Economic Instability and Choices Involving Income and Risk In Livestock and Poultry Production

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CONTENTS

SUMMARY

This study is an empirical one dealing particularly with adjustments to uncertainty. Its purposes are (1) to evaluate price factors contributing to uncertainty in livestock production, (2) to measure income variability for different enterprises and (3) to test different patterns of diversification as means of reducing income variability. To accomplish these ends, data were drawn from a reconstruction of income experience for 10 livestock and poultry enterprises over a period of 32 years. These budgets assumed average physical productivity and used Iowa annual prices.

Price fluctuations are the factors of most importance in contributing to uncertainty in livestock production. Variation of total costs and gross income combine to cause high variability of net income and feed returns. The correlation between total cost and gross income also has some bearing on net income variability.

Variability of returns from the different livestock enterprises was measured by the variance, standard deviation, coefficient of variation, year-to-year change as a percent of the mean and the range as a percent of the mean. These measures were generally consistent in ranking the income variability of the 10 enterprises.

The numbers in parentheses give the rank of the enterprises in income stability:

Enterprise	Coefficient of variation	Average year-to-year change as percent of the mean
Hogs	(7) 25.28	(7) 24.18
Dairy	(1) 12.17	(2) 10.62
Laying flock	(3) 14.19	(4) 13.27
Broilers	(2) 12.39	(1) 9.63
Turkeys	(5) 21.76	(5) 15.22
Beef-cow herd No. 1	(4) 21.49	(3) 12.32
Beef-cow herd No. 2	(6) 24.95	(6) 17.30
Good-choice calves	(8) 27.70	(8) 28.56
Fed 2-year-olds	(10) 37.41	(9) 36.23
Fed yearlings	(9) 36.31	(10) 37.81

Gross income and total cost correlation coefficients between all enterprises were examined. High gross income correlation between enterprises was associated with fairly high correlation between the same enterprises for returns per $100 all costs. Most of the enterprises' total costs were highly correlated with the costs of the other enterprises.

For diversification, those enterprises combined best which had low correlation of returns between each other. Accordingly, the poultry enterprises generally combined with the non-poultry enterprises to reduce variability of income.

The following data show the relative variability when enterprise pairs are combined so that 50 percent of the resources are used by each of the paired enterprises:

Enterprise pairs	Average year-to-year change as percent of the mean	Coefficient of variation
Hogs, dairy	16.63	18.34
Hogs, laying flock	15.42	14.40
Dairy, laying flock	8.06	7.92
Laying flock, beef-cow herd No. 1	9.67	10.22
Laying flock, good-choice calves	14.01	12.37
Hogs, 2-year-olds	25.00	22.97
Hogs, broilers	13.61	11.67
2-year-olds, broilers	17.34	18.99

Three and four enterprise combinations were tested for effectiveness in reducing variability. Combinations in excess of two, with the added enterprises held in fixed proportion, usually did not reduce variability appreciably more than did enterprise pairs.

Choice of enterprises or of enterprise combinations was investigated. Where the possibilities confronting the individual can be approximated, the ideal choice is determined by psychological and financial considerations.

Economic Instability and Choices Involving Income and Risk in Livestock and Poultry Production[1]

BY WILLIAM G. BROWN AND EARL O. HEADY

Economic uncertainty is a strong restraint on efficient farm production. It causes farmers to sacrifice profits and society to realize fewer goods and services from available resources. With perfect knowledge or foresight, ideal production decisions could be made. Acquisition of perfect knowledge is unlikely, but the sources of uncertainty in the form of yield, cost and price variability can be analyzed as a step in aiding farmers to make more efficient decisions.

While great improvements have been made in producing crops and livestock, little progress has been made in analyzing those facets of uncertainty which confront farmers in making production plans. At times farmers have been advised to "not put all their eggs in one basket," and, at other times, to concentrate their attention on one or two major enterprises. However, little or no empirical basis existed for such recommendations; information regarding alternatives between income and variability of income for different crop or livestock plans have not been available for the farmer's choice.

Because of the magnitude of this problem of uncertainty, the Iowa Agricultural Experiment Station has initiated studies dealing with risk and uncertainty in the primary and secondary industries of Iowa agriculture. A fundamental study of variability in primary or crop production has been completed.[2] This second study is an empirical one dealing with "risk" and "uncertainty" phenomena in livestock production.

OBJECTIVES

The alternatives of income and risk for different production plans must be known to make sound production decisions. Hence, the objective of this study is to present some of these alternatives. The study includes the following four steps:

(1) Evaluation of certain factors contributing to uncertainty in livestock enterprises.

(2) Measurement of the degree of uncertainty or income variability associated with different livestock enterprises.[3]

(3) Testing diversification as a means of reducing variability of returns from livestock enterprises, particularly in respect to price change.

(4) Determination of the amount of income sacrificed to attain a given level of income stability, and vice versa, through different patterns of enterprise combinations.

Differences in income variability between enterprises or combinations of enterprises are used to denote the degree of "uncertainty" associated with single enterprises or enterprise combinations. In this sense, the study is parallel to the one for crops where the advantages and limitations of the measures are discussed.[4]

SOURCE OF DATA

Data for this study were drawn from budgeted annual costs and returns for livestock enterprises over a period of 32 years. These enterprise budgets were constructed to find returns per $100 feed and returns per $100 all costs. Average productivity or technical coefficients and annual prices for Iowa were used in calculating costs and returns. Budgets for the period 1917 to 1948 included the most important livestock and poultry enterprises in Iowa.[5] These enterprises were: (1) hogs, (2) dairy, (3) laying flock, (4) turkeys, (5) beef-cow herd with sale of calves each fall (beef-cow herd number 1 in the tables), (6) beef-cow herd with calves retained and fed (beef-cow herd number 2 in the tables), (7) full feeding program for good to choice calves, (8) full feeding program for yearlings, (9) full feeding program for 2-year-olds and (10) broilers. After income had been determined for each of these enterprises over the 32-year period, different systems of allocating resources (i.e., different systems of enterprise diversification) were examined. Sacrifices or gains in income in relation to gains or losses in income stability were then determined.

