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Factors Influencing the Production of Milk in South Dakota

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FACTORS INFLUENCING THE PRODUCTION OF MILK IN SOUTH DAKOTA

BY

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FACTORS INFLUENCING THE PRODUCTION

OF MILK IN SOUTH DAKOTA

This thesis is approved as a creditable, independent investigation by a candidate for the degree, Master of Science, and acceptable as meeting the thesis requirements for this degree; but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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Thesis Advisor

Head of the Major Department

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CHAPTER I

INTRODUCTION

The production of milk on farms in South Dakota during 1958 totaled 1,454 million pounds. This resulted in a cash income of nearly thirty-three millions of dollars. Although this represents less than five percent of the source of South Dakota cash farm income, it still is a sizeable industry.

The Problem

Each year the production of milk increases or decreases in accordance with certain factors which may or may not be identifiable. The total production of milk represents the decisions of thousands of farmers, and to determine objectively all the factors involved in the decision making process would be impossible. However, it is considered feasible to determine those factors which are most important in the decision making process.

Table I shows that there is little uniformity in the movement of prices received for dairy products and changes in milk production. The Index of Prices Received for Dairy Products increased in twenty of the thirty-three years, and total milk production increased in eight of these years and decreased in twelve. The Index decreased in eleven of the thirty-three years, while during the same period, milk production increased in seven years and decreased in four. When the Index did not change, as it did in two of the years in the study, total milk

production increased in both years.

TABLE I. SUMMARY OF APPENDIX TABLE I TOTAL RELATIVE CHANGE IN PRODUCTION OF MILK IN SOUTH DAKOTA AND PRICES RECEIVED BY SOUTH DAKOTA FARMERS FOR DAIRY PRODUCTS (1926-1959)

Relative change in prices received for dairy products (in number of years)	Relative change in total milk production (in number of years)			
	Increased	Decreased	No change	Total
Prices increased	8	12		20
Prices decreased	7	4		11
Prices did not change	2	0		2
	17	16		33

One of the more common reasons given for a variation in the total production of milk is that as a reduction in dairy prices occurs, production is increased, and conversely as an increase in dairy prices occurs, production is decreased. According to Heady[1] a historic explanation given to account for agriculture's failure to contract output during depression or its "assumed" inability to expand output in high price or food emergency periods includes:

> "4. Farmers attempt to maintain income at constant levels. Under this reaction to price decline farmers supposedly work harder and longer hours and otherwise increase resource inputs in an attempt to offset price reductions through the

[1] Earl O. Heady, Economics of Agricultural Production and Resource Use, pp. 675-676, Prentice-Hall, Inc.: Englewood Cliffs, New Jersey, 1957.

greater products."

Heady qualifies the above quotation in a footnote:

> "5. This reaction is logical on the individual farm only if (a) underemployed resources are present or (b) marginal costs have been much lower than marginal returns and the operator has additional funds or is able to obtain credit. Because of their micro-environment many farm operators may view increased production from a given collection of resources as one means of offsetting income losses through price declines. While a single farmer might offset the decline through this type of adjustment, farmers in the aggregate can only push profits to lower levels because of the highly inelastic demand for agricultural products."

Additional reasons given for the lack of responsiveness to price changes are the length of the period involved in agricultural production; it is a highly competitive industry; agricultural costs are composed largely of fixed costs; and many others. Because of the difficulty of measuring the influence of prices on future production, many have concluded that trends in production are largely independent of past prices.

Objectives

The objectives of this study are to isolate those factors which are pertinent to the production of milk on South Dakota farms, determine whether production of milk is responsive to these factors and to prove or disprove the theory that as the price of milk decreases in South Dakota, the farmer increases production to maintain a constant income and its corollary that as the price of milk increases, the farmer reduces production.

Hypotheses

In order to achieve the above objective, the following hypotheses were tested:

1. That as the price of dairy products decreases the South Dakota farmer increases production in order to maintain a constant income.

2. That as the price of dairy products increases the South Dakota farmer decreases production of milk in order to maintain a constant income.

Procedure

Application of the Chi-square test to the hypotheses indicated that the number of observations available were too limited, having observed cell frequencies less than ten with only one degree of freedom, to consider the test to have the required validity.[2] Upon failure to obtain a statistically significant Chi-squared value, the study proceeded to isolate the causes for change in the production of milk on South Dakota farms. A statistical analysis of the available relevant factors was made and, by means of induction, conclusions were determined. Attempts were made to make the evidence accurate, to use relevant factors in the determinations, and to make it as complete as feasible from

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[2]Arkin, Herbert and Colton, Raymond R., Tables for Statisticians, p. 16, College Outline Series, Barnes and Noble: New York, N. Y., 1959.

available secondary data. The statistical method utilized was Bean's[3] "Short-Cut Method of Approximation", a method of approximating curvilinear relationships without the previous determination of linear regressions. Specific analysis was then made of the variation not resolved by the curvilinear relationships and from the facts so developed a summary and conclusion is stated. Pertinent theory on selected material is included wherever feasible.

Limitations of the Study

The study did not attempt to enter into the field of production economics and alternative enterprises except in a causal manner required to assist in interpretation of results. The lack of statistical information covering a protracted period was a severe handicap to the study and some assumptions were necessary due to this deficiency.

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[3] Louis H. Bean, "A Simplified Method of Graphic Curvilinear Correlation", Journal of the American Statistical Association, vol. XXIV, December, 1929, 386-397.

CHAPTER II

NUMBER OF COWS MILKED FUNCTION

Any problem concerned with the total production of milk must encompass two separate and distinct primary functions. The first primary function in the total production of milk is the number of cows milked. The second primary function is the amount of milk produced by the individual producing unit, the milk cow. The same factors may or may not be involved with each of these separate functions when considered in relation to the hypotheses. Accordingly, each of the primary functions will be dealt with as separate determinations in separate chapters in this study.

The total production of milk can be simply stated in the following empirical equation:

$$TMP = f(Y_1 X_1)$$

Where:

TMP = Total milk production

Y_1 = Number of cows milked

X_1 = Production per cow milked

This formula is, of course, a simplification of the problem and only justifies itself as a point of departure in our endeavor to determine the real causes in the variation in total milk production on South Dakota farms.

As indicated above, one of the primary functions in the total production of milk is the number of cows milked. It thus becomes

necessary to determine what causal relationships exist in the determination, in South Dakota, of how many cows are milked and whether the hypotheses are substantiated by the results.

Theory

A recent report by the Agricultural Marketing Service[4] indicates the number of milk cows in the United States has declined in every year since 1944 except two; Table II shows that milk cow numbers are down in all regions of the United States since 1945.

TABLE II. MILK COW NUMBERS BY REGIONS
(PERCENTAGE DECLINE 1945 TO 1960)

Region	Percent decline
Western	- 11.4%
West North Central	- 33.1%
South Central	- 33.9%
East North Central	- 22.3%
North Atlantic	- 5.8%
South Atlantic	- 6.2%
Total United States	- 23.2%

This regional redistribution of milk cows reflects two major developments; first, the decline in butter consumption which in turn reduced the demand for milk in many states in the Great Plains and Western Corn Belt; and, second, increased demands for fluid milk near the

[4]Herbert Kriesel, "Has the Decline in Milk Cow Numbers Ended?", Agricultural Situation, vol. 44, No. 4, 12-13, Agricultural Marketing Service, U. S. Department of Agriculture, Washington, D. C., April, 1960.

populous areas of the country. The gradual decrease in number of milk cows within the past several years reflected the decline in the number of dairy farms, only partly offset by the increase in number of cows kept per farm. In the years gone by, farmers often shifted from milk production to beef production, or vice versa, depending on economic conditions. Because of the expensive facilities now needed on dairy farms, there is relatively little shifting from beef to milk. The rate of decline in numbers of dairy cows depends mainly on the rate at which dairy farms shift to other enterprises.[5]

Jensen et al.[6] point out that on most farms it is possible to make an even greater expansion in size of herd and in the production of milk by increasing the production of home-grown roughage in addition to feeding grain more heavily. This increase in roughage production can be accomplished, in time, without increasing the total crop acreage. In this fashion, some dairy farmers have doubled and trebled the number of cows in their herds and have increased milk production even more without increasing the size of their farms.

Discussion and Analysis

A comparison of the number of cows milked in 1945 and the number

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[5]Ibid., p. 12.

[6]Einar L. Jensen et al., "Intensification of Dairying Through Increased Roughage Production", Input-Output Relationships in Milk Production, p. 73, Technical Bulletin No. 815, United States Department of Agriculture: Washington, D. C., May 1942.

of cows milked in 1959 in South Dakota from Appendix Table II indicates that South Dakota had a decrease of over 62 percent in the number of cows milked. This is almost twice the average for West North Central States. A shift of this magnitude could hardly be accounted for by a reduction in the demand for butter but must be attributed to a much more fundamental cause.

If the contention of Jensen et al.in the above theory is correct, that milk herds can be expanded without the addition of an expansion in acreage, the increase in size of the average farm in South Dakota would indicate that alternative products were the fundamental reason for this expansion. This expansion in alternative products is substantiated by Wayne Dexter[7] who states, "Since 1937, prices for beef cattle have increased more than the average for all farm products." Accordingly, we may expect to find a close correlation between the number of farms in South Dakota and the number of cows milked. In the past it was customary for each farmer to maintain some dairy cattle. This micro operation was not an efficient means to produce milk for the market. This is borne out by a recent study by the University of Wisconsin[8] showing that a herd of twenty milk cows produces milk at less cost than herds of smaller size. In addition to the relatively unfavorable climate for milk

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[7]Wayne Dexter, "The General Price Level", What Makes Farmers' Prices, p. 1, Agriculture Information Bulletin 204, United States Department of Agriculture: Washington, D. C., April 1959.

[8]Staff of College of Agriculture, "Costs With Herds of Various Sizes", The Cost of Producing Milk, Economic Information for Wisconsin Farmers, vol. 28, No. 2, Special Circular, June 1959.

production compared to other products in South Dakota, the man hours involved in a micro operation are much higher than in other alternative products, and with the sale of farms it is reasonable to assume that the new owners would not have the manpower available to maintain or increase the number of cows to be milked without adding to their labor costs. This would probably not be accomplished unless the alternative products were not as attractive. An additional problem in maintaining or increasing the size of the herd would be the added capital investment which would be necessary to consolidate the milk cows from one or more farms into one herd. It is not reasonable to expect that the farmer would maintain one or more cows in the purchased acreage because of the distance involved unless the product was very profitable and the cost of increasing the size of his own dairy herd was prohibitive. Probably, the farmer desiring to increase the size of his herd would make the necessary capital improvements before he would find it necessary to increase his land holdings. Thus, there appears to be a causal relationship between the number of South Dakota farms and the number of cows milked. Accordingly, the first variable plotted against the number of cows milked was the number of farms in South Dakota. In consonance with the hypotheses, the second variable analyzed was the Index of Prices Received by South Dakota farmers for Dairy Products. Table III is a summary of the results of the initial study for the period 1924 to 1959 from Appendix Tables II and III, and Table IV from Appendix Tables IV and V is a summary of the results of the study after deleting the war period 1940 to 1946. The analysis, utilizing Bean's Short Cut Method of

Approximation, was accomplished by the empirical formula

$Y_1 = f(Y_2, Y_3)$

Y_1 = Number of milk cows

Y_2 = Number of farms

Y_3 = Index of prices received for dairy products

The steps outlined in Table III are analyzed as follows:

Period 1924-1959

After the first step, it was apparent that more than 81 percent of the squared variability in Y_1 was explained by Y_2 $p^2_{1.2} = 0.8151$. The effects of Y_3 or of any interrelation between Y_2 and Y_3 were not considered.

After the second step, it was apparent that more than 83 percent of the squared variability in Y_1 was explained by Y_2 and Y_3 ($p^2_{1.23}$=0.8331). This also indicated that Y_3 only explained less than 2 percent of the variability in Y_1, in addition to that explained by Y_2 (o.8331 - 0.8151 = 0.180). In this step the interrelationship between Y_2 and Y_3 was partly considered.

After the third step, it was apparent that there was no increase in the explanation of the squared variability in Y_1 by the interrelationship between Y_2 and Y_3.

In order to improve upon the percent of the variability in Y_1 and based upon the fact that during the war period of 1940 to 1946 the farmer may well have had as a goal the maximization of production rather than the maximization of profits, the period 1924 to 1959 was analyzed omitting the war period of 1940 to 1946. The steps involved in Table IV

are analyzed as follows:

Period 1924-1959 (1940-1946 omitted)

After the first step, it was apparent that more than 96 percent of the squared variability in Y_1 was explained by Y_2 $\rho^2_{1.2} = 0.96872$. The effects of Y_3 or of any interrelation between Y_2 and Y_3 were not considered.

After the second step, it was apparent that more than 98 percent of the squared variability in Y_1 was explained by Y_2 and Y_3 ($\rho^2_{1.23} = 0.9848$). This also indicated that Y_3 only explained less than two percent of the squared variability in Y_1, in addition to that explained by Y_2 ($0.9848 - 0.9687 = 0.0161$). In this step the interrelationship between Y_2 and Y_3 was partly considered.

After the third step, it was apparent that the remainder of the interrelationship between Y_2 and Y_3 did not increase the explanation of the squared variability in Y_1.

TABLE III. SUMMARY OF SHORT-CUT APPROXIMATION METHOD CALCULATION OF MILK COWS ON SOUTH DAKOTA FARMS (1924-1959) FROM TABLES STEP BY STEP

Step	Relationship	Independent variable considered	Interrelationship considered	AZ^2	p		p^2
1	Y_1Y_2	Y_2	None	1675.5	$\rho_{1.2}$	= 0.9028	0.8151
2	Y_1Y_3	Y_3 after eliminating effect Y_2	Y_2Y_3 partly	1512.94	$\rho_{1.23}$	= 0.912743	0.8331
3	Y_1Y_2	Y_2, after Y_3, after Y_2	Y_2Y_3 all	1512.94	$\rho_{1.23(2)}$	= 0.912743	0.8331

Sources: Appendix Table II and III.

TABLE IV. SUMMARY OF SHORT-CUT APPROXIMATION METHOD CALCULATION OF MILK CONS ON SOUTH DAKOTA FARMS (1924-1959 - 1940-1946 OMITTED)

Step	Relationship	Independent variable considered	Interrelationship considered	AZ^2	ρ		ρ^2
1	Y_1Y_2	Y_2	None	341.69	$\rho_{1.2}$	= 0.984187	0.96862
2	Y_1Y_3	Y_3 after eliminating effects Y_2	Y_2Y_3 partly	166.17	$\rho_{1.23}$	= 0.992371	0.9848
3	Y_1Y_2	Y_2 after Y_3, after Y_2	Y_2Y_3 all	166.17	$\rho_{1.23(2)}$	= 0.992371	0.9848

Source: Appendix Table IV and V.

If we look at Figure 1, the linear line of regression indicates that as the number of farms decreases in South Dakota, the number of cows milked also decreases. The war years of 1940 to 1946 do not fit the line of regression as closely as desirable. When the residuals are plotted against the Farm Price Index of Prices Received for Dairy Products, Figure 2, a linear line of regression is apparent, but at the same time the war period of 1940 to 1946 does not closely fit the linear regression. In Figure 3 the second line of approximation is the same as the first so that no change is indicated in the original regression line of the first approximation.

Figures 4, 5, and 6 show the lines of regression for the period 1924 to 1959 with the war years (1940 to 1946 inclusive) omitted. Figure 4 has the same line of regression as Figure 3, and the only result of omitting the war period is to improve the index of correlation. Figure 5 indicates that during the period when the Farm Price Index of Prices Received for Dairy Products was extremely low, there is evidence that the number of cows milked increased, particularly in the years 1932, 1933, 1938, and 1939. Figure 5 gives what is considered to be a more accurate line of regression than Figure 2. Figure 6 does not indicate that the first approximation curve should be changed.

