). Defined as expenditures for fuel, power, light, water, and refrigeration.

[a] All monetary charges were direct charges or were allocated charges to the butter enterprise.

Table 25. Definitions of variables for Northern aggregate creameries.[a]

Variable	Definition
Y	Value of butter output (in dollars). Defined as butter sales plus ending inventory, less beginning inventory.
X_1	Pounds of butterfat input.
X_2	Inputs of labor services (in dollars). Defined as creamery labor, office labor, and directors' fees.
X_3	Inputs of operating expenses (in dollars). Defined as packing supplies, general supplies, salt, unclassified plant expense, office supplies, telephone and telegraph, quality improvement, and unclassified general expense.
X_4	Inputs of capital services (in dollars). Defined as expenditures for fuel, power, light, water, refrigeration depreciation of buildings and equipment, repairs to buildings and equipment, and rentals.

[a] All monetary charges were direct charges or were allocated charges to the butter enterprise.

Table 26. Hypothetical elasticity coefficients and values of t for determining significant differences of marginal products in one function with marginal products in another function, Kansas-Nebraska and Northern low-division creameries, 1953.

Resource and function (tested against)	Hypothetical coefficient and function tested: Low-div. A	Low-div. B	Kans.-Nebr. A	Kans.-Nebr. C	T-Value
Butterfat					
Low-div. A.	---		.9796		.169
Kans.-Nebr. A	.8327		----		.169
Labor					
Low-div. B		---		.3986	1.255
Kans.-Nebr. C		.9867		---	1.255
Operating expenses					
Low-div. B		---		.2170	.052
Kans.-Nebr. C		.4981		---	.052

Table 27. Values of t and levels of significance for tests of differences between factor productivities and factor costs of Northern low-division and Kansas-Nebraska creameries, 1953.

Function	No. of firms	Resource: Butterfat	Labor	Oper. expense
Northern				
Low-div. A	49	.634		
Low-div. B	49		1.851**	2.110***
Kansas-Nebr. A	28	5.910****		
Kansas-Nebr. C	28		2.367***	1.502*

* Significant at the twenty percent level.

** Significant at the ten percent level.

*** Significant at the five percent level.

**** Significant at the one percent level.

RESOURCE PRODUCTIVITY IN KANSAS-NEBRASKA
AND NORTHERN CREAMERIES

by

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Significant changes have taken place in the dairy industry within the past several decades. Per capita consumption of butter declined while consumption of fluid milk and non-fat milk solids increased considerably over pre-World War II levels. The proportion of non-fat milk solids utilized for human consumption increased from 55 percent in 1940 to 80 percent in 1956.

During the time that changes in consumption were taking place, milk production and butter manufacturing decreased in Kansas and Nebraska, and farmers switched to marketing a larger proportion of milk output in the form of whole milk. The changes in production, farm marketing, and consumption caused creameries to make adjustments in their operations. A smaller supply of cream resulted in some plants ceasing operations entirely or merging with other plants. Many creameries reorganized their operations to receive a larger proportion in the form of whole milk and some shifted to manufacturing other products besides butter, such as evaporated milk, American cheese, and ice cream.

The general objective of the study was to determine whether the goal of economic efficiency in the use of resources was achieved by Kansas-Nebraska creameries. Specific objectives were: (1) to compare resource productivity of Kansas-Nebraska creameries with those of Northern creameries; (2) to determine whether plants were of optimum size;

(3) to determine the efficiency of factor markets; and (4) to observe the statistical results obtained from varying the definition of capital service inputs.

Data for the Kansas-Nebraska creameries were collected from surveys and audit records of a sub-population from a universe defined as all plants producing butter or butter and other products. Data for Northern creameries were obtained from a cooperative auditing firm in Minnesota. Northern creamery data were stratified and the substratum which received all of their butterfat supplies in the form of farm-separated cream was considered to be the most comparable to Kansas-Nebraska creameries.

Cobb-Douglas production functions were fitted to the data computed by the method of least squares and the abbreviated Doolittle method of matrix inversion. Input variables consisted of butterfat, labor, operating expenses, and capital services. Labor inputs made up approximately three-fifths of the total productive inputs in Kansas-Nebraska, while operating expenses and capital composed the remaining two-fifths.

Basic estimates used to compare resource productivities were the marginal products. The null hypothesis was that marginal products of Kansas-Nebraska creameries were equal in value to marginal products of Northern creameries. Marginal products were computed for each area and the differences tested for significance by the t-test. The results indicated that there was no significant difference between the marginal products of butterfat, labor, and operating expenses of the two groups at the twenty percent level.

In general, the results of the functions provided evidence of decreasing returns to scale for Kansas-Nebraska creameries in contrast to increasing and constant returns to scale for Northern creameries.

Evidence of disequilibrium in factor markets was provided by the significant differences between factor prices and marginal products for butterfat, labor, and operating expense resources.

Regression coefficients for capital service inputs were statistically non-significant at the 40 percent level except for the Northern aggregate function. Capital inputs were variously defined as depreciation, repairs, and maintenance charges; expenditures for electricity only, expenditures for all utilities, and the combination of these measures of capital service inputs. More refined techniques of measuring this resource are needed. Bookkeeping systems of many creameries also needed improving.

The economic model of this analysis was cast in a static environment. A dynamic model which would account for lag effects and uncertainty would have been more realistic of the actual conditions which prevailed for the period studied.

However, limited funds and time precluded a dynamic analysis of these problems.