IMPLICATIONS OF BUDGET APPROACH

In examining diversification as a means of reducing income variability, technical input-output ratios have been used as constant parameters. The technical coefficients used (see Appendix) are those available from other studies and approximate average Iowa farm conditions. The average Iowa price for cost items and products for each year has been applied to these technical constants. The technical constants do include unusual death and other losses affecting returns and, hence, suppose that the farmer has herds and flocks large enough to approximate these "average" coefficients in each year. In this sense, the section on diversification deals with reduction of variability due to prices alone.

[1]Project 1199. Iowa Agricultural Experiment Station.

[2]Heady, E. O., Kehrberg, E. and Jebe, E. Economic instability and choices involving income and risk in crop production. Iowa Agr. Exp. Sta. Res. Bul. 404. 1954.

[3]For previous work of this nature, see Heady, E. O. and Olson, R. O. Substitution relationships, resource requirements and income variability in the utilization of forage crops. Iowa Agr. Exp. Sta. Res. Bul. 390. 1952.

[4]Heady, Kehrberg and Jebe. op. cit.

[5]More information regarding the various livestock systems is given in the Appendix.

The procedures used in this study are exactly the counterpart of those used in the empirical method known as linear programming. In this process, the analysis deals with parameters which are known or assumed; it does not deal with statistics in the sense of probability distributions and predicted variance. It establishes optimum use of resources within the framework of the known or assumed parameters. Hence, not only the technical coefficients and income of livestock enterprises are treated as constants but the variance, standard deviation and coefficient of variation for prices also are treated as parameters for the years studied. The study is one of empirical method and perhaps less one of statistical inference of the conventional sense. The system has both advantages and limitations which are outlined elsewhere.[6] In this study, as in linear programming, it is assumed that production and income of an enterprise is a linear function of the resources used for this enterprise.

LEVEL OF TECHNIQUES

The techniques and levels of production for the livestock and poultry included in this study are drawn from farm surveys and records. In other words, they were those used on farms for about the 3 years prior to the initiation of the study in 1949. With the rapid improvement in nutrition and management practices over the past few years, the production rates used need not reflect those in widespread use at the present. Improvements in nutrition and management practices have been particularly rapid for hogs and broilers. The development of stilbestrol may have similar effects in cattle feeding.

However, these changes have only slight impacts on the types of income variability figures included in this study. Price is the only variable introduced in the figures since production rates or levels are taken as constants. Hence, the same relative differences in income variability would be expressed with different production rates but the same prices.

The main objectives of this study are (1) to compare the relative rank of livestock and poultry enterprises in terms of income variability and (2) to examine the effects of different livestock combinations in lessening income variability. Though income figures are presented, they are not used to compare the relative profitability of different enterprises. Individual farmers may produce a particular class of livestock or poultry with greater or lesser efficiency than shown here. The figures suppose enterprises as they are typically found on Iowa farms. Dairy and poultry figures suppose the small supplementary flocks and herds found in the state. Commercial enterprises of larger scale and better techniques would return greater profits than shown on the following pages. For the typical dairy or poultry enterprise using family labor, the place and profitability of the enterprise in the farm business is defined by the returns above feed costs.

PRICES

The prices used for livestock and poultry products and cost items are yearly averages for Iowa. They have been taken from *Agricultural Statistics, Crops and Markets* and other publications of the United States Department of Agriculture. In the period covered, 1917-48, two wars are included. This question may be raised: should the war periods have been left out? However, since the price data were selected to include a period about equal to a farmer's decision-making lifetime, all prices were used for the 1917-48 period. The frequency of wars and depression may differ between the future and the past. However, the two war spans were retained since they were "normal" to the decision-making lifetime of farmers in past decades.

BASIC PRINCIPLES OF DIVERSIFICATION

Diversification, or selection of more than one enterprise, is a means of increasing income by utilizing surplus labor, feed or equipment. However, diversification may also be a means of reducing income variability. For this reason, farmers may choose not to produce a single product, even if profits in the long run would be largest by so doing.

Diversification can be accomplished by (1) using additional capital to produce a new product or (2) shifting some of the initial resources to the new enterprise. In this study it is assumed that limited resources are available, and part of these resources must be shifted from one enterprise to another. If we let σ^2_A represent the income variance for one livestock enterprise, q the proportion of total resources allocated to this enterprise, σ^2_B the variance for the second enterprise and 1-q the proportion of resources allocated to this enterprise, then the total variance, σ^2_T, for any allocation of resources between the two enterprises can be represented by the equation:

$$(1)\quad \sigma^2_T = q^2\sigma^2_A + (1-q)^2\sigma^2_B + 2\rho_{AB}q(1-q)\sigma_A\sigma_B$$

This equation states that the income variance for the combined operation is equal to q^2 times σ^2_A, the variance for enterprise A, plus $(1-q)^2$ times σ^2_B, the variance for enterprise B, plus the covariance. In the covariance term, ρ_{AB} is the correlation coefficient of income for the two enterprises and σ_A and σ_B represent the standard deviations of income for each enterprise.[7]

Marginal variance, an estimate of the change in variability accompanying each change in resourse division between enterprises A and B, can be computed as:

$$(2)\quad \frac{d\sigma^2_T}{dq} = 2q\sigma^2_A - 2(1-q)\sigma^2_B + 2\rho_{AB}(1-2q)\sigma_A\sigma_B$$

By setting this derivative equal to zero, the following equation can be derived. It defines the value of q, the proportion of resources allocated to enterprise A, which minimizes income variance:

$$(3)\quad q = \frac{\sigma^2_B - \rho_{AB}\sigma_A\sigma_B}{\sigma^2_A + \sigma^2_B - 2\rho_{AB}\sigma_A\sigma_B}$$

This equation defines the value of q, which will minimize total variance, but this combination could give an absolute variance which would be high relative

[6]See Heady, Kehrberg and Jebe, op. cit.; and Koopmans, T. (editor) Activity analysis of production and allocation. John Wiley & Sons, Inc. New York. 1951.