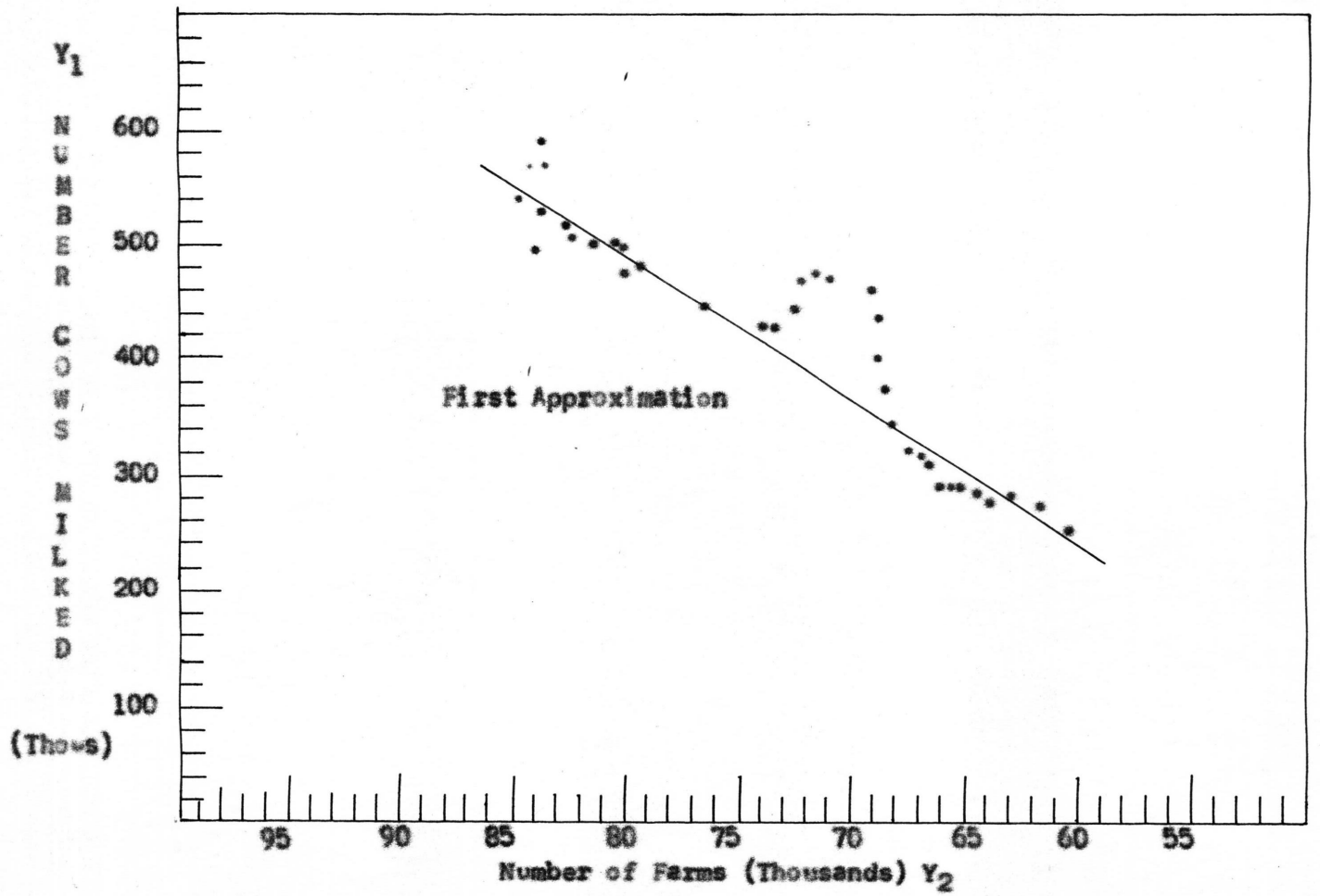

Figure 1. First Short Cut Approximation Curve for Y_1Y_2 Relationship

Source: Appendix Table II.

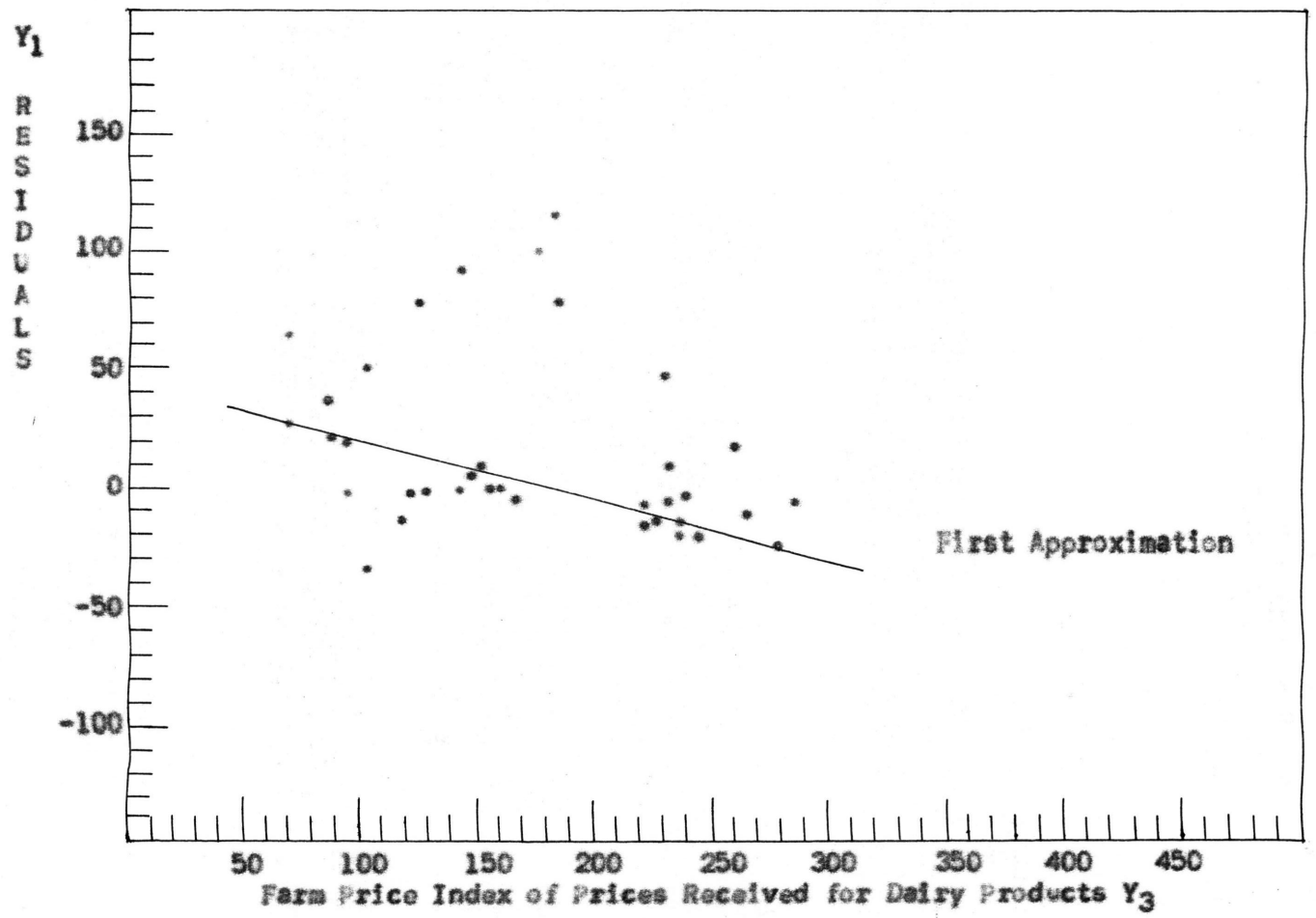

Figure 2. Residuals From Y_1Y_2 Approximation Curve Plotted With Y_3

Source: Appendix Table II and III.

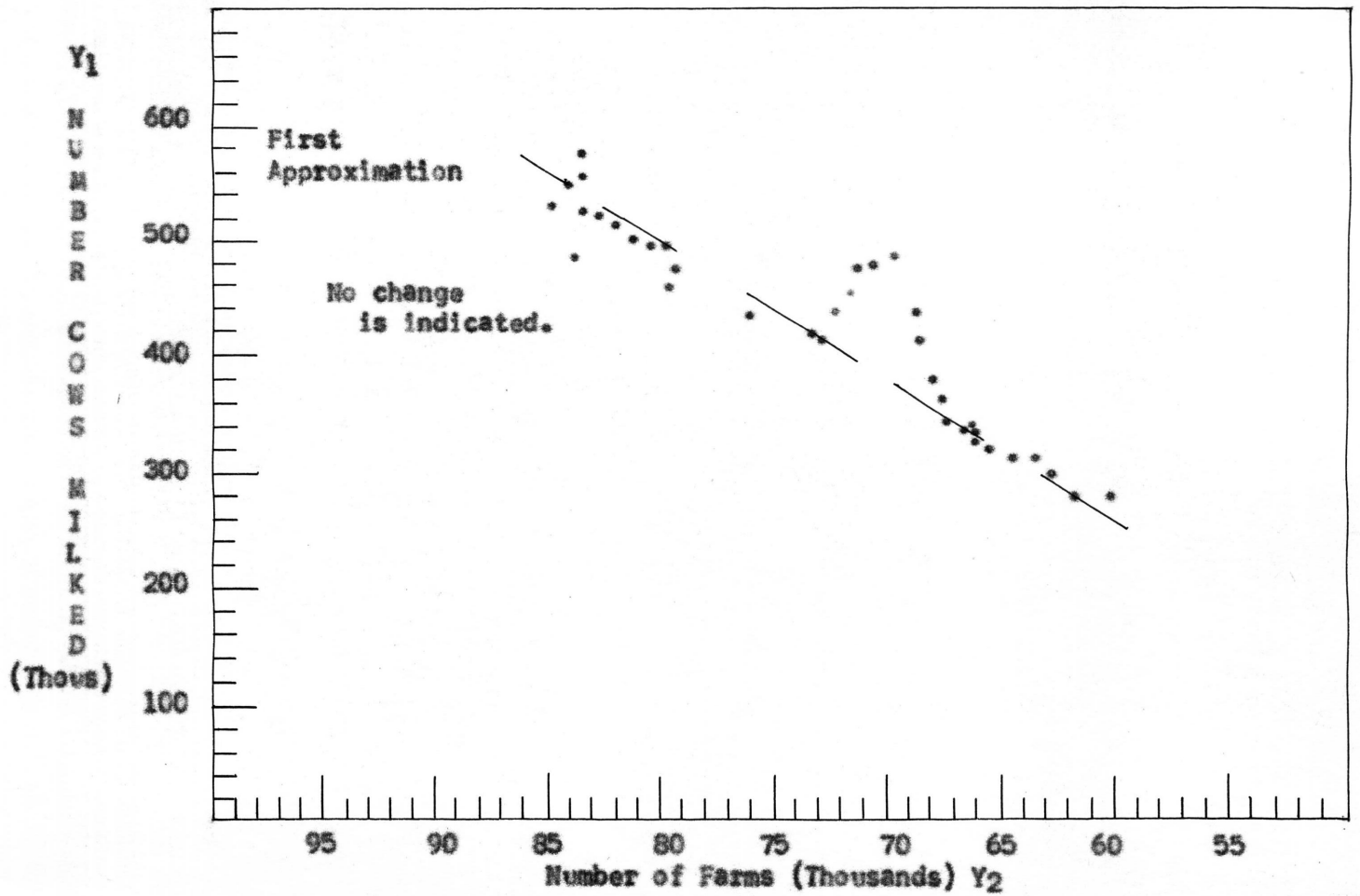

Figure 3. Residuals from Y_1Y_3 Approximation Plotted About the Y_1Y_2 Approximation Curve with Respect to Y_2

Source: Appendix Table III.

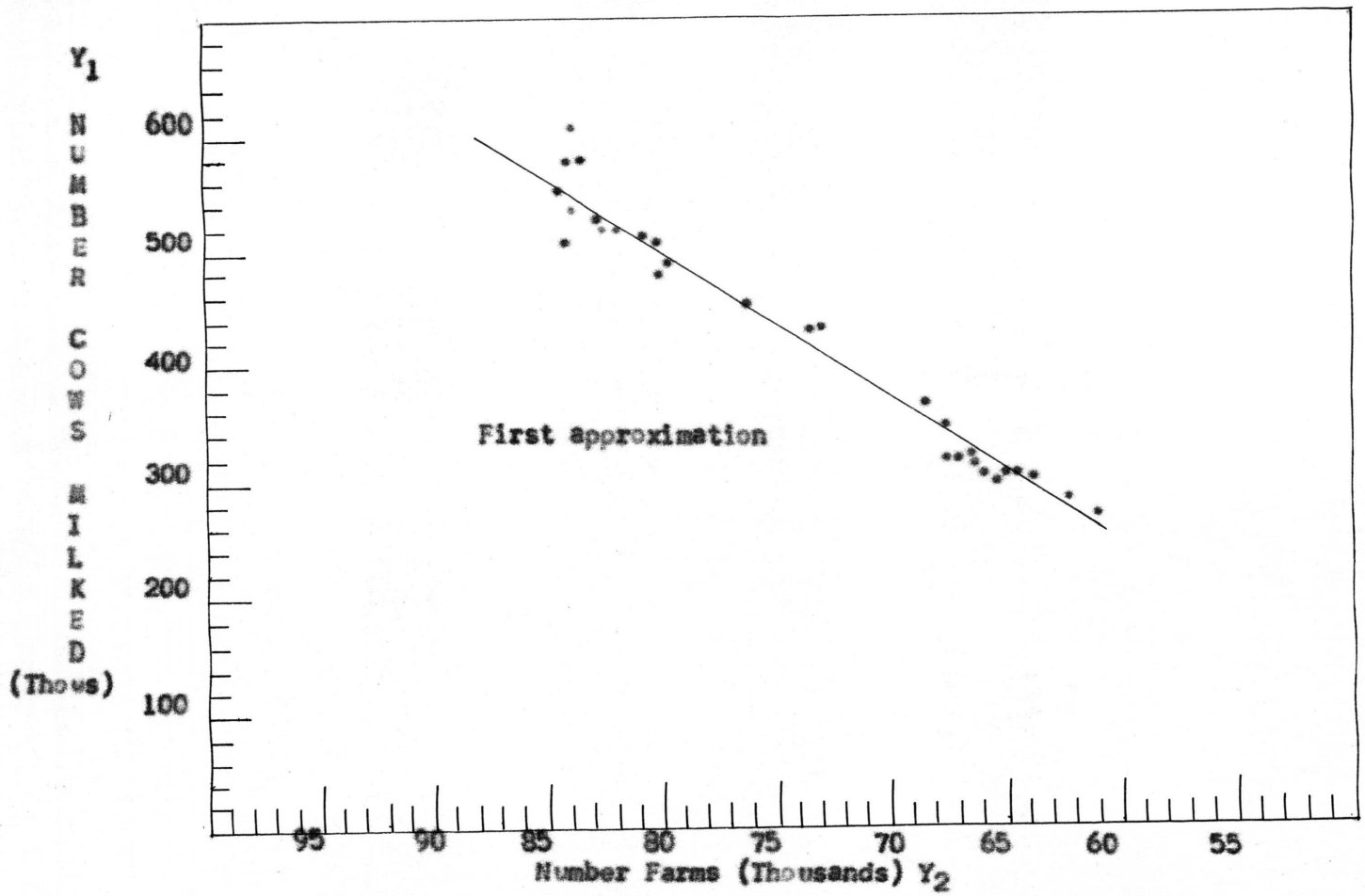

Figure 4. First Short Cut Approximation Curve for Y_1Y_2 Relationship (1940-1946 Omitted)

Source: Appendix Table IV.

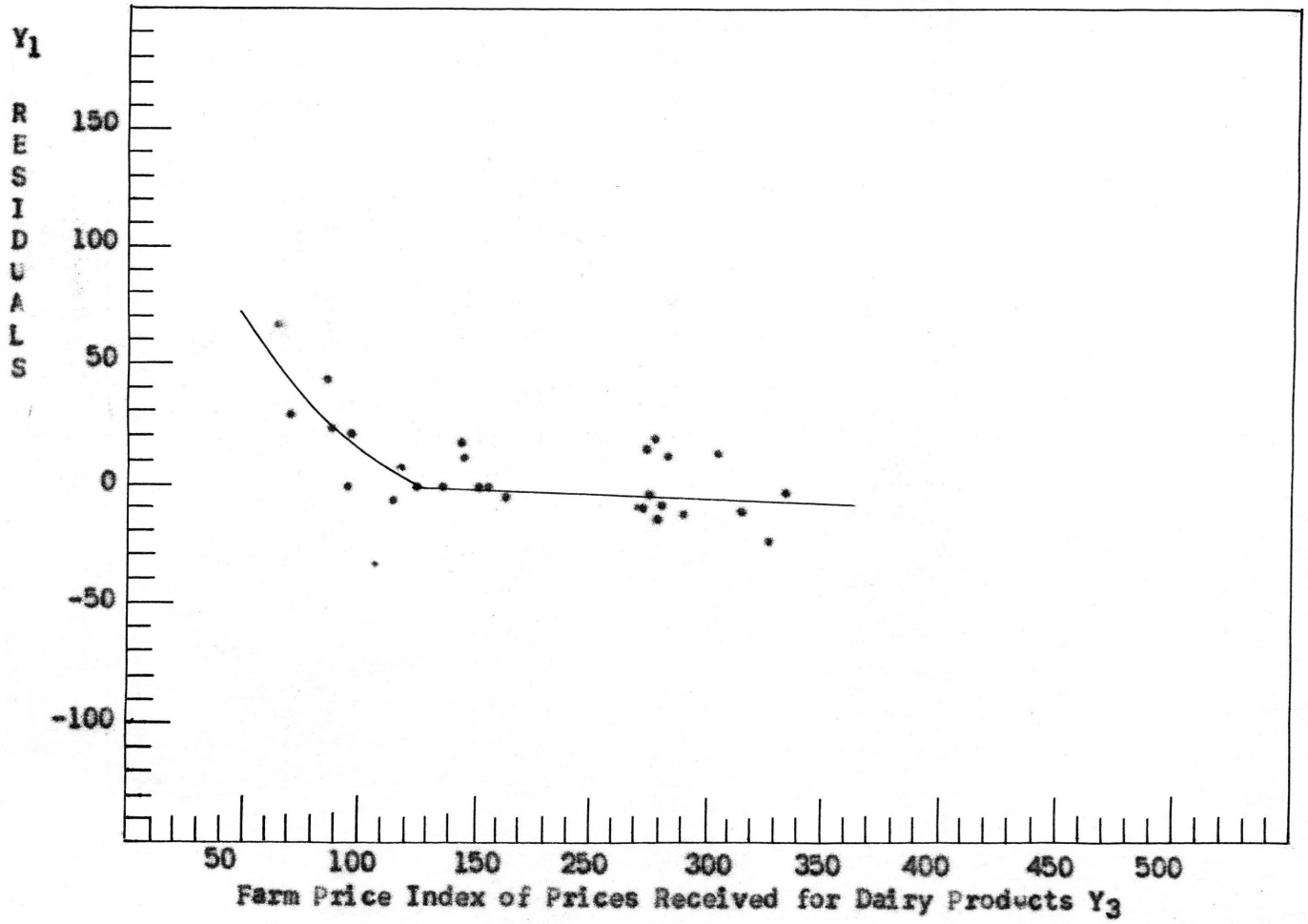

Figure 5. Residuals From Y_1Y_2 Approximation Curve Plotted with Y_3

Source: Appendix Table IV and V.