[7]Managerial limitations may also give rise to increased variance as enterprises are added. Enterprise complementarity and interaction could also cause a different variance reduction than would occur for independently competitive enterprises.

to the level of income. Consequently, the next equation has been derived. It specifies the value of q, which minimizes the coefficient of variation, the variability of income relative to the magnitude of income.

$$(4) \qquad q = \frac{I_A\sigma^2{}_B - \rho_{AB}I_B\sigma_A\sigma_B}{I_B\sigma^2{}_A + I_A\sigma^2{}_B - \rho_{AB}(I_A + I_B)\sigma_A\sigma_B}$$

MEASURES OF VARIABILITY USED IN THIS STUDY

On the following pages, variance, standard deviation and coefficient of variation are all used as a measure of income variability. This procedure has been followed since some farmers may be interested in absolute variability while others are interested in relative variability. The procedure followed is one of first determining the variance for each of the individual enterprises and of then using the above equations to determine variances for various uses of resources for two or more enterprises. Variance for each individual enterprise is in terms of $100 in resources available to the particular enterprise; the variance for the combined enterprise organization thus refers to the proportion of $100 allocated to each enterprise. While the variance quantity itself would be larger for resource costs in excess of $100, the relative position of enterprises would be the same under the linear, homogeneous production functions used as a basis for the analysis.

Other measures also are used to denote the "degree of uncertainty" or variability which attaches to different livestock enterprises. These include (1) the year-to-year change in income or price as a percent of the mean and (2) the range of highest and lowest values realized in the 1917-48 period. Usually, these measures show the same enterprises to rank high or low in variability of income. However, some small differences explained later are encountered.

The figures used here refer to "outcomes over a period of years." They do not refer to income experience in a single year, except as denoted by the range or the maximum loss. The limitation of the measures used are explained in the previous study on crops and are not repeated here.[8] In each case where a variance figure is used, it refers to variance per $100 of cost or income unless otherwise specified.

RANK OF ENTERPRISES IN UNCERTAINTY

The purpose of this section is to measure the degree of variability associated with each individual enterprise. It is hoped that these measures will give some objective measure of the enterprises which are "more certain" or "more uncertain" than others. Farmers will then have some basis for selecting enterprises to fit the degree of risk or uncertainty which they can undertake in light of their capital and equity position, their family responsibilities and "need for sure income," or their like or aversion for risks. There are no adequate data currently available to show which enterprises are most risky.

GROSS INCOME VARIABILITY

Variability of gross income for the 10 livestock and poultry enterprises is presented in table 1. Physical production is "held constant"; consequently, variations in gross income are due to product price variation over the 1917-48 period. If the coefficient of variation is used as the measure of variability, gross incomes of the poultry and dairy enterprises are the most stable.

TABLE 1. GROSS INCOME VARIABILITY PER UNIT FOR 10 TYPES OF LIVESTOCK AND POULTRY ENTERPRISES IN IOWA FOR THE PERIOD FROM 1917 TO 1948.*

Enterprise	Coefficient of variation	Year-to-year change as a percent of the mean†	Range as a percent of mean	Average of ranks‡
Hogs	(7) 52.11	(7) 18.07	(5) 217.38	(6.3)
Dairy	(4) 38.66	(3) 12.64	(4) 171.37	(3.7)
Laying flock	(3) 32.53	(4) 14.02	(3) 115.39	(3.3)
Turkeys	(2) 30.58	(2) 12.10	(2) 105.52	(2)
Beef-cow herd No. 1§	(6) 45.09	(5) 14.89	(6) 218.05	(5.7)
Beef-cow herd No. 2**	(5) 44.46	(6) 15.71	(7) 220.49	(6)
Fed calves	(8) 58.42	(8) 31.79	(9) 270.80	(8.3)
Fed 2-year-olds	(10) 61.80	(10) 36.56	(10) 321.03	(10)
Fed yearlings	(9) 60.73	(9) 36.43	(8) 238.65	(8.7)
Broilers	(1) 22.08	(1) 10.08	(1) 92.99	(1)
Average	44.646	20.229	197.167	
Av. excluding beef enterprises	35.192	13.382	140.53	
Av. of beef enterprises	54.10	27.076	253.804	

* Enclosed numbers refer to the rank of the enterprise in stability. Variability is computed from the gross receipts of each enterprise over the 32-year period. (Size of livestock unit is not a factor since each measure of variability is divided by the mean.)

† Computed by adding the changes in income from one year to the next and dividing this total by the number of years and the average income.

‡ Computed as the mean of the ranks shown in the other three columns.

§ In this and subsequent tables, No. 1 refers to the beef-cow system with sale of the calves each fall as stockers.

** In this and subsequent tables, No. 2 refers to the beef-cow system where the calves are retained and fed.

Hogs and the beef-cow herds were intermediate while the cattle-feeding enterprises ranked highest in variability as measured by the coefficient of variation. These figures are in agreement with traditional farmer opinion; most farmers regard purchased feeder cattle as being more "risky" than other livestock enterprises.

Farmers may be as interested in year-to-year changes and range of outcomes as in the coefficient of variation (or related measures such as variance) as an indicator of uncertainty. It is possible for the coefficient of variation for returns over a period of years to be large, yet changes from year to year may be small. Under this situation, the farmer would face less severe adjustments in farming and could better predict from one year to the next. Hence, year-to-year changes, as a percent of the mean, have been included in table 1. However, the relative year-to-year changes have ranks between enterprises which are similar to the coefficient of variation; the position of only two pairs of enterprises is reversed. The range from highest to lowest income, as a measure of dispersion, also gives somewhat similar rankings. When the average of the three ranks is used as a measure of "uncertainty," broilers, dairy, laying flock and turkeys rank lowest in variability of gross income due to price; fed cattle and hogs rank highest.

TOTAL COST VARIABILITY

Coefficients of cost variability for the same 10 enterprises are given in table 2. Again, poultry enterprises rank among the lowest enterprises in variability. The dairy and beef-cow enterprises rank after the poultry enterprises. Cost variability is less for these enterprises than for hogs or beef cattle since the former use more labor relative to feed. Labor prices tend to vary less

[8] See Heady, Kehrberg and Jebe. op. cit.

TABLE 2. TOTAL COST VARIABILITY PER UNIT FOR 10 TYPES OF LIVESTOCK AND POULTRY ENTERPRISES IN IOWA FOR THE PERIOD FROM 1917 TO 1948.*

Enterprise	Coefficient of variation	Year-to-year change as a percent of the mean†	Range as a percent of mean	Average of ranks‡
Hogs	(10) 46.17	(10) 22.25	(10) 221.28	(10)
Dairy	(4) 36.61	(6) 16.02	(6) 162.61	(5.3)
Laying flock	(6) 37.16	(4) 12.74	(4) 153.79	(4.7)
Turkeys	(3) 35.50	(3) 12.27	(3) 146.49	(3)
Beef-cow herd No. 1	(5) 36.97	(5) 14.83	(5) 154.79	(5)
Beef-cow herd No. 2	(2) 31.18	(2) 12.18	(2) 132.97	(2)
Fed calves	(8) 42.78	(8) 21.17	(8) 205.66	(8)
Fed 2-year-olds	(9) 42.84	(9) 21.34	(9) 206.75	(9)
Fed yearlings	(7) 39.82	(7) 20.64	(7) 185.96	(7)
Broilers	(1) 30.14	(1) 10.07	(1) 123.79	(1)
Average	37.917	16.351	169.409	
Av. excluding beef enterprises	37.116	14.67	161.592	
Av. of beef enterprises	38.718	18.032	177.226	

* Enclosed numbers refer to the rank of the enterprise in stability. Variability is computed from the annual total expenses of each enterprise over the 32 years. (Size of the livestock unit is not a factor since each measure of variability is divided by the mean.)
† Computed by adding the changes in income from one year to the next and dividing this total by the number of years and the average income.
‡ Computed as the mean of the ranks shown in the other three columns.

TABLE 3. RELATIVE LEVELS OF NET INCOME VARIABILITY AND CORRELATION BETWEEN TOTAL COSTS AND GROSS INCOME FOR 10 TYPES OF LIVESTOCK AND POULTRY ENTERPRISES IN IOWA FOR THE PERIOD FROM 1917 TO 1948.

Enterprise	Coefficient of variation for returns per $100 all cost	Rank of enterprises for coefficient of variation	Correlation coefficient between total cost and gross income
Hogs	25.28	(7)	0.865
Dairy	12.17	(1)	0.941
Laying flock	14.19	(3)	0.910
Turkeys	21.76	(5)	0.769
Beef-cow herd No. 1	21.49	(4)	0.878
Beef-cow herd No. 2	24.95	(6)	0.759
Good-choice calves	27.70	(8)	0.859
Fed 2-year-olds	37.41	(10)	0.770
Yearlings	36.31	(9)	0.754
Broilers	12.39	(2)	0.891

from year to year or over short periods of economic fluctuations than do feed prices. Feed constitutes about 80 percent, as an average of years, of costs for hogs and beef cattle; it is only 65 to 70 percent of costs for poultry and dairy cattle.

The beef enterprises show greater stability in costs than in income. On the other hand, hog and dairy costs are more variable than were their corresponding gross incomes in table 2. Stability of costs does not, however, cause stability of net income as long as gross income is unstable. Instability of net income is accentuated where costs are stable and gross income is unstable; costs which fluctuate in the same direction as gross income give more stability of net income than do stable costs.

NET INCOME VARIABILITY

Farmers are interested in variability of gross income and costs to the extent that these contribute to net income variability. High variability of costs or prices does not necessarily specify high variability in net income; variation in one can offset variation in another.

The correlation coefficients between gross returns and total costs are given in table 3 for each of the 10 enterprises. Costs and returns generally go up and down together; the correlation coefficients range from 0.75 to 0.94 for the several enterprises. The association between changes in costs and gross income is positive and relatively high because of the one major force giving rise to price variation—namely, fluctuation in the general price level.

The coefficient of variation figures in table 3 give an index of variability in net income for the 10 enterprises. Using the coefficient of variability as the measure of variability (year-to-year change and the range have the same order), the dairy enterprise, broilers and laying flock are the most stable. The three cattle-feeding enterprises are the least stable and are followed by hogs, turkeys and the beef-cow herds in the intermediate position.

These figures alone are of interest to farmers choosing a livestock enterprise. However, average net income and the way in which income is distributed over the years should also be considered. Table 4 gives the distribution of income over the 32 years. For a farmer with low equity, a low-income year could force bankruptcy; consequently, most farmers would prefer a high income, low variance enterprise except that this "pair" does not always go together. Level of income and stability do not usually run in favor of the same enterprise. Often the farmer must choose between the two; level of income and stability of income are often rivals, and a choice must be made on the basis of the risk which the farmer can stand.

Another complication arises in using these income figures if the farmer's opportunity is "above average" for one enterprise while only "average" for another. Such could be the case for a farmer experienced in

TABLE 4. VARIABILITY OF RETURNS PER $100 ALL COST FOR 10 TYPES OF LIVESTOCK AND POULTRY ENTERPRISES IN IOWA FOR THE PERIOD FROM 1917 TO 1948.

Intervals for frequency distribution*	Hogs	Dairy	Laying flock	Turkeys	Beef-cow herd No. 1	Beef-cow herd No. 2	Good-choice calves	Fed 2-year-olds	Fed yearlings	Broilers
152.5 and over	2	—	—	1	—	—	—	4	1	—
137.5 — 152.4	1	—	1	1	4	3	2	3	6	—
122.5 — 137.4	2	—	1	3	2	4	5	2	1	1
107.5 — 122.4	4	10	7	5	4	6	6	2	3	8
92.5 — 107.4	7	12	12	9	7	4	9	4	7	15
77.5 — 92.4	12	10	10	7	12	8	3	8	6	7
62.5 — 77.4	2	—	1	6	3	7	3	4	5	1
47.5 — 62.4	—	—	—	—	—	—	3	3	2	—
Less than 47.5	2	—	—	—	—	—	1	2	1	—
Range as percent of mean	107.15	41.82	61.57	88.40	72.50	82.22	111.04	152.26	180.53	54.85
Maximum loss and gain per $100 all cost	-46.95 75.21	-36.59 2.90	-27.80 29.81	-24.62 77.14	-46.54 8.93	-39.11 37.33	-64.09 48.09	-86.42 71.10	-72.12 114.52	-22.86 38.30
Average year-to-year change as percent of mean	24.18	10.62	13.27	15.22	12.32	17.30	28.56	36.23	37.81	9.63
Coefficient of variation	25.28	12.17	14.19	21.76	21.49	24.95	27.70	37.41	36.31	12.39

* Deviation from mean expressed as a percent of the mean.