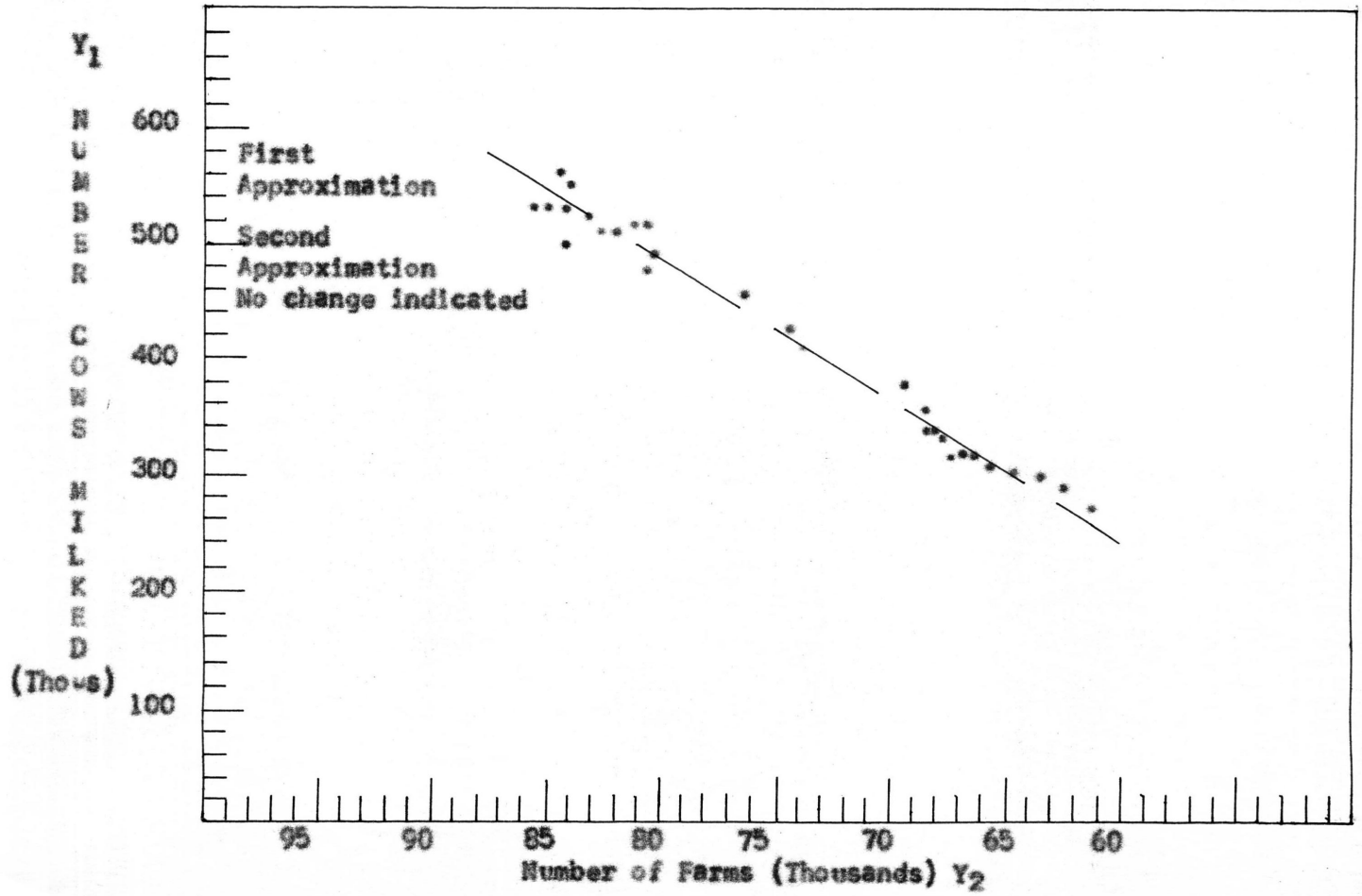

Figure 6. Residuals from Y_1Y_3 Approximation Plotted About Y_1Y_2 Approximation Curve with Respect to Y_2

Source: Appendix Table V.

Preliminary Conclusions

The following conclusions may be made based on the assumption that the war years 1940 to 1946 may be excluded as a resultant of a different goal being desired rather than that of maximization of profits.

1. The number of cows milked on South Dakota farms decreased with the number of farms.

2. The above decrease is linear in nature and has a high index of correlation of more than 98 percent.

3. The Farm Price Index of Prices Received for Dairy Products has in general very little effect on the number of cows milked except when the index is relatively low.

4. At the lower range of 120 and below for the Index of Prices Received for Dairy Products, there is evidence that more cows are milked.

5. More than 96 percent of the squared variability in the number of cows milked is explained by the decrease in the number of farms.

6. Less than 1 percent of the squared variability in the number of cows milked is explained by the Farm Price Index of Prices Received for Dairy Products.

CHAPTER III

MILK PRODUCTION PER MILK COW

The production of milk per milk cow or the milk production function is concerned with the relationship between input of feed and the resulting output of milk from the dairy cow. This part of the study concerns itself with the determinations of the factors which account for the variation in the output of milk per milk cow and their relationship with those factors which result in the changes in output.

Theory

Einar Jensen, Principal Agricultural Economist, United States Department of Agriculture et al., initially studied input-output relationships in milk production. Figure 7 indicates the two concepts of the milk production function. Jensen[9] points out that under the first concept production would either take place at the standard feeding rate according to the accepted standard or would not take place at all. The accepted standard would be followed so long as profits could be made, but when unprofitable, production would stop completely. If the diminishing returns concept of production response is true, it can be seen that feeding would change as price changes. Jensen[10] concludes that on

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[9]Einar L. Jensen et al, Input-Output Relationships in Milk Production, Technical Bulletin No. 815, p. 6, United States Department of Agriculture: Washington, D. C., May 1942.

[10]Ibid, p. 86.

the basis of input-output experiments, it was determined that the law of diminishing output applies to milk production, and that on the basis of input-output experiments, it was determined to what degree milk output can be raised by more intensive feeding. It was found that in the herds used for experiments, 15 to 20 percent more milk was obtained from the cows at high levels of feeding than from cows fed at standard, and 45 percent more than from cows fed at 70-80 percent of standard. It also was found that it is not possible by increased feeding to stimulate the milk production of cows of low inherent productivity.

Heady[11] and Helfinstine[12] both recognized that the inherent breed qualities were factors in the milk production function. Arthur J. Hintzman[13] in a recent article states, "In the United States there are five dairy breeds which are considered to be of major importance for milking purposes. These five major breeds are Holsteins (officially known as Holstein-Friesian in Canada and the United States), Jersey, Guernsey, Ayrshire, and Brown Swiss. Dutch Belted, Kerry, and Dexter cattle are also recognized dairy breeds but are only of very minor importance in the dairy industry in Wisconsin and the nation. In

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[11] Earl O. Heady et al., Milk Production Functions, Hay/Grain Substitution Rates and Economic Optima in Dairy Cow Rations, Iowa Agricultural Experiment Station Research Bulletin 444: Ames, Iowa, 1956.

[12] Rex Helfinstine, Unpublished Mimeographed Paper, Milk Production Functions, South Dakota State College: Brookings, South Dakota.

[13] Arthur J. Hintzman, Breeds of Livestock Marketed from Wisconsin Farms, Special Bulletin No. 26, p. 3, The Crop and Livestock Reporting Service, Wisconsin and United States Departments of Agriculture: Madison, Wisconsin, September 1952.

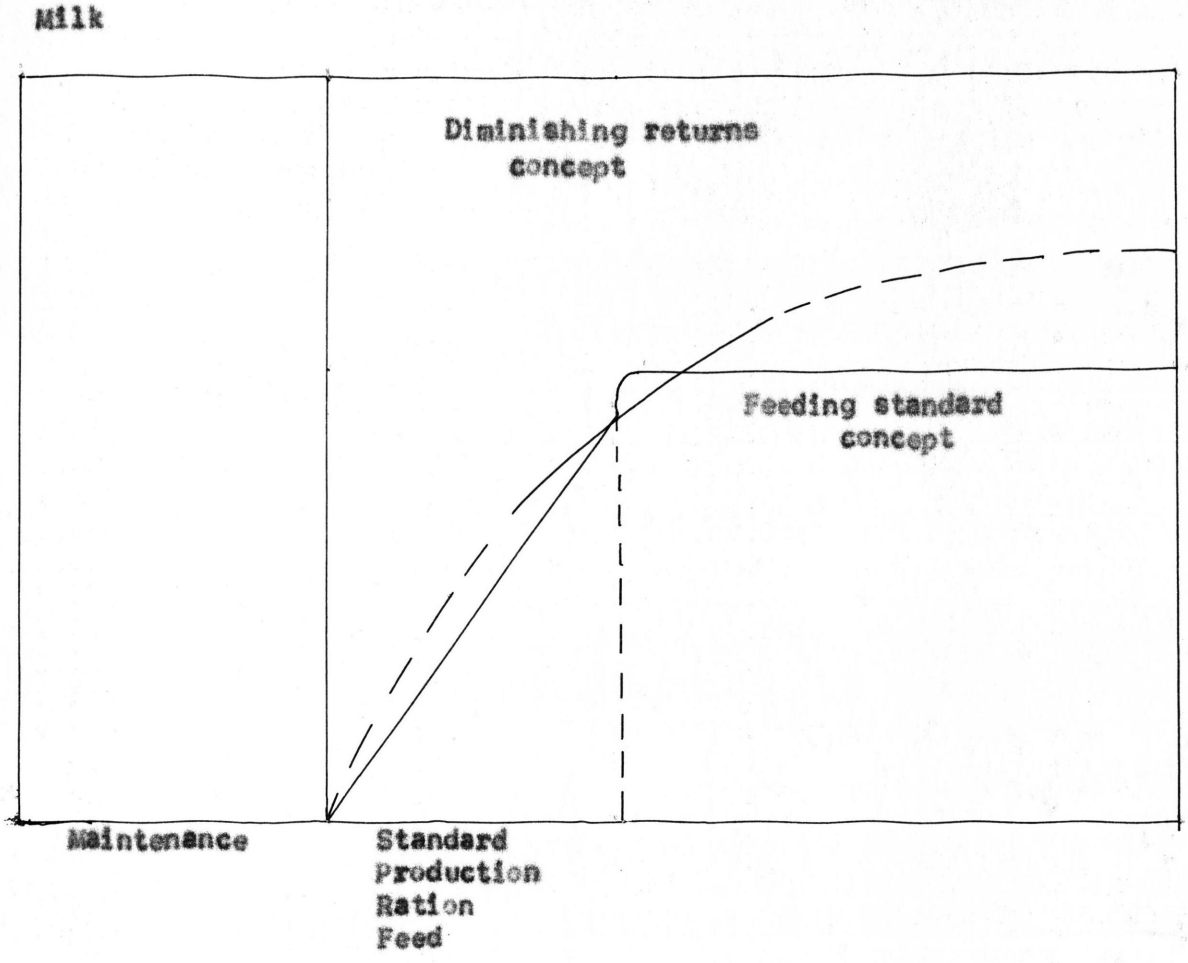

Figure 7. Two concepts of Production Response to Increased Feeding

Source: Jensen, Einar L., et al., "Intensification of Dairying Through Increased Roughage Production," Input-Output Relationships in Milk Production, p. 6, Technical Bulletin No. 815, United States Department of Agriculture: Washington, D. C., May, 1942.

In addition to these dairy breeds, there are three recognized dual-purpose purebred breeds of cattle found in this country. These are the Milking Shorthorns (not to be confused with the beef type shorthorns), Red Poll, and Devon." The same breeds are recognized by Anderson[14] who points out that the dual purpose cattle permit diversification and are suitable to medium sized farms, where they will provide for the utilization of farm-grown feeds and surplus labor. Additionally, to some extent it is practical to stress dairying when milk and butterfat are profitable and beef and perhaps veal production when slaughter animals are in demand.

Dexter[15] states that "When the price of a commodity is good, compared with prices for alternative products, farmers as a group tend to produce more of it."

Selection of Variables

In consonance with the hypotheses the first variable selected was the Farm Price Index of Prices Received for Dairy Products. Throughout the study it was considered that this index was more indicative of the changes in production made by the farmers than either the price for whole milk or the price of butterfat as it was more inclusive being weighted

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[14]Arthur L. Anderson, "Dairy Cattle Breeds and Breeding," pp. 298-327, Introductory Animal Husbandry, Third Edition, The Macmillan Company: New York, 1958.

[15]Wayne Dexter, "Changes in Supply", What Makes Farmers' Prices, p. 5, Agriculture Information Bulletin 204, United States Department of Agriculture: Washington, D. C., April 1959.

specifically by marketings in South Dakota.

The second variable selected was the milk-feed price ratio as it was considered that an unfavorable milk-feed price ratio would tend to reduce the amount of concentrate fed the animal with consequent reduction in milk output.

The third variable selected was the percentage of cows of dairy breed. Morrison[16] calls attention to the widely differing nature of milk and flesh production in that the best beef cows are not economical milkers and the best dairy cows are not satisfactory beef makers. Dairy herd-improvement association records show that, on the average, purebred dairy cows produce more milk and fat and return a greater income over feed costs than do grade cows. This is because they have a greater inherent capacity for milk production. The added capacity for milk production as a result of improvement in the percentage of cows of dairy breed is closely correlated with the amount of United States Government purchases of non-fat dry milk solids as indicated in Appendix Figure 3. An assumption is made that this production correlated with cows of dairy breed on South Dakota farms is representative of government purchases under the purchase support plan. It is not considered that production for purposes of marketing to the government should be considered as having any effect on the index of prices received for dairy products or on any theory or explanation of the hypothesis but that it represents

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[16]Frank R. Morrison, "General Problems in Dairy Husbandry", Feeds and Feeding, p. 656, Twenty-First Edition, Unabridged, The Morrison Publishing Company: Ithaca, New York, 1949.

production which can be pushed to the point where marginal revenue is equal to marginal costs.

The fourth variable to be included was the effect of alternative prices for other commodities.

The condition of the pasture in South Dakota, Appendix Table VI, was not utilized as it had a very small effect on the index of correlation as shown by Appendix Figure 1.

Discussion and Analysis

That there is a wide variation in the production of milk from South Dakota dairy cows is indicated in Appendix Table VII. In 1934 the average milk cow produced 2900 pounds of milk which was the smallest amount during the period under consideration, and in 1959, 5190 pounds of milk were produced, which is the highest amount during the period under consideration of 1926 to 1959.

Figures 8, 9, 10, and 11 are preliminary estimates of Figures 12, 13, 14, and 15. An inspection of Figure 12 shows that production of milk per cow increases as the price received for dairy products increases. This in general refutes the hypotheses insofar as it concerns the production of milk from the individual milk cow.

Figure 13 shows the effect of the milk-feed price ratio on the production of milk per cow milked. At a low ratio production is low, and correspondingly as the milk-feed ratio increases, the output of milk from the individual cow increases linearly.