TABLE 5. VARIABILITY OF RETURNS PER $100 FEED FOR 10 TYPES OF LIVESTOCK AND POULTRY ENTERPRISES IN IOWA FOR THE PERIOD FROM 1917 TO 1948.

Intervals for frequency distribution*	Hogs	Dairy	Laying flock	Turkeys	Beef-cow herd No. 1	Beef-cow herd No. 2	Good-choice calves	Fed 2-year-olds	Fed Yearlings	Broilers
152.5 and over	3	—	1	2	3	2	1	4	2	—
137.5 — 152.4	2	3	1	1	2	4	2	—	4	1
122.5 — 137.4	2	3	1	4	1	2	4	4	1	2
107.5 — 122.4	4	5	10	7	3	3	5	6	3	4
92.5 — 107.4	4	7	5	4	7	5	9	2	7	16
77.5 — 92.4	10	9	8	7	8	8	3	6	6	7
62.5 — 77.4	5	5	6	6	8	6	4	7	4	1
47.5 — 62.4	1	—	—	1	—	2	3	1	4	1
Less than 47.5	1	—	—	—	—	—	1	2	1	—
Average return per $100 feed	156.83	151.06	126.47	162.12	110.26	129.21	133.55	135.66	127.69	159.55
Range as percent of mean	115.25	79.25	106.60	120.84	95.92	101.12	123.03	172.51	185.03	78.55
Average year-to-year change as percent of mean	48.54	24.87	28.61	31.75	16.40	19.55	28.95	37.36	37.99	14.06
Coefficient of variation	31.27	23.31	23.52	27.77	28.65	29.67	30.60	38.51	37.93	17.34
Maximum loss or gain	-34.09	+2.44	-18.06	-10.86	-29.66	-22.25	-55.30	-83.02	-67.20	-1.20
per $100 feed fed	146.66	122.12	116.76	185.05	76.11	108.42	109.02	151.02	169.07	124.14

* Deviation from mean expressed as a percent of the mean.

TABLE 6. CORRELATION COEFFICIENTS OF GROSS RETURNS FOR 10 TYPES OF LIVESTOCK AND POULTRY ENTERPRISES IN IOWA FOR THE PERIOD FROM 1917 TO 1948.

Livestock enterprise	Hogs	Dairy	Laying flock	Turkeys	Beef-cow herd No. 1	Beef-cow herd No. 2	Good-choice calves	2-year-olds	Yearlings	Broilers
Hogs	1.0									
Dairy	0.924	1.0								
Laying flock	0.823	0.865	1.0							
Turkeys	0.723	0.816	0.847	1.0						
Beef-cow herd No. 1	0.890	0.966	0.753	0.727	1.0					
Beef-cow herd No. 2	0.848	0.933	0.682	0.707	0.973	1.0				
Good-choice calves	0.875	0.912	0.692	0.647	0.935	0.946	1.0			
2-year-olds	0.713	0.761	0.490	0.453	0.821	0.865	0.857	1.0		
Yearlings	0.880	0.875	0.635	0.653	0.884	0.890	0.956	0.771	1.0	
Broilers	0.778	0.884	0.924	0.917	0.788	0.746	0.706	0.521	0.682	1.0

TABLE 7. CORRELATION COEFFICIENTS OF TOTAL COSTS FOR 10 TYPES OF LIVESTOCK AND POULTRY ENTERPRISES IN IOWA FOR THE PERIOD FROM 1917 TO 1948.

Livestock enterprise	Hogs	Dairy	Laying flock	Turkeys	Beef-cow herd No. 1	Beef-cow herd No. 2	Good-choice calves	2-year-olds	Yearlings	Broilers
Hogs	1.0									
Dairy	0.960	1.0								
Laying flock	0.937	0.951	1.0							
Turkeys	0.936	0.952	0.999	1.0						
Beef-cow herd No. 1	0.937	0.971	0.975	0.977	1.0					
Beef-cow herd No. 2	0.905	0.926	0.859	0.861	0.881	1.0				
Good-choice calves	0.994	0.963	0.918	0.918	0.928	0.919	1.0			
2-year-olds	0.994	0.958	0.914	0.914	0.922	0.916	0.999	1.0		
Yearlings	0.981	0.957	0.893	0.893	0.914	0.922	0.995	0.995	1.0	
Broilers	0.936	0.963	0.995	0.994	0.974	0.887	0.923	0.918	0.902	1.0

poultry production but less familiar with other enterprises. For example, if his expected return per $100 all cost is actually about $115 for the laying flock due to high production, but only $114 for hogs, he likely would choose hens over hogs. The laying flock would give as much income in this case with much less variability. Relative variability of income would remain about the same as that given in table 4. Relative variability for an enterprise remains about the same for different levels of production and income.[9]

VARIABILITY OF RETURNS FROM FEED OUTLAY

Feed returns are most important for short-run planning. Most farmers have a fixed investment in buildings and equipment The labor supply also is often "fixed" in the form of family labor. Therefore, variability and level of returns for feed outlay, such as those in table 5, are of prime interest to the farm planner in the short run.

For farmers with fixed obligations to meet, the "less risky" enterprises may be more attractive than "high income" enterprises. For example, dairy and young chicken enterprises appear almost certain to return the value of the feed and provide stock or chick replacements. The other poultry flocks and the beef-cow herds also seldom incur large losses on feed outlay. However, beef feeding often results in large losses—and alternatively, very large gains.