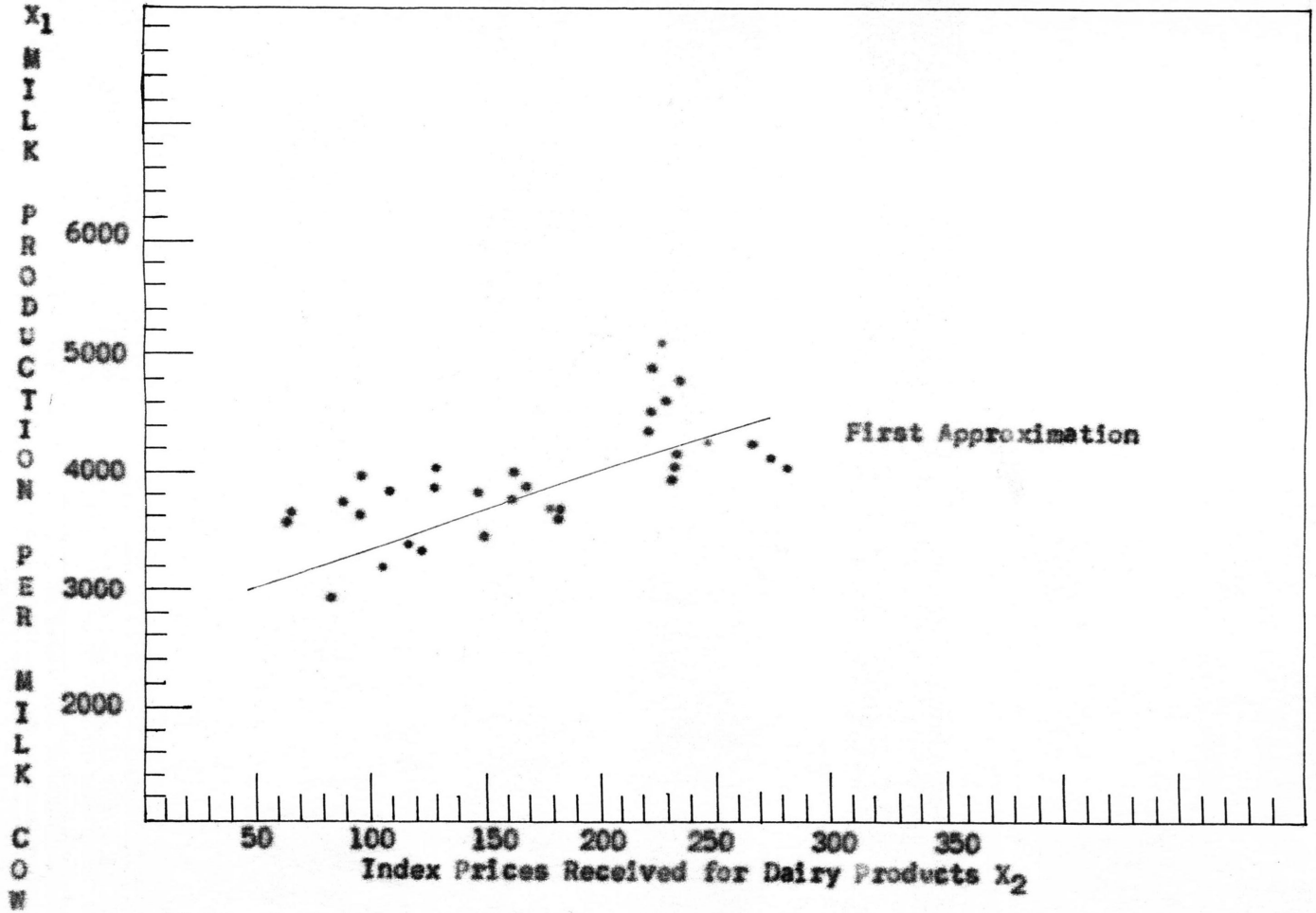

Figure 8. First Short-Cut Approximation Curve for X_1X_2 Relationship

Source: Appendix Table VII

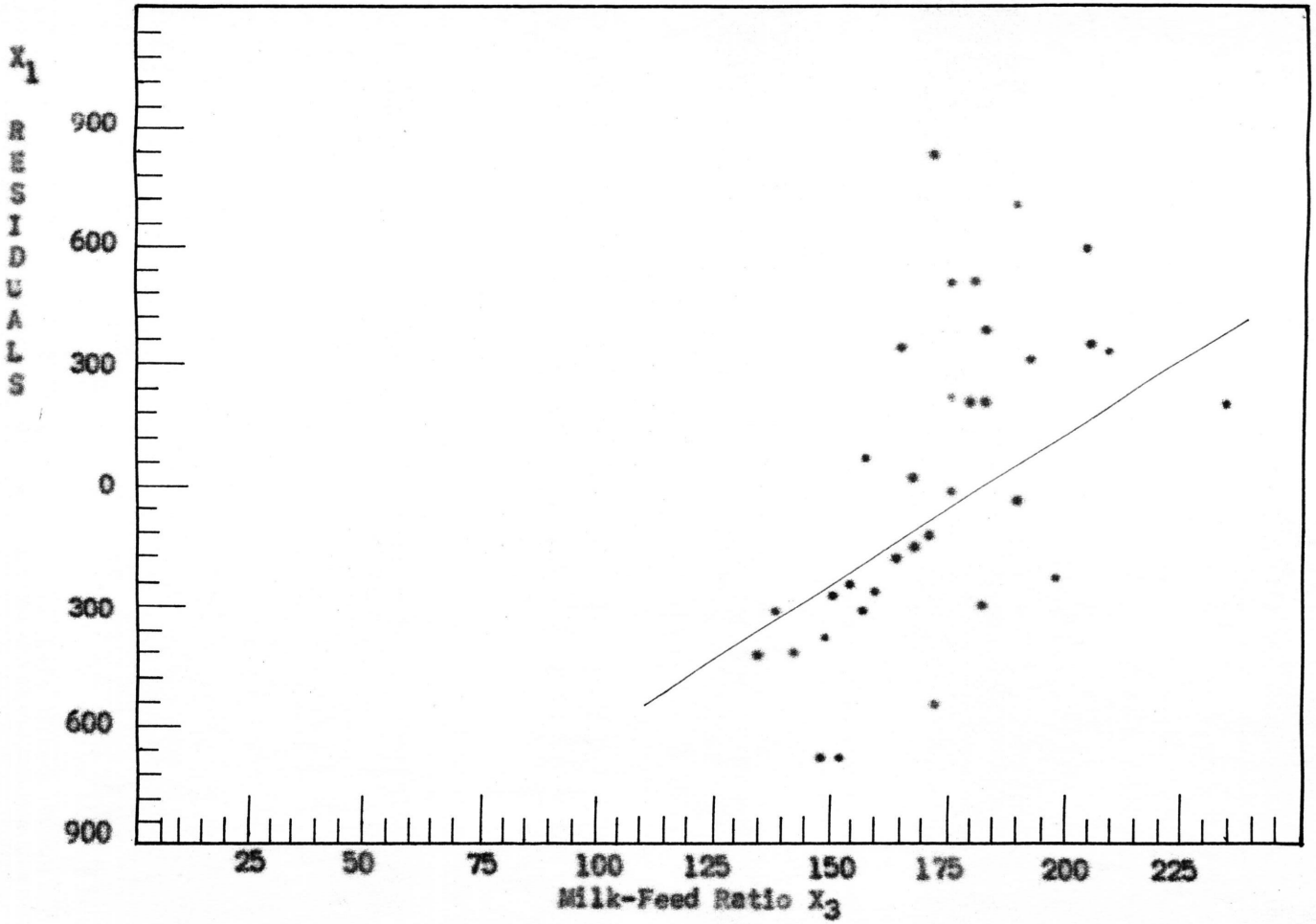

Figure 9. Residuals From X_1X_2 Approximation Curve Plotted with X_3

Source: Appendix Table VIII.

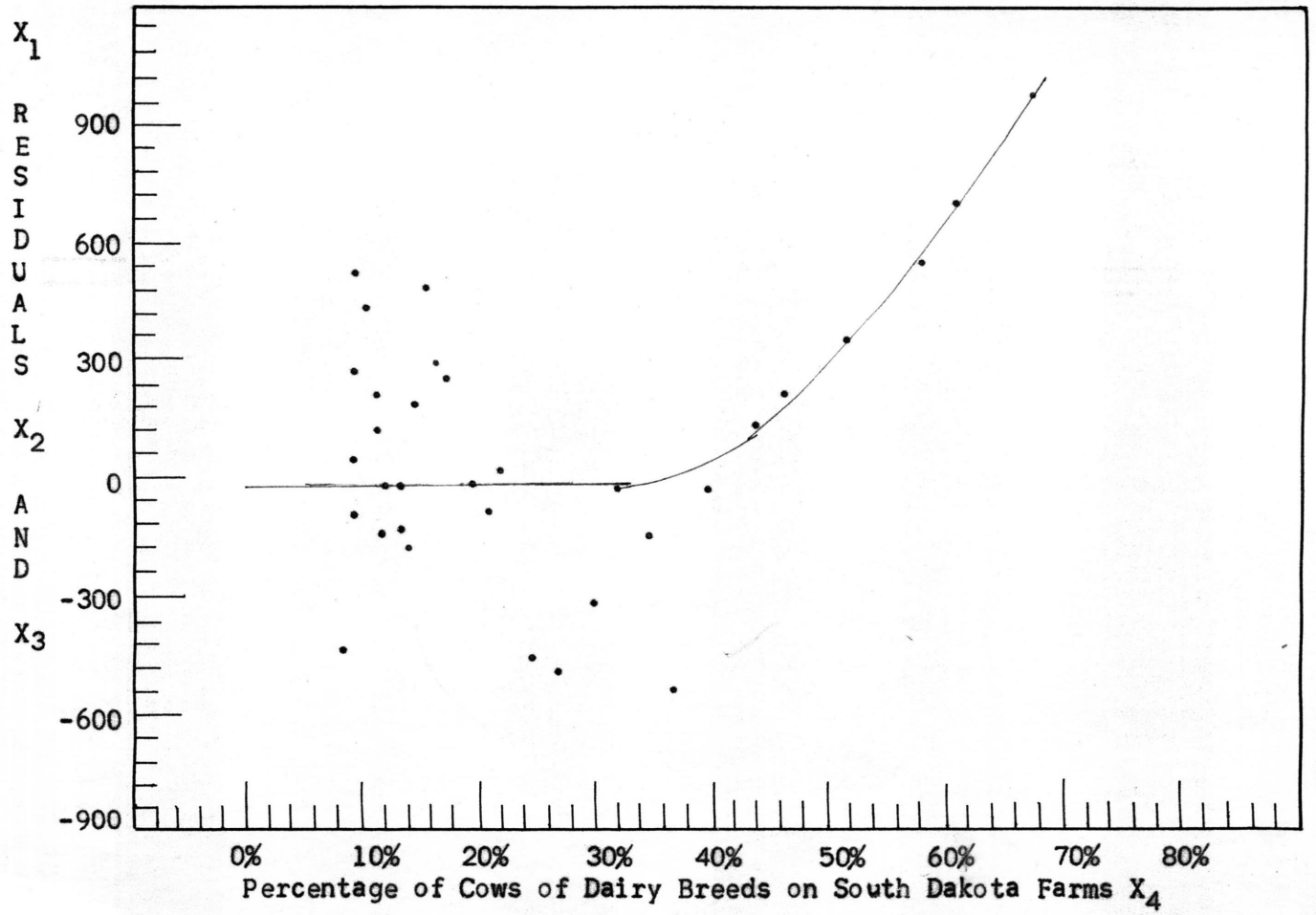

Figure 10. Residuals from X_1X_3 Approximation Curve Plotted With X_1

Source: Appendix Table IX.

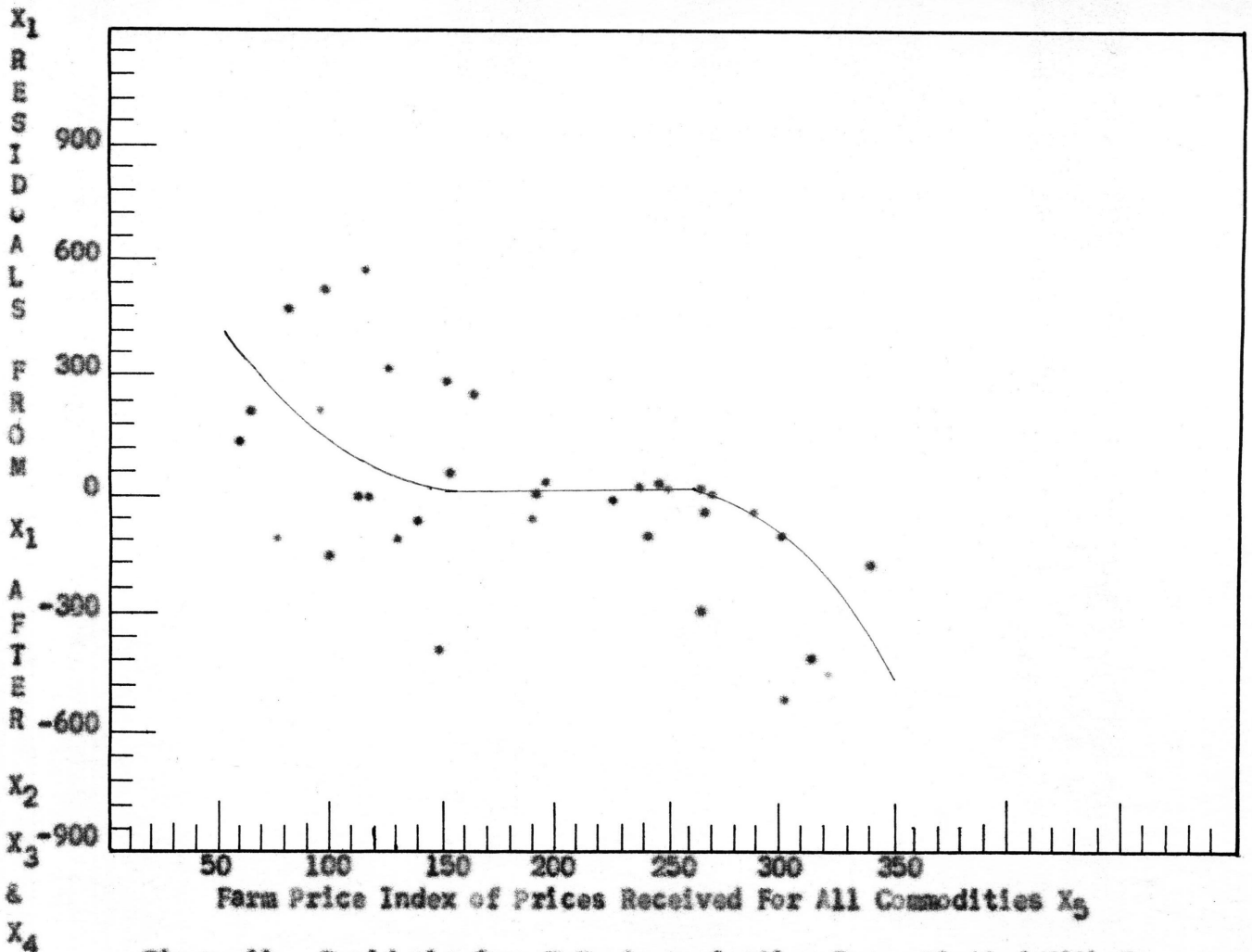

Figure 11. Residuals from X_1X_4 Approximation Curve Plotted With X_5

Source: Appendix Table X.