GROSS INCOME AND TOTAL COST CORRELATION

When the farmer is able to choose more than one livestock or poultry enterprise, the correlation of income between these enterprises becomes important. Two enterprises which have low correlation between their gross incomes can, when combined, reduce total income variability. Low income from one enterprise then is offset by high income from the other. Correlation coefficients between enterprises are given in table 6. Least correlated (or most "independent") were the movements of the poultry and beef-feeder prices.

Total cost correlation coefficients are given in table 7 and are even higher than for gross returns. This is

[9]See Heady, Earl O. and Olson, R. O. Economic use of forages in livestock production on Corn Belt farms. USDA Cir. 905. 1952.

TABLE 8. CORRELATION COEFFICIENTS OF RETURNS PER $100 ALL COSTS FOR 10 TYPES OF LIVESTOCK AND POULTRY ENTERPRISES IN IOWA FOR THE PERIOD FROM 1917 TO 1948.

Livestock enterprise	Hogs	Dairy	Laying flock	Turkeys	Beef-cow herd No. 1	Beef-cow herd No. 2	Good-choice calves	2-year-olds	Yearlings	Broilers
Hogs	1.0									
Dairy	0.61	1.0								
Laying flock	-0.15	-0.32	1.0							
Turkeys	-0.14	-0.24	0.23	1.0						
Beef-cow herd No. 1	0.20	0.68	-0.33	-0.11	1.0					
Beef-cow herd No. 2	0.29	0.64	-0.51	-0.19	0.67	1.0				
Good-choice calves	0.50	0.57	-0.51	-0.26	0.46	0.70	1.0			
2-year-olds	0.08	0.32	-0.35	-0.22	0.44	0.43	0.32	1.0		
Yearlings	0.54	0.53	-0.49	-0.13	0.44	0.62	0.87	0.23	1.0	
Broilers	-0.41	-0.31	0.61	0.70	-0.13	-0.38	-0.36	-0.02	-0.32	1.0

because the enterprises all use similar inputs such as feed and labor; high feed cost for one enterprise is matched by high feed costs for the other enterprises. Likewise, a decrease in feed costs for one enterprise in a particular year is matched by a similar decrease for the other enterprises. Labor and other costs also increase and decrease at the same time for all enterprises.

NET INCOME AND FEED RETURNS CORRELATION

Net income and feed returns correlations between enterprises are directly important in diversification. Net income correlation coefficients in table 8 cannot specify alone which enterprises should be combined to "lower uncertainty" but they are suggestive of "good" combinations.[10] For example, the dairy enterprise and laying flock have a low negative correlation coefficient; they should combine to lessen income variability more than dairy and beef-cow herd number 1, which have a fairly high positive correlation coefficient. High and low income years tend to offset each other for dairy and laying flock; for dairy and beef-cow herd number 1, the high and low years "tend to occur" at the same time for both.

Correlation of returns per $100 feed outlay in table 9 follow those for returns per $100 all costs. Poultry enterprises again had the lowest correlation coefficients when paired with the other enterprises. Years of high feed returns for poultry tended to be low for non-poultry enterprises and vise versa.

VARIABILITY UNDER DIVERSIFICATION

We are now ready to examine the effect of diversification, or combining livestock enterprises in different proportions rather than specializing, on variability of income. The "diversification" or variance equations outlined earlier give a clue to what might happen as specified pairs of enterprises are combined. From these variance equations, we know that enterprises with a negative correlation coefficient in tables 8 and 9 will be most effective in reducing income variance. The negative correlation coefficient, the ρ in the equations, will cause the $2\rho q\ (1\text{-}q)\ \sigma_A\ \sigma_B$ term to be negative. Where the correlation coefficient is positive, a quantity is added, rather than subtracted from the "weighted variances."

Information from table 8 can be combined with the variability figures of the individual enterprises to estimate the income variability of the enterprise pairs when they have been combined with each other. For example, what happens to the level of returns and income variability when hogs and dairy are combined? The answer is given in table 10 for all the enterprise pairs. The column, value of q, indicates the proportion of the total resource allocated to the first-mentioned enterprise; the remainder, (1-q), is used on the second-mentioned enterprise. A q value of 0.4 for hogs, dairy means that 40 percent of the total outlay or quantity of resources is used on the hog enterprise, and 60 percent is used on the dairy enterprise. The table shows each proportion in which resources might be divided between enterprises: (1) the net income, (2) the variance (the mean square), (3) the standard deviation (the square root of the mean square) and (4) the coefficient of variation (the standard deviation divided by the level of income).

These figures not only show the effect of various enterprise combinations on variability of income; they also provide information regarding the choices open to farmers between level of income and stability of income. The choice should vary with the individual farmer and his capital and risk position. Where income can be increased and risk can be lowered, most farmers will want to shift resources in this direction. Few will ever move in the direction where risk increases and income decreases as resources are reallocated. In table 10 for hogs and dairy cows, the coefficient of variation or relative variability of income can be lowered continuously by shifting more resources to dairy cows. But a lessening of income is required. Is the greater stability worth the sacrifice in returns? For hogs and the laying flock, the use of resources which gives the highest return over the 1917-48 period is for hogs alone; the resource pattern which gives

[10]Some caution must be attached to these coefficients since they are not independent of the input assumptions in the original enterprise budgets. Also, relationships in the future may differ from those of the past.

TABLE 9. CORRELATION COEFFICIENTS OF RETURNS PER $100 FEED OUTLAY FOR 10 TYPES OF LIVESTOCK AND POULTRY ENTERPRISES IN IOWA FOR THE PERIOD FROM 1917 TO 1948.