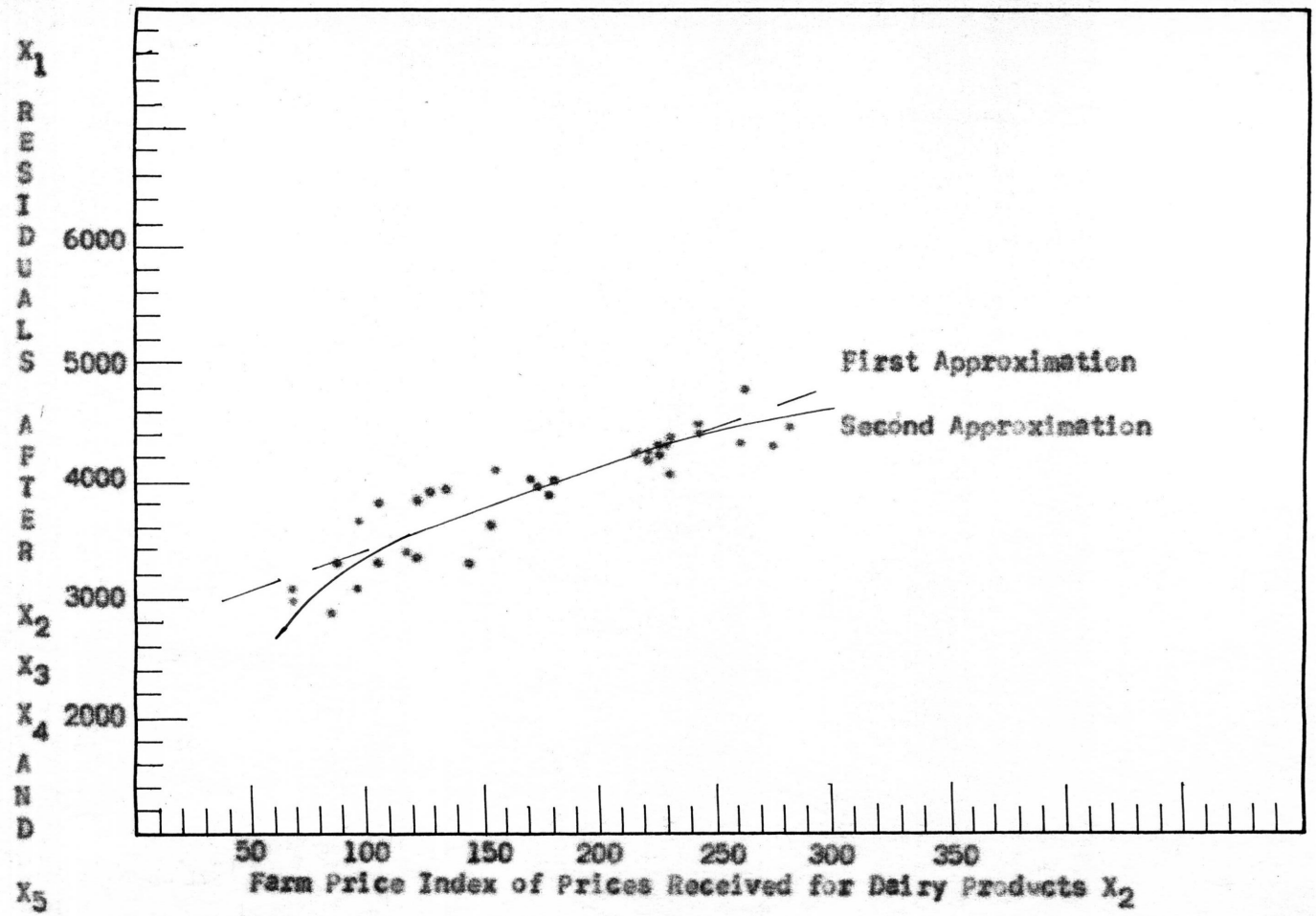

Figure 12. Residuals From X_1X_5 Approximation Plotted About X_1X_2 Approximation Curve with Respect to X_2

Source: Appendix Table XI.

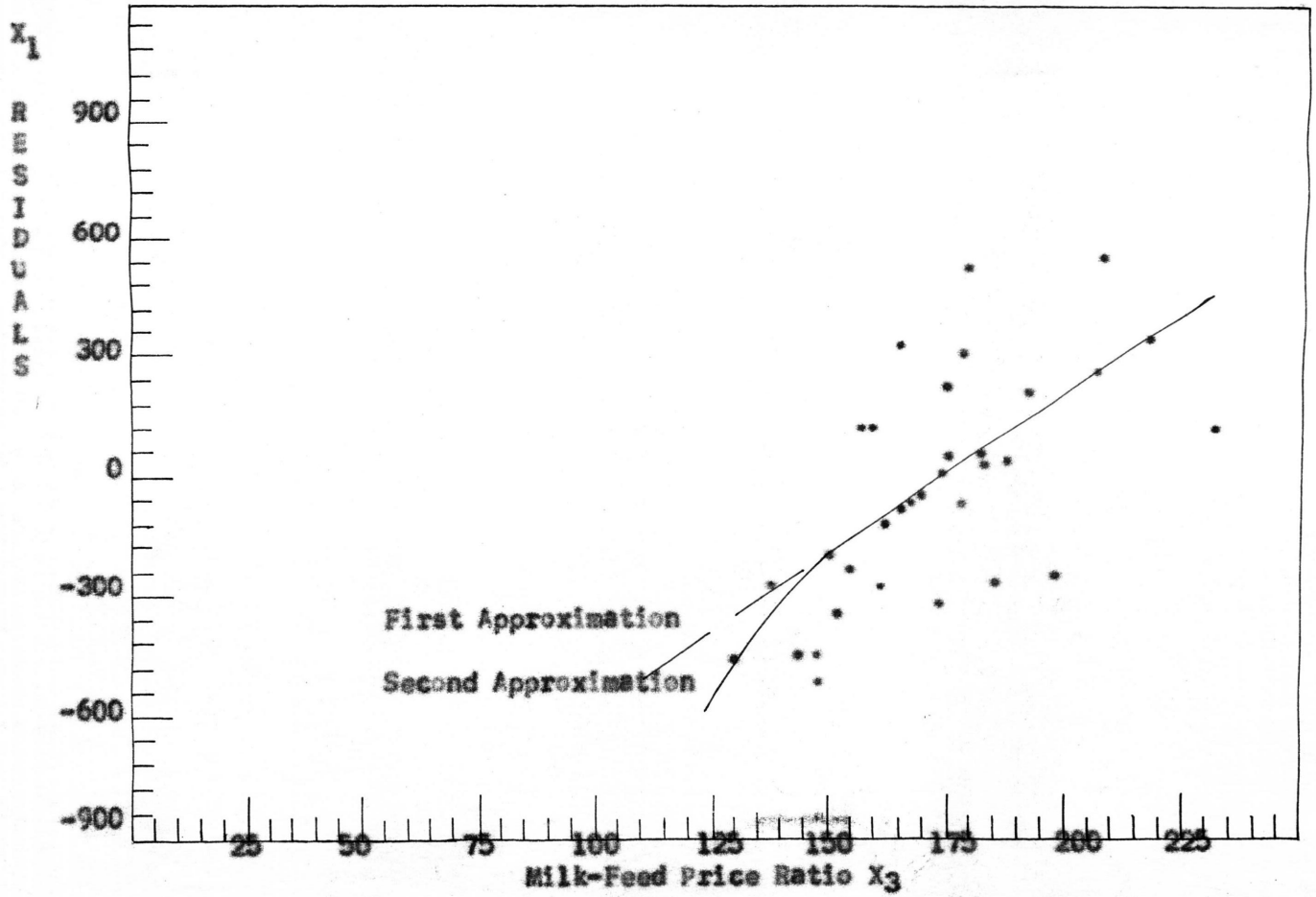

Figure 13. Residuals From X_1X_2 Second Approximation Plotted About X_1X_3 First Approximation Curve With Respect to X_3

Source: Appendix Tables XI and XII.

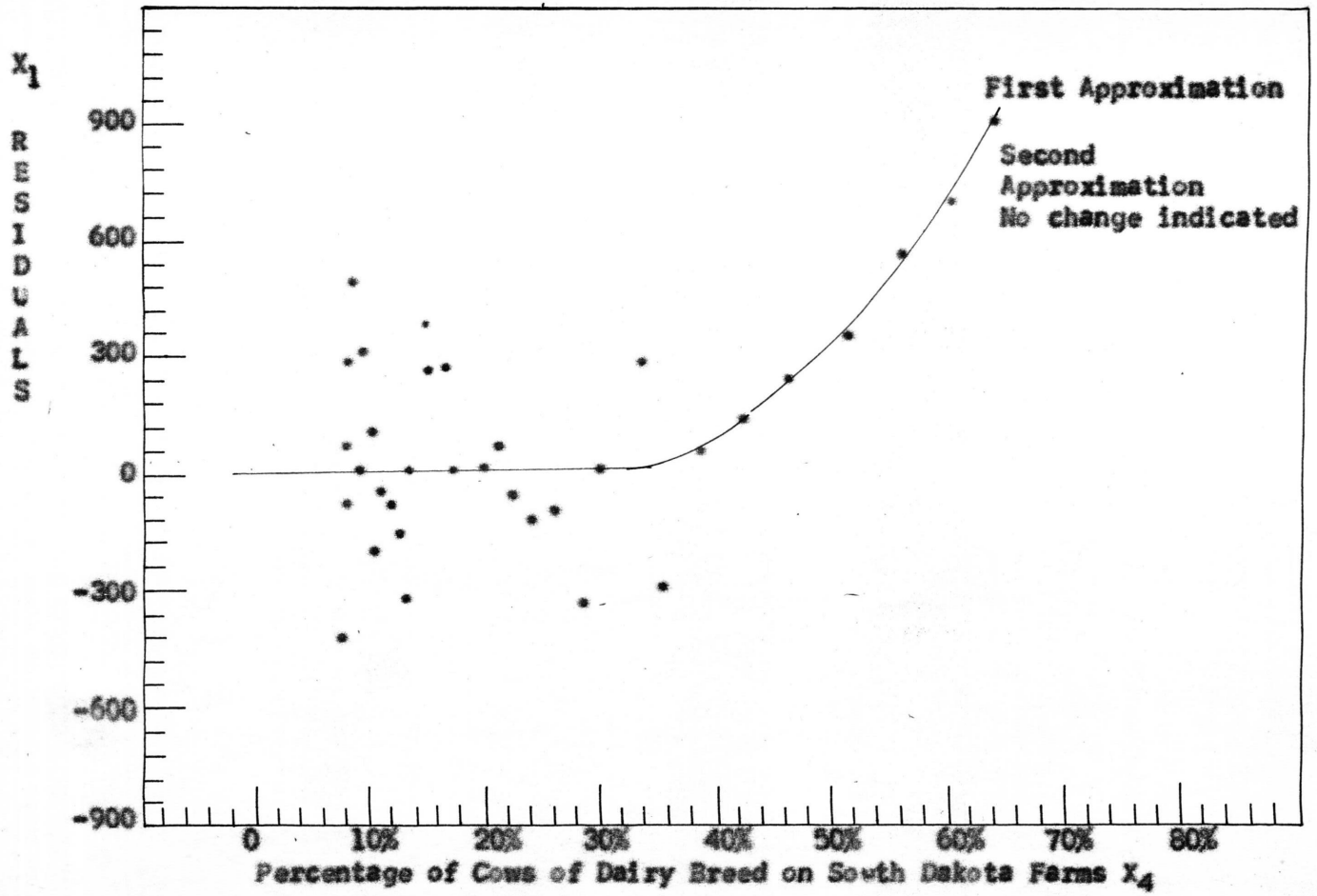

Figure 14. Residuals From X_1X_3 Second Approximation Curve Plotted About X_1X_4 First Approximation Curve with Respect to X_4

Source: Appendix Table XII.

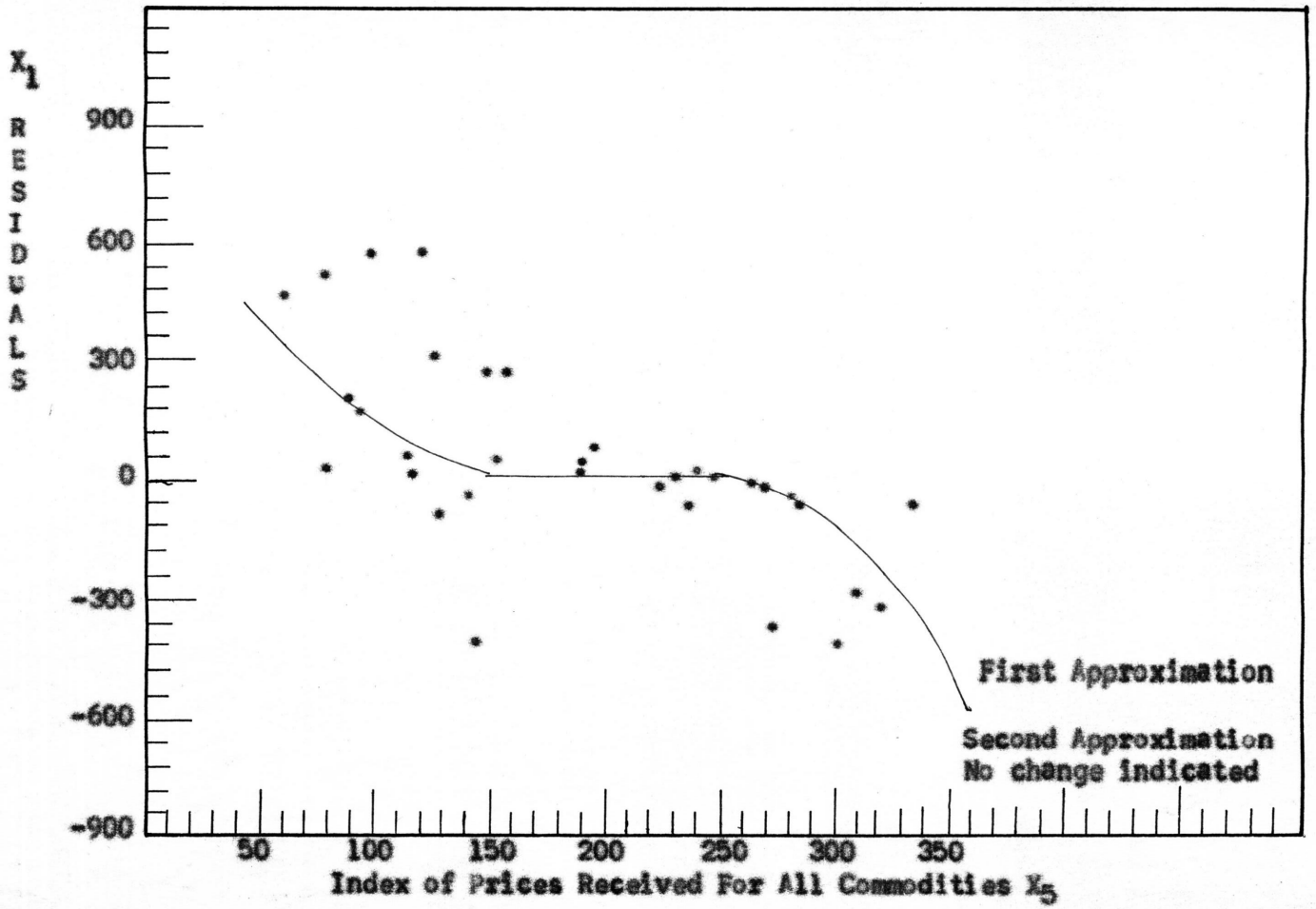

Figure 15. Residuals From X_1X_4 Second Approximation Plotted About X_1X_5 First Approximation Curve With Respect to X_5

Source: Appendix Table XII.

The effect of the percentage of cows of dairy breed is very significant during the later years but of minor or no particular significance during earlier years as indicated in Figure 14. It is quite feasible that corresponding to the increase in the percentage of cows of dairy breeds that there has been a technological growth coinciding with the increase in dairy type milk cows. As an example, larger herds, better equipment, and more careful feeding, or in general a change from a micro operation to professional large scale operation results in the higher production. In view of the correlation between milk production per cow and government purchases of non-fat dry solids, as indicated in Appendix Figure 3, it is considered that this production is channeled into government purchases under the purchases support plan.

The effect of alternative products on the production of milk per milk cow is indicated in Figure 15. In the earlier years when the price received for alternative products was low, there was a tendency to increase the production of milk per cow milked and conversely when the price for alternative products was high, there was a tendency to reduce the production of milk. This would indicate that milk production is to some extent curtailed when the price for alternative products is high and increased when the price for alternative products is low.

The analysis was accomplished by the empirical formula

$$X_1 = f(X_2, X_3, X_4, X_5)$$

X_1 = Milk Production Per Cow Milked

X_2 = Index of Prices Received by South Dakota Farmers for Dairy Products

X_3 = South Dakota Milk-Feed Price Ratio

X_4 = Cows of Dairy Breed on South Dakota Farms

X_5 = Index of Prices Received by South Dakota Farmers for All Farm Commodities.

Table V is a summary from Appendix Tables VII, VIII, IX, X, XI, and XII of the results of the calculation, step by step, of the factors accounting for the production of milk per milk cow. The detailed analysis is as follows:

a. After the first step, it was apparent that slightly more than 34 percent of the squared variability in X_1 was explained by X_2 ($p^2_{1.2}$ = 0.3416). The effects of X_3, X_4, and X_5 or any interrelationship were not considered.

b. After the second step, it was apparent that 51.3 percent of the squared variability in X_1 was explained by X_2 and X_3 ($p^2_{1.23}$ = 0.5132). This also indicated that X_3 explained 17.2 percent of the variability in X_1, in addition to that explained by X_2(0.5132 - 0.3416 = 0.1716). In this step the interrelationship between X_2 and X_3 was partly considered.

c. After the third step, it was clear that 74 percent of the squared variability in X_1 was explained by X_2, X_3, and X_4 ($p^2_{1.234}$ = 0.7400). This indicated that X_4 accounted for 22.7 percent of the variability in X_1, in addition to that explained by X_2 and X_3. With this step, the interrelationship X_2X_3, X_2X_4, and X_3X_4 had been partly considered.

d. After the fourth step, 80 percent of the variability in X_1 had been explained by X_2, X_3 and X_4 ($p^2_{1.234}$ = 0.8081), X_4 accounting for almost 7 percent of the added variability accounted for in X_1.

TABLE V. SUMMARY OF SHORT-CUT APPROXIMATION METHOD CALCULATION OF STEP BY STEP PRODUCTION OF MILK PER COW MILKED ON SOUTH DAKOTA FARMS

Step	Relationship	Independent variables considered	Interrelationship considered	AZ^2	p	p^2
1	X_1, X_2	X_2	None	162,500	$p_{1.2} = 0.587026$	0.3416
2	X_1, X_3	X_3 after eliminating effect X_2	X_2X_3 partly	120,667.35	$p_{1.23} = 0.717112$	0.51325
3	X_1, X_4	X_4 after eliminating effect X_2 and X_3	X_2X_3, X_2X_4, and X_3X_4 partly	64,452.94	$p_{1.234} = 0.86023$	0.74001
4	X_1, X_5	X_5 after X_2X_3 and X_4	X_2X_3, X_2X_4, X_2X_5 and X_4X_5 partly	47,576.47	$p_{1.2345} = 0.89893$	0.80808
5	X_1, X_2	X_2 after X_5 after X_4, after X_3, after X_2	X_2X_3, X_2X_4 and X_2X_5 all; and X_3X_4 and X_4X_5 partly	42,091.17	$p_{1.2345(2)} = 0.91686$	0.83117
6	X_1, X_3	X_3, after X_5, after X_4, after X_3 after X_2, after X_3 after X_3	X_2X_3, X_2X_4, X_2X_5, X_3X_4 and X_3X_5 all and and X_4X_5 partly	39,326.47	$p_{1.2345(2.3)} = 0.917791$	0.84234

TABLE V. SUMMARY OF SHORT-CUT APPROXIMATION METHOD CALCULATION OF STEP BY STEP PRODUCTION OF MILK PER COW MILKED ON SOUTH DAKOTA FARMS

Step	Relationship	Independent variables considered	Interrelationship considered	AZ^2	p	p^2
7	X_1, X_4	X_4, after X_2, after X_3, after X_4, after X_5, after X_2, after X_3	X_2X_3, X_2X_4, X_2X_5, X_3X_4, X_3X_5, and X_4X_5 all	39,326.47	$P_{1.2345(2,3,4)} = 0.917791$	0.84234
8	X_1, X_5	X_5, after X_2, after X_3, after X_4 after X_5, after X_2, after X_3 after X_4	X_2, X_3, X_2X_4 X_2X_5, X_3X_4 X_3X_5, X_4X_5all	39,326.47	$P_{1.2345(2,3,4,5)}=0.917791$	0.84234

Source: Appendix Tables VII, VIII, IX, X, XI, and XII

e. The fifth step increased the percentage of variability accounted for in X_1, to 83 percent explained by X_2, X_3, X_4, and X_5 ($p^2_{1.2345} = 0.8312$). X_5 accounted for only 2 percent.

f. Step six resulted in only a one percent increase in accounting for the variability in X_1, making the total 84 percent. Additional steps did not increase the amount of squared variability accounted for in the dependent variable X_1.

In order to further analyze the variation in the milk production per cow milked, Appendix Table XIV was prepared indicating a Relative Index for the Farm Price Index of Prices Received for Dairy Products and the Farm Price Index of Prices Received for All Commodities and the Residuals of Milk Production Per Cow Milked after the eighth step. A summary table, Table VI, was prepared to show those years in which production was higher or lower than a 50 pound variation and whether the relative index was favorable or unfavorable.

TABLE VI. SUMMARY OF APPENDIX TABLE XIV, NUMBER OF YEARS AND YEARS THE RESIDUALS OF THE STUDY OF MILK PRODUCTS PER COW MILKED WERE ABOVE OR BELOW THE LINE OF REGRESSION BY MORE THAN 50 POUNDS BY FAVORABLE AND UNFAVORABLE RELATIVE INDEX

	Favorable (100+)		Unfavorable (below 100)	
	No.	years	No.	years	Total No.
With Higher production	6	1928,29,30, 31,33,40	4	1941,42,45, 51	10
With lower production	4	1926,27,34, 36	7	1937,38,46, 47,48,49,52	11
Total number	10		11		21

As indicated in Table VI above, there were six years in which the production of milk per cow milked was substantially higher and four years in which production was substantially lower with a relative index which was favorable. On the assumption that we would expect higher production in relatively favorable years, an explanation is required for the years 1926, 27, 34, and 36. A reasonable explanation is found in Appendix Figure 1 which shows that the average pasture condition was very poor in 1934, at 22 percent of normal, and in 1936 with 36.25 percent, and relatively poor in 1926 at 53.8 of normal. However, the condition of pasture does not account for 1927, as it was 85.7 percent of normal. However, the amount of variation is relatively small, being only 40 pounds lower than the 50 pounds of variation allowable. If we look again at Table VI, we see that of the eleven years in which the relative index was unfavorable to the production of milk, in four years the production of milk per cow milked was substantially higher, and in seven years production was substantially lower. In the assumption that less milk is produced in the relatively unfavorable years, an explanation is required for the years 1941, 42, 45, and 51. In consideration of the fact that all of these years were during wartime, it is considered logical to assume that production goals tended to be maximized instead of profit maximization.

Preliminary Conclusions

From the above study the following conclusions can be made:

1. Milk production per cow milked increases with the Farm Price

Index of Prices Received for Dairy Products.

2. Milk production per cow milked increases linearly as the milk-feed price ratio becomes more favorable.

3. Milk production per cow milked is increasing at an increased rate as the Percentage of Cows of Dairy Breeds increases.

4. Milk production per cow milked increases as the Farm Price Index of Prices Received for All Commodities decreases below 150 and decreases as the Farm Price Index of Prices Received for All Commodities increases above 265.

5. The four independent variables of Farm Price Index of Prices Received for Dairy Products, the Milk-Feed Price Ratio, Breeds of Dairy Cows, and the Farm Price Index of Prices Received for All Commodities account for more than 84 percent of the squared variability in the dependent variable Production of Milk Per Cow Milked.

6. Further analysis of the residuals of more or less than 50 pounds of milk production variation in the dependent variable indicates that when the Relative Index of the Farm Price Index of Prices Received for Dairy Products and the Farm Price Index of Prices Received for All Commodities is favorable, more milk will be produced unless the average pasture condition is poor; and conversely when the relative index is unfavorable, less milk will be produced unless it is a war year when goals may be changed from profit maximization to production maximization.

CHAPTER IV

CONCLUSIONS

The hypothesis, that as the price of dairy products decreases, the South Dakota farmer increases production in order to maintain a constant income, cannot be supported by the study.

In the inter year production period the number of cows milked is dependent upon whether alternative enterprises are more profitable than the milk industry. As farms are consolidated or increased in size, the sideline dairy enterprise goes out of business.

In the intra year production period there are factors which tend to increase and decrease the production of milk as follows:

a. The production of milk increased under the following conditions:

   1. Generally as the Index of Prices Received for Dairy Products increases, production of milk increases. However, this relationship has a low elasticity.
   2. When the Milk-Feed Price Ratio increases, production of milk increases with a high degree of elasticity.
   3. When the percentage of cows of dairy breeds on South Dakota farms increases, production is increased when there is excess capacity that can be utilized.
   4. When the Index of Prices Received for All Commodities is at a low level; for example, during periods of depression, production of milk increases.

5. When the Index of Prices Received for Dairy Products is favorable as compared to the Index of Prices Received for All Commodities, production tends to be increased.
6. During periods when war occurs, production is increased in the early years.

b. The production of milk is decreased under the following conditions:

1. Generally as the Index of Prices Received for Dairy Products decreases, production of milk decreases. The relationship has a low elasticity.
2. When the Milk-Feed Price Ratio decreases, production of milk decreases with a high degree of elasticity.
3. The percentage of Cows of Dairy Breeds on South Dakota Farms has increased each year; therefore, no conclusion is possible in event of a decrease.
4. When the Index of Prices Received for All Commodities is high, production of milk tends to be lower.
5. When the Index of Prices Received for Dairy Products is unfavorable as compared to the Index of Prices Received for all Commodities, production tends to be decreased.
6. When pasture conditions are unusually poor, production of milk tends to be lower.

LITERATURE CITED

Anderson, Arthur L., "Dairy Cattle Breeds and Breeding," Introductory Animal Husbandry, Third Edition, the Macmillan Company: New York, N. Y., 1958.

Arkin, Herbert and Colton, Raymond R., Tables for Statisticians, College Outline Series, Barnes and Noble: New York, N. Y., 1959.

Bean, Louis H., "A Simplified Method of Graphic Curvilinear Correlation," Journal of the American Statistical Association, vol. XXIV, December, 1929.

Dexter, Wayne, "The General Price Level," What Makes Farmers' Prices, Agriculture Information Bulletin 204, United States Department of Agriculture: Washington, D. C., April, 1959.

_____ "Changes in Supply," What Makes Farmers' Prices, Agriculture Information Bulletin 204, United States Department of Agriculture: Washington, D. C., April, 1959.

Heady, Earl O., et al., Milk Production Functions, Hay/Grain Substitution Rates and Economic Optima in Dairy Cow Rations, Iowa Agricultural Experiment Station Research Bulletin 444: Ames, Iowa, 1956.

_____ Economics of Agricultural Production and Resource Use, Prentice-Hall, Inc.: Englewood Cliffs, New Jersey, 1957.

Helfinstine, Rex, Unpublished Mimeographed Paper, Milk Production Functions, South Dakota State College: Brookings, So. Dak.

Hintzman, Arthur J., Breeds of Livestock Marketed from Wisconsin Farms, Special Bulletin No. 26, The Crop and Livestock Reporting Service, Wisconsin and United States Departments of Agriculture: Madison, Wisconsin, September, 1952.

Jensen, Einar L., et al., "Intensification of Dairying Through Increased Roughage Production," Input-Output Relationships in Milk Production, Technical Bulletin No. 815, United States Department of Agriculture: Washington, D. C., May, 1942.

_____ Input-Output Relationships in Milk Production, Technical Bulletin No. 815, United States Department of Agriculture: Washington, D. C., May, 1942.

Kriesel, Herbert, "Has the Decline in Milk Cow Numbers Ended?", Agricultural Situation, vol. 44, No. 4, Agricultural Marketing Service, U. S. Department of Agriculture: Washington, D. C., April, 1960.

Morrison, Frank R., "General Problems in Dairy Husbandry," Feeds and Feeding, Twenty-First Edition, Unabridged, The Morrison Publishing Company: Ithaca, New York, 1949.

Staff of College of Agriculture, "Costs With Herds of Various Sizes," The Cost of Producing Milk, Economic Information for Wisconsin Farmers, vol. 28, No. 2, Special Circular: Madison, Wisconsin, June, 1959.

APPENDIX

APPENDIX TABLE I. ANALYSIS OF MOVEMENT OF TOTAL MILK PRODUCTION IN CONNECTION WITH PRICES RECEIVED FOR DAIRY PRODUCTS

Year	Total production of milk (million pounds)	Index of local market prices received for dairy products	Production movement	Index price movement
1926	1788	148		
1927	1935	157	Up	Up
1928	2024	164	Up	Up
1929	2132	158	Up	Down
1930	2197	125	Up	Down
1931	2180	96	Down	Down
1932	2051	70	Down	Down
1933	2118	70	Up	No change
1934	1668	86	Down	Up
1935	1603	103	Down	Up
1936	1640	117	Up	Up
1937	1472	120	Down	Up
1938	1570	97	Up	Down
1939	1642	89	Up	Down
1940	1746	103	Up	Up
1941	1827	123	Up	Up
1942	1867	144	Up	Up
1943	1804	178	Down	Up
1944	1710	181	Down	Up
1945	1650	182	Down	Up
1946	1600	231	Down	Up
1947	1489	261	Down	Up
1948	1417	282	Down	Up
1949	1369	232	Down	Down
1950	1402	232	Up	No change
1951	1389	264	Down	Up
1952	1297	273	Down	Up
1953	1369	245	Up	Down
1954	1360	221	Down	Down
1955	1368	220	Up	Down
1956	1411	229	Up	Up
1957	1453	236	Up	Up
1958	1454	224	Up	Down
1959 1/	1422	232	Down	Up

1/ Preliminary

TABLE I. FOOTNOTES CONTINUED

Source: South Dakota Agriculture 1953, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak., January, 1953.

South Dakota Agriculture 1958, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak., June, 1958.

South Dakota Agriculture 1959, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak.

APPENDIX TABLE II. COMPUTATION OF THE EFFECT OF THE NUMBER OF FARMS IN SOUTH DAKOTA ON THE NUMBER OF COWS MILKED (1924-1959)

Year	No. cows milked (thous.) Y_1	y	y^2	Number of farms (thous.) Y_2	Residuals Variability in no. cows milked not accounted for by no. farms Z	Z^2
1924	487	56.6	3203.56	79.5	0	0
1925	506	75.6	5715.36	80.0	+ 10	100
1926	508	77.6	6021.76	80.5	+ 7	49
1927	508	77.6	6021.76	81.4	- 1	1
1928	511	80.6	6496.36	82.0	- 4	16
1929	520	89.6	8028.16	82.2	0	0
1930	532	101.6	10322.56	83.2	0	0
1931	545	114.6	13133.16	84.2	0	0
1932	573	142.6	20334.76	84.0	+ 30	900
1933	600	169.6	28764.16	83.6	+ 64	4096
1934	575	144.6	20909.16	83.4	+ 40	1600
1935	501	70.6	4984.36	83.4	- 35	1225
1936	478	47.6	2265.76	79.8	- 14	196
1937	446	15.6	243.36	75.9	0	0
1938	436	5.6	31.36	73.5	+ 20	400
1939	438	7.6	57.76	73.2	+ 24	576
1940	456	25.6	655.36	72.5	+ 52	2704
1941	477	46.6	2171.56	72.2	+ 80	6400
1942	485	54.6	2981.16	71.8	+ 92	8464
1943	485	54.6	2981.16	70.9	+100	10000
1944	475	44.6	1989.16	69.1	+112	12544
1945	440	9.6	92.16	68.8	+ 80	6400
1946	403	- 27.4	750.76	68.6	+ 48	2304
1947	375	- 55.4	3069.16	68.3	+ 19	361
1948	349	- 81.4	6625.96	67.9	- 2	4
1949	334	- 96.4	9292.96	67.5	- 12	144
1950	333	- 97.4	9486.76	67.1	- 18	324
1951	323	- 107.4	11534.76	66.7	- 12	144
1952	311	- 119.4	14256.36	66.3	- 22	484
1953	314	- 116.4	13548.96	66.0	- 18	324
1954	309	- 121.4	14737.96	65.5	- 14	196
1955	302	- 128.4	16486.56	64.7	- 7	49
1956	299	- 131.4	17265.96	64.0	- 4	16
1957	299	- 131.4	17265.96	63.0	+ 3	9
1958	289	- 141.4	19993.96	61.7	+ 12	144
1959	1/274	- 156.4	24460.96	60.5	+ 12	144
	15496		326180.96			60318
$\bar{Y}^1$	430.4	σ^2 =	9060.58		s^2 =	1675.5

APPENDIX TABLE II. CONTINUED

Year	No. cows milked (thous.) Y_1	y	y^2	Number of farms (thous.) y_2	Residuals variability in no. cows milked not accounted for by no. farms Z	Z^2

$\rho = \sqrt{1 - 1675.5/9060.58}$

$\rho = \sqrt{1 - .1849}$

$\rho = \sqrt{.8150}$

$\rho = .902829$

$\rho^2 = .8151$

Sources: South Dakota Agriculture 1953, South Dakota Crop and Livestock Reporting Service: Sioux Falls, S. Dak., January, 1953.

South Dakota Agriculture 1958, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak., June, 1958.

South Dakota Agriculture 1959, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak.