Livestock enterprise	Hogs	Dairy	Laying flock	Turkeys	Beef-cow herd No. 1	Beef-cow herd No. 2	Good-choice calves	2-year-olds	Yearlings	Broilers
Hogs	1.0									
Dairy	0.60	1.0								
Laying flock	-0.17	-0.20	1.0							
Turkeys	-0.12	-0.13	0.79	1.0						
Beef-cow herd No. 1	0.24	0.79	-0.23	-0.07	1.0					
Beef-cow herd No. 2	0.29	0.72	-0.45	-0.19	0.70	1.0				
Good-choice calves	0.60	0.61	-0.47	-0.24	0.52	0.70	1.0			
2-year-olds	0.12	0.37	-0.35	-0.19	0.51	0.45	0.36	1.0		
Yearlings	0.53	0.56	-0.47	-0.16	0.47	0.63	0.86	0.27	1.0	
Broilers	-0.33	-0.23	0.67	0.76	-0.08	-0.32	-0.31	-0.03	-0.32	1.0

TABLE 10. LEVEL OF INCOME, VARIANCE, STANDARD DEVIATION AND COEFFICIENT OF VARIATION FOR RETURNS PER $100 ALL COSTS FOR 10 TYPES OF LIVESTOCK AND POULTRY ENTERPRISES IN IOWA FOR THE PERIOD FROM 1917 TO 1948.*

Value of q	Income	Variance	Std. dev.†	C/V‡	Income	Variance	Std. dev.†	C/V‡	Income	Variance	Std. dev.†	C/V‡
	Hogs, dairy				Hogs, laying flock				Dairy, laying flock			
1.0	114.01	830.4	28.8	25.2	114.01	830.4	28.8	25.2	80.55	96.0	9.8	12.1
0.9	110.66	704.8	26.5	23.9	111.96	664.2	25.7	23.0	81.85	72.1	8.4	10.3
0.8	107.31	590.7	24.3	22.6	109.92	520.4	22.8	20.7	83.15	55.4	7.4	8.9
0.7	103.97	488.3	22.0	21.2	107.87	399.0	19.9	18.5	84.45	45.7	6.7	8.0
0.6	100.62	397.4	19.9	19.8	105.83	300.0	17.3	16.3	85.75	43.1	6.5	7.6
0.5	97.28	318.2	17.8	18.3	103.79	223.4	14.9	14.4	87.05	47.5	6.8	7.9
0.4	93.93	250.6	15.8	16.8	101.74	169.2	13.0	12.7	88.36	59.1	7.6	8.7
0.3	90.58	194.5	13.9	15.3	99.70	137.4	11.7	11.7	89.66	77.8	8.8	9.8
0.2	87.24	150.1	12.2	14.0	97.65	127.9	11.3	11.5	90.96	103.5	10.1	11.1
0.1	83.89	117.3	10.8	12.9	95.67	140.9	11.8	12.4	92.26	136.4	11.6	12.6
0.0	80.55	96.0	9.8	12.1	93.56	176.3	13.2	14.1	93.56	176.3	13.2	14.1
	Hogs, turkeys				Dairy, turkeys				Laying flock, turkeys			
1.0	114.01	830.4	28.8	25.2	80.55	96.0	9.8	12.1	93.56	176.3	13.2	14.1
0.9	114.12	660.0	25.6	22.5	84.00	73.4	8.5	10.2	95.72	192.5	13.8	14.4
0.8	114.23	523.0	22.8	20.0	87.46	67.7	8.2	9.4	97.87	215.0	14.6	14.9
0.7	114.34	419.4	20.4	17.9	90.91	78.7	8.8	9.7	100.03	244.0	15.6	15.6
0.6	114.45	349.0	18.6	16.3	94.37	106.6	10.3	10.9	102.18	279.5	16.7	16.3
0.5	114.56	312.1	17.6	15.4	97.83	151.3	12.3	12.5	104.34	321.3	17.9	17.1
0.4	114.67	308.4	17.5	15.3	101.28	212.8	14.5	14.4	106.49	369.6	19.2	18.0
0.3	114.78	338.1	18.3	16.0	104.74	291.2	17.0	16.2	108.64	424.4	20.6	18.9
0.2	114.89	401.1	20.0	17.4	108.19	386.3	19.6	18.1	110.80	485.5	22.0	19.8
0.1	115.00	497.5	22.3	19.3	111.65	498.3	22.3	19.9	112.95	553.1	23.5	20.8
0.0	115.11	627.2	25.0	21.7	115.11	627.2	25.0	21.7	115.11	627.2	25.0	21.7
	Turkeys, good-choice calves				Beef-cow herd No. 1, good-choice calves				Beef-cow herd No. 2, good-choice calves			
1.0	115.11	627.2	25.0	21.0	76.50	270.2	16.4	21.4	93.00	538.3	23.2	24.9
0.9	113.70	483.0	21.9	19.3	78.95	265.1	16.2	20.6	93.80	525.7	22.9	24.4
0.8	112.29	374.4	19.3	17.2	61.41	272.5	16.5	20.2	94.60	521.3	22.8	24.1
0.7	110.88	301.3	17.3	15.6	83.86	292.5	17.1	20.3	95.40	525.1	22.9	24.0
0.6	109.47	263.6	16.2	14.8	86.31	324.9	18.0	20.8	96.21	537.2	23.1	24.0
0.5	108.06	261.4	16.1	14.9	88.76	369.9	19.2	21.6	97.01	557.5	23.6	24.3
0.4	106.65	294.7	17.1	16.0	91.21	427.5	20.6	22.6	97.81	586.1	24.2	24.7
0.3	105.25	363.5	19.0	18.1	93.66	497.5	22.3	23.8	98.61	622.9	24.9	25.3
0.2	103.84	467.8	21.6	20.8	96.12	580.1	24.0	25.0	99.41	667.9	25.8	25.9
0.1	102.43	607.5	24.6	24.0	98.57	675.1	25.9	26.3	100.22	721.2	26.8	26.7
0.0	101.02	782.8	27.9	27.6	101.02	782.8	27.9	27.6	101.02	782.8	27.9	27.6
	Hogs, fed 2-year-olds				Dairy, fed 2-year-olds				Laying flock, fed 2-year-olds			
1.0	114.01	830.4	28.8	25.2	80.55	96.0	9.8	12.1	93.56	176.3	13.2	14.1
0.9	112.95	702.7	26.5	23.4	82.84	114.4	10.6	12.9	94.55	125.0	11.1	11.8
0.8	111.89	618.2	24.8	22.2	85.13	159.8	12.6	14.8	95.54	114.4	10.6	11.1
0.7	110.84	576.9	24.0	21.6	87.42	232.3	15.2	17.4	96.53	144.6	12.0	12.4
0.6	109.78	578.9	24.0	21.9	89.71	331.9	18.2	20.3	97.52	215.6	14.6	15.0
0.5	108.73	624.0	24.9	22.9	92.00	458.5	21.4	23.2	98.51	327.3	18.0	18.3
0.4	107.67	712.3	26.6	24.7	94.29	612.2	24.7	26.2	99.49	497.8	21.9	22.0
0.3	106.61	843.8	29.0	27.2	96.58	792.9	28.1	29.1	100.48	673.1	25.9	25.8
0.2	105.56	1,018.5	31.9	30.2	98.87	1,000.7	31.6	31.9	101.47	907.1	30.1	29.6
0.1	104.50	1,236.4	35.1	33.6	101.16	1,235.6	35.1	34.7	102.46	1,181.9	34.3	33.5
0.0	103.45	1,497.5	38.6	37.4	103.45	1,497.5	38.6	37.4	103.45	1,497.5	38.6	37.4
	Turkeys, fed 2-year-olds				Beef-cow herd No. 1, fed 2-year-olds				Beef-cow herd No. 2, fed 2-year-olds			
1.0	115.11	627.2	25.0	21.7	76.50	270.2	16.4	21.4	93.00	538.3	23.2	24.9
0.9	113.94	485.2	22.0	19.3	79.20	284.7	16.8	21.3	94.04	528.0	22.9	24.4
0.8	112.77	394.1	19.8	17.6	81.89	323.3	17.9	21.9	95.09	541.3	23.2	24.4
0.7	111.61	353.9	18.8	16.8	84.59	385.9	19.6	23.2	96.13	578.2	24.0	25.0
0.6	110.44	364.6	19.0	17.2	87.28	472.5	21.7	24.9	97.18	638.8	25.2	26.0
0.5	109.28	426.2	20.6	18.8	89.97	583.2	24.1	26.8	98.22	722.9	26.8	27.3
0.4	108.11	538.6	23.2	21.4	92.67	718.0	26.7	28.9	99.27	830.6	28.8	29.0
0.3	106.94	702.0	26.4	24.7	95.36	876.8	29.6	31.0	100.31	961.9	31.0	30.9
0.2	105.78	917.3	30.2	28.6	98.06	1,059.6	32.5	33.1	101.36	1,116.8	33.4	32.9
0.1	104.61	1,181.4	34.3	32.8	100.75	1,266.5	35.5	35.3	102.40	1,295.3	35.9	35.1
0.0	103.45	1,497.5	38.6	37.4	103.45	1,497.5	38.6	37.4	103.45	1,497.5	38.6	37.4
	Good-choice calves, fed 2-year-olds				Hogs, yearlings				Dairy, yearlings			
1.0	101.02	782.8	27.9	27.6	114.01	830.4	28.8	25.2	80.55	96.0	9.8	12.1
0.9	101.26	712.0	26.6	26.3	112.94	790.9	28.1	24.8	82.83	126.9	11.2	13.6
0.8	101.50	672.9	25.9	25.5	111.88	773.0	27.8	24.8	85.11	180.1	13.4	15.7
0.7	101.75	665.3	25.7	25.3	110.82	776.8	27.8	25.1	87.39	255.7	15.9	18.2
0.6	101.99	689.4	26.2	25.7	109.75	802.2	28.3	25.8	89.68	353.5	18.8	20.9
0.5	102.23	745.1	27.2	26.6	108.69	849.2	29.1	26.8	91.96	473.6	21.7	23.6
0.4	102.48	832.4	28.8	28.1	107.63	917.9	30.2	28.1	94.24	616.1	24.8	26.3
0.3	102.72	951.2	30.8	30.0	106.57	1,008.2	31.7	29.7	96.53	780.8	27.9	28.9
0.2	102.96	1,101.7	33.1	32.2	105.50	1,120.1	33.4	31.7	98.81	967.9	31.1	31.4
0.1	103.20	1,283.8	35.8	34.7	104.44	1,253.7	35.4	33.9	101.09	1,177.2	34.3	33.9
0.0	103.45	1,497.5	38.6	37.4	103.38	1,408.9	37.5	36.3	103.38	1,408.9	37.5	36.3