APPENDIX TABLE III. COMPUTATION OF THE EFFECT OF THE FARM PRICE INDEX OF PRICES RECEIVED FOR DAIRY PRODUCTS ON THE RESIDUALS FROM APPENDIX TABLE II (1924-1959)

Year	Farm price index or price received for dairy products X_3	Residuals variability Z_2	Not accounted for by X_2 and X_3 Z_2^2
1924	140	- 10	100
1925	149	+ 1	1
1926	148	- 2	4
1927	157	- 7	49
1928	164	- 8	64
1929	158	- 7	49
1930	125	- 15	225
1931	96	- 22	484
1932	70	+ 2	4
1933	70	+ 38	1444
1934	86	+ 18	324
1935	103	- 56	3136
1936	117	- 32	1024
1937	120	- 14	196
1938	97	0	0
1939	89	0	0
1940	103	+ 34	1156
1941	123	+ 66	4356
1942	144	+ 82	6724
1943	178	+ 98	9604
1944	181	+ 112	12544
1945	182	+ 80	6400
1946	231	+ 62	3844
1947	261	+ 38	1444
1948	282	+ 22	484
1949	232	0	0
1950	232	- 6	36
1951	264	+ 6	36
1952	273	0	0
1953	245	- 2	4
1954	221	- 4	16
1955	220	+ 1	1
1956	229	+ 6	36
1957	236	+ 10	100
1958	224	- 1	1

TABLE III. CONTINUED

Year	Farm price index or price received for dairy products X_3	Residuals variability Z_2	Not accounted for by X_2 and X_3 Z_2^2
1959 1/	232	+ 24	576
			54466
			$s^2 = 1512.94$

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$p = \sqrt{1 - 1512.94/9060.58}$

$p = \sqrt{1 - .1669}$

$p = \sqrt{.8331}$

$p = .912743$

$\rho^2 = .8331$

Sources: South Dakota Agriculture 1953, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak., January, 1953.

South Dakota Agriculture 1958, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak., June, 1958.

South Dakota Agriculture 1959, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak.

APPENDIX TABLE IV. COMPUTATION OF THE EFFECT OF THE NUMBER OF FARMS IN SOUTH DAKOTA ON THE NUMBER OF COWS MILKED (1924-1939 1947-1959)

Year	No. cows milked (thous.) Y_1	y	y^2	Number of farms (thous.) Y_2	Residuals variability in no. cows milked not accounted for by no. farms Z_1	Z^2
1924	487	65.1	4238.01	79.5	- 0	0
1925	506	84.1	7072.81	80.0	+ 7	49
1926	508	86.1	7413.21	80.5	+ 2	4
1927	508	86.1	7413.21	81.4	- 3	9
1928	511	89.1	7938.81	82.0	- 10	100
1929	520	98.1	9623.61	82.2	- 8	64
1930	532	110.1	12122.01	83.2	- 8	64
1931	545	123.1	15153.61	84.2	- 0	0
1932	573	151.1	22831.21	84.0	+ 25	625
1933	600	188.1	35381.61	83.6	+ 60	3600
1934	575	153.1	23439.61	83.4	+ 35	1225
1935	501	79.1	6256.81	83.4	- 39	1521
1936	478	56.1	3147.21	79.9	- 18	324
1937	446	24.1	580.81	75.9	- 1	1
1938	436	14.1	198.81	73.5	+ 14	196
1939	438	16.1	259.21	73.2	+ 20	400
1947	375	- 46.9	2199.61	68.3	+ 16	256
1948	349	- 72.9	5314.41	67.9	- 2	4
1949	334	- 87.9	7726.41	67.5	- 12	144
1950	333	- 88.9	7903.21	67.1	- 8	64
1951	323	- 98.9	9781.21	66.7	- 15	225
1952	311	- 110.9	12298.81	66.3	- 20	400
1953	314	- 107.9	11642.41	66.0	- 18	324
1954	309	- 112.9	12746.41	65.5	- 14	196
1955	302	- 119.9	14376.01	64.7	- 6	36
1956	299	- 122.9	15104.41	64.0	- 6	36
1957	299	- 122.9	15104.41	63.0	+ 1	1
1958	289	- 132.9	17662.41	61.7	+ 4	16
1959 1/	274	- 147.9	21874.41	60.5	+ 5	25
	12275		216804.69			9909
Mean	$\bar{Y}_1 = 421.9$		$\sigma^2 = 10924.275$			$s^2 = 341.69$

1/ Preliminary

APPENDIX TABLE IV. CONTINUED

$$p = \sqrt{1 - 341.69/10924.275}$$

$$p = \sqrt{1 - .03138}$$

$$p = \sqrt{.96862}$$

$$p = .984187$$

$$p^2 = .9686$$

Sources: South Dakota Agriculture 1953, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak., January, 1953.

South Dakota Agriculture 1958, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak., June, 1958.

South Dakota Agriculture 1959, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak.

APPENDIX TABLE V. COMPUTATION OF FARM PRICE INDEX OR PRICE RECEIVED FOR DAIRY PRODUCTS ON THE RESIDUALS FROM APPENDIX TABLE IV (1924-1939 1947-1959)

Year	Farm price index or price received for dairy products X_3	Residuals variability Z_2	Not accounted for by X_2 and X_3 Z_2
1924	140	0	0
1925	149	+ 16	256
1926	148	+ 12	144
1927	157	0	0
1928	164	- 2	4
1929	158	0	0
1930	125	- 2	4
1931	96	- 17	289
1932	70	- 15	225
1933	70	+ 21	441
1934	86	+ 14	196
1935	103	- 42	1764
1936	117	- 14	196
1937	120	+ 2	4
1938	97	+ 2	4
1939	89	0	0
1947	261	+ 12	144
1948	282	+ 2	4
1949	232	- 8	64
1950	232	- 4	16
1951	264	- 4	16
1952	273	- 18	324
1953	245	- 6	36
1954	221	- 4	16
1955	220	- 4	16
1956	229	0	0
1957	236	+ 12	144
1958	224	+ 16	256
1959 1/	232	+ 16	256
			4819
			$s^2 = 166.17$

1/ Preliminary

APPENDIX TABLE V. FOOTNOTES CONTINUED

$p = \sqrt{1 - 166.17/10924.275}$

$p = \sqrt{1 - .0152}$

$p = \sqrt{.9848}$

$p = .992371$

$p^2 = .9848$

Sources: South Dakota Agriculture 1953, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak., January, 1953.

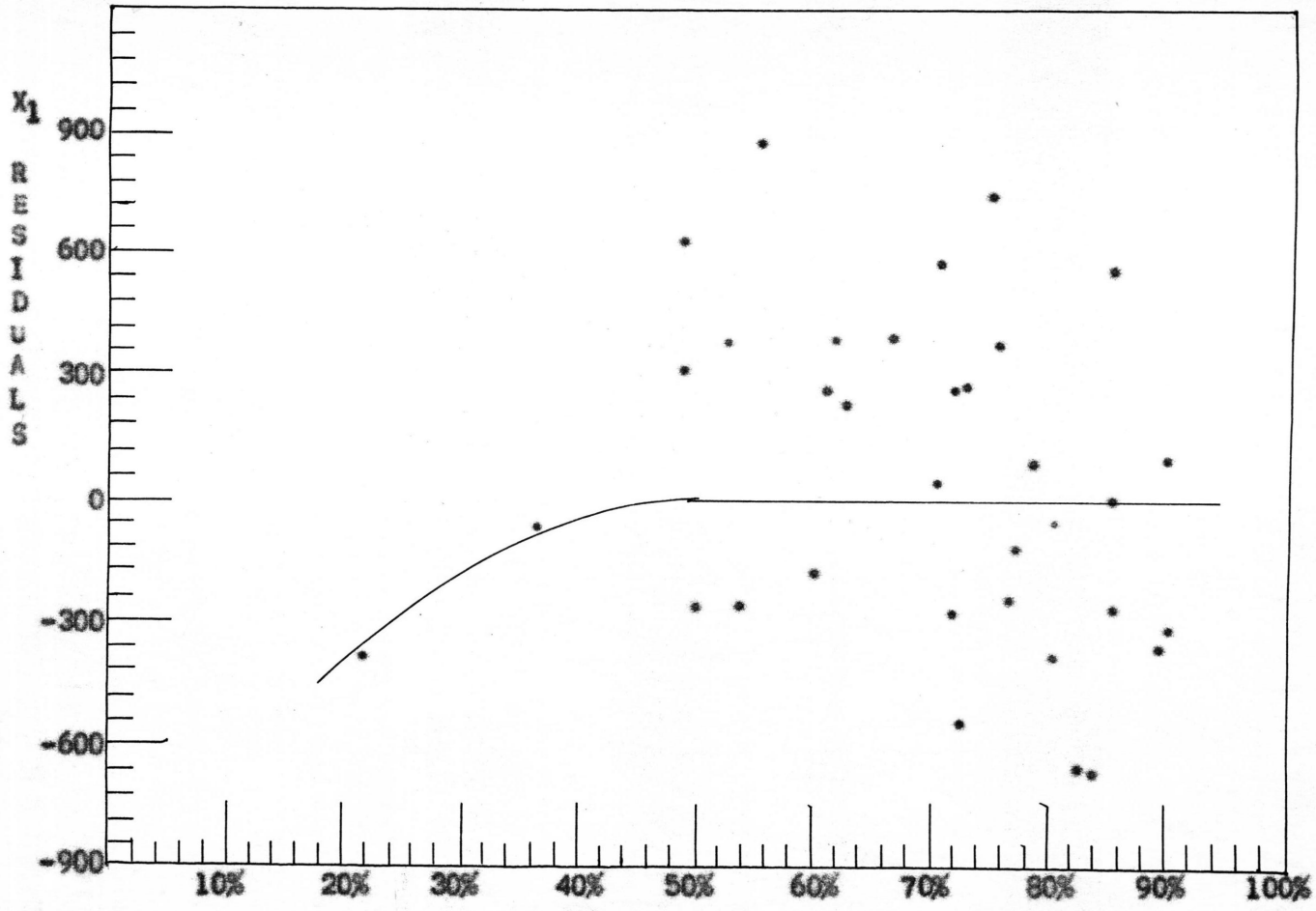
South Dakota Agriculture 1958, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak., June, 1958.

South Dakota Agriculture 1959, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak.

APPENDIX TABLE VI. CONDITION OF PASTURE X_2

Year	Condition of pasture
1926	53.8
1927	85.7
1928	71.4
1929	73.5
1930	72.00
1931	49.29
1932	74.57
1933	49.29
1934	22.00
1935	62.75
1936	36.25
1937	50.13
1938	63.25
1939	53.38
1940	62.75
1941	73.00
1942	90.63
1943	77.88
1944	90.00
1945	86.00
1946	81.50
1947	83.50
1948	84.88
1949	72.50
1950	78.00
1951	90.75
1952	73.13
1953	81.75
1954	79.88
1955	61.88
1956	66.63
1957	85.50
1958	76.10
1959	54.60

Source: Melvin Koehn, George Wangen, South Dakota Dairying, South Dakota Crop and Livestock Reporting Service; Sioux Falls, So. Dak., January, 1953.



Appendix Figure 1. Pasture Condition Percent of Normal X_3

Source: Appendix Tables V and VI.

APPENDIX TABLE VII. COMPUTATION OF EFFECT OF THE INDEX OF PRICES RECEIVED BY SOUTH DAKOTA FARMERS ON MILK PRODUCTION PER COW MILKED (1926 - 1959)

Year	Milk production per cow milked (lbs.) X_1	x_1	x_1^2	Index of prices received for dairy products X_2	Residuals after X_2 Z_1	Z_1^2
1926	3520	- 458.2	209947.24	149	- 250	62500
1927	3810	- 168.2	28291.24	158	0	0
1928	3960	- 18.2	331.24	165	+ 40	1600
1929	4100	+ 121.8	14835.24	159	+ 280	78400
1930	4130	+ 151.8	23043.24	125	+ 560	313600
1931	4000	+ 21.8	475.24	96	+ 640	409600
1932	3580	- 398.2	158563.24	70	+ 380	144400
1933	3530	- 448.2	200883.24	70	+ 330	108900
1934	2900	- 1078.2	1162515.24	86	- 380	144400
1935	3200	- 778.2	605595.24	103	- 200	40000
1936	3430	- 548.2	300523.24	117	- 60	3600
1937	3300	- 678.2	459955.24	120	- 260	67600
1938	3600	- 378.2	143035.24	97	+ 250	62500
1939	3750	- 228.2	52075.24	89	+ 400	160000
1940	3830	- 148.2	21963.24	103	+ 400	160000
1941	3830	- 148.2	21963.24	123	+ 280	78400
1942	3850	- 128.2	16435.24	144	+ 100	10000
1943	3720	- 258.2	66667.24	178	- 240	57600
1944	3600	- 378.2	143035.24	181	- 420	176400
1945	3750	- 228.2	52075.24	182	- 300	90000
1946	3970	- 88.2	67.24	231	- 400	160000
1947	3970	- 8.2	67.24	261	- 650	422500
1948	4060	+ 81.8	6691.24	282	- 650	422500
1949	4100	+ 121.8	14835.24	232	- 280	78400
1950	4210	+ 231.8	53731.24	232	- 140	19600
1951	4300	+ 321.8	103555.24	264	- 320	102400
1952	4170	+ 191.8	36787.24	273	- 520	270400
1953	4360	+ 381.8	145771.24	245	- 80	6400
1954	4400	+ 421.8	177915.24	221	+ 80	6400
1955	4530	+ 551.8	304483.24	220	+ 280	78400
1956	4720	+ 741.8	550267.24	227	+ 400	160000
1957	4860	+ 881.8	777571.24	230	+ 540	291600
1958	5030	+ 1051.8	1106283.24	222	+ 750	562500

APPENDIX TABLE VII. CONTINUED

Year	Milk production per cow milked (lbs.) X_1	x_1	x_1^2	Index of prices received for dairy products X_2	Residuals after X_2 Z_1	Z_1^2
1959 1/	5190	+1211.8	1468459.24	226	+ 880	774400
	135260		8428694.16			5525000
	$\bar{X}_1$ = 3978.2		o^2 = 247902.8			s^2 = 162500

$$\rho = \sqrt{1 - 162500/247902.8}$$

$$\rho = \sqrt{1 - .6554}$$

$$\rho = \sqrt{.3446}$$

$$\rho = .587026$$

$$\rho^2 = .3446$$

1/ Preliminary

Sources: South Dakota Agriculture 1953, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak., January, 1953.

South Dakota Agriculture 1958, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak., June, 1958.

South Dakota Agriculture 1959, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak.

APPENDIX TABLE VIII. COMPUTATION OF EFFECT OF MILK-FEED PRICE RATIO ON THE RESIDUALS FROM APPENDIX TABLE VII

Year	Milk-feed price ratio[1] X_3	Residuals after X_2 and X_3 Z_2	Z_2^2
1926	1.98	- 420	176400
1927	1.89	- 90	8100
1928	1.76	+ 50	2500
1929	1.80	+ 270	72900
1930	1.82	+ 540	291600
1931	2.08	+ 460	211600
1932	2.17	+ 140	19600
1933	1.93	+ 210	44100
1934	1.47	- 150	22500
1935	1.55	- 10	100
1936	1.77	- 10	100
1937	1.61	- 140	19600
1938	2.33	- 180	32400
1939	2.06	- 200	40000
1940	1.65	+ 510	260100
1941	1.75	+ 310	96100
1942	1.59	+ 250	62500
1943	1.50	- 10	100
1944	1.29	- 80	6400
1945	1.37	+ 20	400
1946	1.43	- 120	14400
1947	1.47	- 420	176400
1948	1.52	- 460	211600
1949	1.83	- 330	108900
1950	1.62	- 20	400
1951	1.58	- 160	25600
1952	1.73	- 510	260100
1953	1.70	- 20	400
1954	1.67	+ 150	22500
1955	1.82	+ 240	57600
1956	1.83	+ 380	144400
1957	1.75	+ 580	336400
1958	1.84	+ 680	462400
1959 1/	1.69	+ 990	980100
			4102690

$S^2 = 120667.35$

APPENDIX TABLE VIII. FOOTNOTES CONTINUED

$$p = \sqrt{1 - 12066735/247902.8}$$

$$p = \sqrt{1-.48576}$$

$$p = \sqrt{.51325}$$

$$p = .717112$$

$$p^2 = .51325$$

[1]Note: Figures for period 1926-1937 (incl) are adjusted ratios of West North Central States Department of U. S. Agriculture Statistics.

1/ Preliminary

Sources: South Dakota Agriculture 1953, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak., January, 1953.

South Dakota Agriculture 1958, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak., June, 1958.

South Dakota Agriculture 1959, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak.

APPENDIX TABLE IX. COMPUTATION OF EFFECT OF BREEDS OF DAIRY MILK COWS ON SOUTH DAKOTA FARMS RESIDUALS FROM APPENDIX TABLE VIII

Year	Breeds of dairy milk cows in per cent cows milked[2] X_4	Residuals after X_2, X_3 and X_4 Z_3	Z_3^2
1926	8.0	- 420	176400
1927	8.3	- 90	8100
1928	8.1	+ 50	2500
1929	9.0	+ 270	72900
1930	9.5	+ 540	291600
1931	10.0	+ 460	211600
1932	10.5	+ 140	19600
1933	11.0	+ 210	44100
1934	11.4	- 150	22500
1935	11.8	- 10	100
1936	12.2	- 10	100
1937	13.0	- 140	19600
1938	13.5	- 180	32400
1939	14.2	+ 200	40000
1940	15.0	+ 510	260100
1941	16.0	+ 310	96100
1942	17.0	+ 250	62500
1943	18.3	- 10	100
1944	20.0	- 80	6400
1945	21.0	+ 20	400
1946	22.4	- 120	14400
1947	24.4	- 420	176400
1948	26.4	- 460	211600
1949	29.0	- 330	108900
1950	31.0	- 20	400
1951	34.0	- 160	25600
1952	36.2	- 510	260100
1953	39.5	- 60	3600
1954	43.0	0	0
1955	47.0	0	0
1956	52.0	- 20	400
1957	57.0	+ 20	400
1958	61.0	0	0
1959 1/	66.0	0	0
			2191400

$s^2 =$ 64452.9

APPENDIX TABLE IX. FOOTNOTES

[2]Note: See graph appendix figure 2 for approximation of intermediate points from appendix table III.

1/ Preliminary

$p = \sqrt{1 - 64452.9/247902.8}$

$p = \sqrt{1 - .25999}$

$p = \sqrt{.74001}$

$p = .86023$

$p^2 = .74001$

Sources: South Dakota Agriculture 1953, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak., January, 1953.

South Dakota Agriculture 1958, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak., June, 1958.

South Dakota Agriculture 1959, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak.

APPENDIX TABLE X. COMPUTATION OF EFFECT OF INDEX OF PRICES RECEIVED FOR ALL COMMODITIES ON RESIDUALS FROM APPENDIX TABLE IX

Year	Index of prices received for all commodities	Residuals after $X_2X_3X_4$ and X_5	Z_4^2
1926	149	- 420	176400
1927	143	- 90	8100
1928	152	+ 50	2500
1929	151	+ 270	72900
1930	122	+ 480	230400
1931	84	+ 220	48400
1932	58	- 220	48400
1933	62	- 120	14400
1934	80	- 400	168100
1935	114	- 100	10000
1936	117	- 90	8100
1937	130	- 170	28900
1938	103	- 330	108900
1939	97	0	0
1940	101	+ 360	129600
1941	128	+ 260	67600
1942	164	+ 250	62500
1943	190	- 10	100
1944	190	- 80	6400
1945	199	+ 20	400
1946	240	- 120	14400
1947	311	- 250	62500
1948	321	- 240	57600
1949	268	- 330	108900
1950	285	0	0
1951	339	+ 160	25600
1952	301	- 390	152100
1953	269	- 60	3600
1954	260	0	0
1955	234	0	0
1956	227	- 20	400
1957	246	- 20	400
1958	268	0	0
1959 1/	250	0	0
			1617600

$s^2 = 47576.5$

APPENDIX TABLE X. FOOTNOTES

1/ Preliminary

$p = \sqrt{1 - 47576.5/247902.8}$

$p = \sqrt{1 - .19192}$

$p = \sqrt{.80808}$

$p = .89893$

$p^2 = .80808$

Sources: South Dakota Agriculture 1953, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak., January, 1953.

South Dakota Agriculture 1958, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak., June, 1958.

South Dakota Agriculture 1959, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak.

APPENDIX TABLE XI. COMPUTATION OF EFFECT OF RESIDUALS ON FIRST APPROXIMATION EFFECT OF INDEX OF PRICES RECEIVED FOR DAIRY PRODUCTS ON MILK PRODUCTION PER COW MILKED FROM APPENDIX TABLE X

Year	Residuals after second approximation Z_5	Z_5^2
1926	- 420	176400
1927	- 90	8100
1928	+ 50	2500
1929	+ 270	72900
1930	+ 480	230400
1931	+ 300	90000
1932	0	0
1933	+ 100	10000
1934	- 240	57600
1935	- 60	3600
1936	- 90	8100
1937	- 170	28900
1938	- 330	108900
1939	0	0
1940	+ 400	160000
1941	+ 260	67600
1942	+ 250	62500
1943	- 10	100
1944	- 80	6400
1945	+ 20	400
1946	- 120	14400
1947	- 150	22500
1948	- 120	14400
1949	- 330	108900
1950	0	0
1951	+ 260	67600
1952	- 300	70000
1953	0	0
1954	0	0
1955	0	0
1956	- 20	400
1957	- 20	400
1958	0	0
1959 1/	0	0
		1423000
		s^2 = 41.852.9

APPENDIX TABLE XI. FOOTNOTES

1/ Preliminary

$p = \sqrt{1 - 41852.9/247912.8}$

$p = \sqrt{1 - .1688.3}$

$p = \sqrt{.83117}$

$p = .91686$

$p^2 = .83117$

Sources: South Dakota Agriculture 1953, South Dakota Crop and Livestock Reporting Service: Sioux Falls, S. Dak., January, 1953.

South Dakota Agriculture 1958, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak., June, 1958.

South Dakota Agriculture 1959, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak.

APPENDIX TABLE XII. COMPUTATION OF EFFECT OF RESIDUALS ON FIRST APPROXIMATION EFFECT OF MILK-FEED PRICE RATIO FROM APPENDIX TABLE XI

Year	Residuals after second approximation Z_{6-7-8}	Z_{6-7-8}
1926	- 420	176400
1927	- 90	8100
1928	+ 50	2500
1929	+ 270	72900
1930	+ 480	230400
1931	+ 300	90000
1932	0	0
1933	+ 100	10000
1934	- 220	48400
1935	- 40	1600
1936	- 90	8100
1937	- 160	25600
1938	- 330	108900
1939	0	0
1940	+ 400	160000
1941	+ 260	67600
1942	+ 270	0
1943	0	0
1944	- 10	100
1945	+ 80	6400
1946	- 70	4900
1947	- 130	16900
1948	- 110	12100
1949	- 330	108900
1950	0	0
1951	+ 280	78400
1952	- 300	90000
1953	0	0
1954	0	0
1955	0	0
1956	- 20	400
1957	+ 20	400
1958	0	0
1959 1/	0	0
		1329000
		s^2 = 39088.2

APPENDIX TABLE XII. FOOTNOTES

1/ Preliminary

$p = \sqrt{1 - 39088.2/247902.8}$

$p = \sqrt{1 - .1576755}$

$p = \sqrt{.84234}$

$p = .917791$

$p^2 = .84234$

Sources: South Dakota Agriculture 1953, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak., January, 1953.

South Dakota Agriculture 1958, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak., June, 1958.

South Dakota Agriculture 1959, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak.

APPENDIX TABLE XIII. BREEDS OF MILK COWS ON SOUTH DAKOTA FARMS (1944-1951 and 1958) X_3

	January 1 number			Percentage of total		
	1944	1951	1958	1944	1954	1958
Holstein	67000	79300	139700	12	22	43
Shorthorn	175000	95200	48800	32	26	15
Guernsey	28000	18300	29200	5	5	9
Brown Swiss	7000	13200	22800	1	4	7
Hereford	112000	59200	13000	21	16	4
Jersey	6000	10200	6500	1	3	2
Red Pollard	18000	11200	6500	3	3	2
Angus	9000	3900	1/	2	1	1/
Ayrshire	4000	1500	1/	1	2/	1/
Others Mixed	119000	76000	5850	22	20	18
Total	545000	368000	325000	100	100	100

	Percentage of dairy breeds		
	1944	1951	1958
Holstein	12	22	43
Guernsey	5	5	9
Brown Swiss	1	4	7
Jersey	1	3	2
Ayrshire	1	-	-
	20	34	61

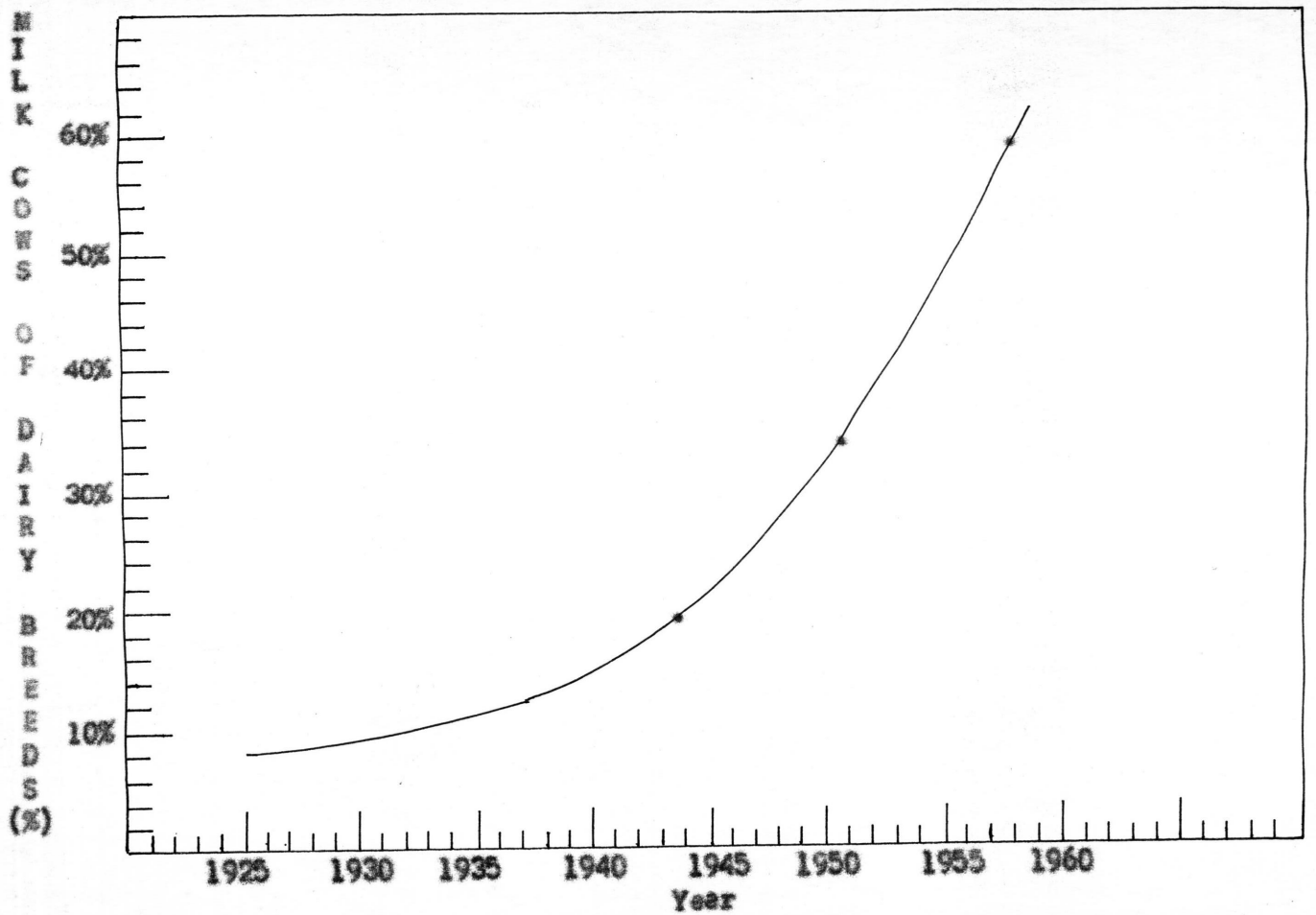
1/ Included in "other"

2/ Less than one percent

Sources: South Dakota Agriculture 1953, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak., January, 1953.

South Dakota Agriculture 1958, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak., June, 1958.

South Dakota Agriculture 1959, South Dakota Crop and Livestock Reporting Service: Sioux Falls, So. Dak.

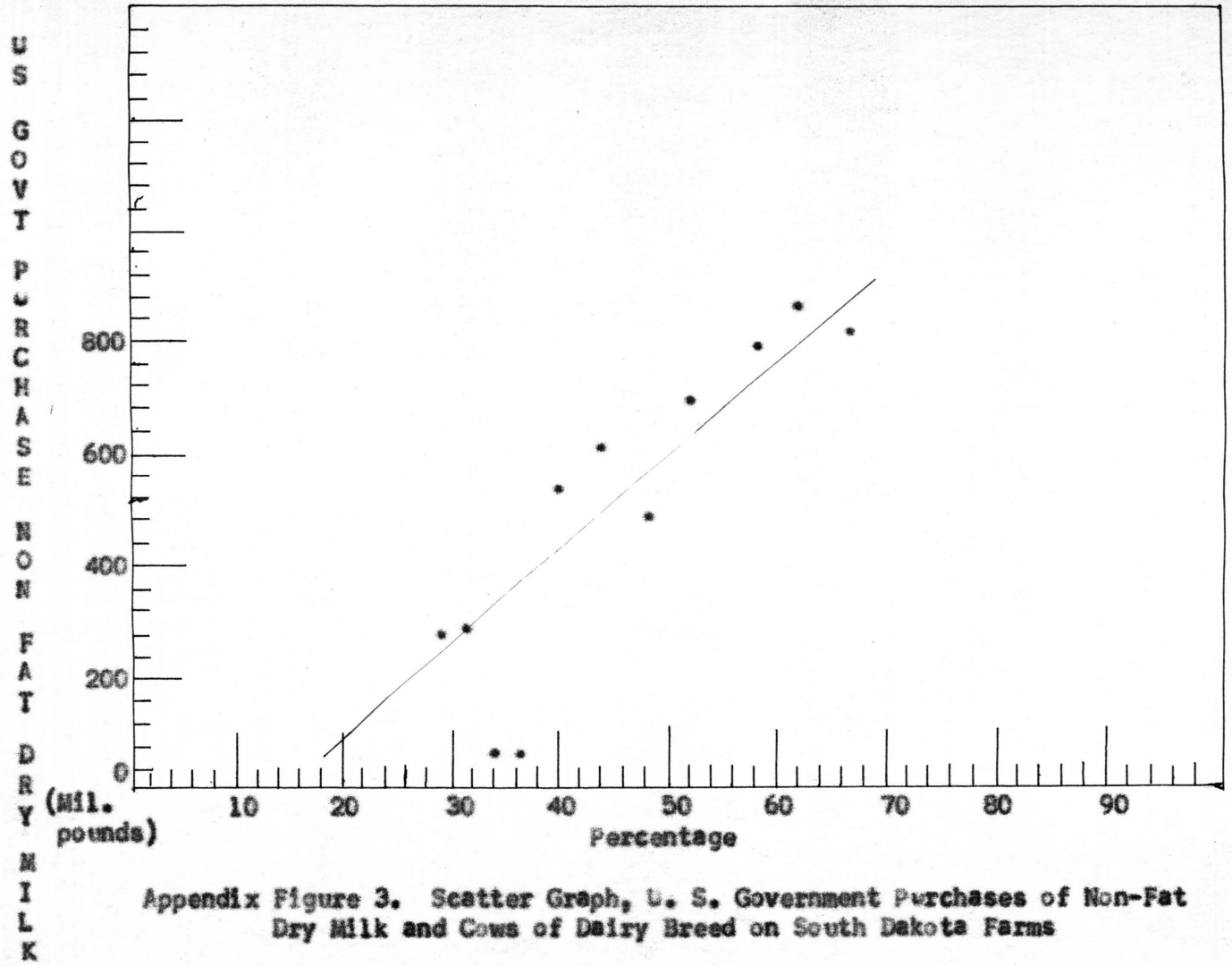


Appendix Figure 2. Breeds of Dairy Milk Cows Interpolation of Table 9

APPENDIX TABLE XIV. RELATIVE INDEX AND RESIDUALS

Year	Index of prices received for dairy products	Index of prices received for all commodities	Relative index farm price index of price received for dairy products and index of prices received for all commodities	Residuals of milk production per milk cow
1926	149	149	100	- 420
1927	158	143	110.5	- 90
1928	165	152	108.6	+ 50
1929	159	151	105.3	+ 270
1930	125	122	102.5	+ 480
1931	96	84	114.3	+ 300
1932	70	58	120.7	0
1933	70	62	112.9	+ 100
1934	86	80	107.5	- 220
1935	103	114	90.4	- 40
1936	117	117	100.0	- 90
1937	120	130	92.3	- 160
1938	97	103	94.2	- 330
1939	89	97	91.8	0
1940	103	101	102.0	+ 400
1941	123	128	96.1	+ 260
1942	144	164	87.8	+ 270
1943	178	190	93.7	0
1944	181	190	95.3	+ 10
1945	182	199	91.5	+ 80
1946	231	240	96.3	- 70
1947	261	311	83.9	- 130
1948	282	321	87.9	- 110
1949	232	268	86.6	- 330
1950	232	285	81.4	0
1951	264	339	77.9	+ 280
1952	273	301	90.7	- 300
1953	245	219	91.1	0
1954	221	260	85.0	0
1955	220	234	94.0	0
1956	227	227	100.0	- 20
1957	230	246	93.5	+ 20
1958	222	268	82.8	0
1959	226	250	90.4	0

Source: Appendix Tables VII and X.



Appendix Figure 3. Scatter Graph, U. S. Government Purchases of Non-Fat Dry Milk and Cows of Dairy Breed on South Dakota Farms

Source: The Dairy Situation February 1961, p. 26, Agricultural Marketing Service, United States Department of Agriculture: Washington, D. C.