* The q value refers to the proportion of $100 allocated to the enterprise mentioned first in each pair. The proportion of resources used for the second-mentioned enterprise is always 1-q.

† Standard deviation.

‡ Coefficient of variation or standard deviation divided by income.

the least variable income is use of 20 percent for hogs and 80 percent for the laying flock. The farmer in a strong capital position may want to "bet on" hogs alone; the man with a weak equity position may prefer the combination which minimizes variability. Other farmers may select "in between" combinations. For example, use of half of his resources (a q value of 0.5) for both enterprises would lower the coefficient of variation by 75 percent, compared to the alternative of specialization in hogs ($q = 1.0$). Is the loss of $10 income per $100 of all costs worth the greater stability? The individual farmer alone can decide this question. There is, of course, neither income nor stability gain from using more than 80 percent ($1\text{-}q = 0.8$) of the resource for the laying flock. If more than 80 percent of resources are allocated to the laying flock, the level of income falls and variability of income increases.

In table 10, absolute variability of income for the dairy, hog combination declines throughout as the proportion of cost resources used for dairy is increased and the outlay for hogs is decreased correspondingly. Likewise, the relative variability of income (C/V column) is lowest when all resources are allocated to the dairy. However, average returns are greatest for hogs alone. A choice of a combination of these two enterprises depends upon the farmer's preference for income versus stability.[11]

Most of the pairs show that a combination of two enterprises results in lower variability than specialization in either one alone. However, if a "more variable" enterprise is combined with an "original enterprise" and the enterprises are closely related, relative variance is likely to be increased. For example, any combination of turkeys and laying hens will increase income variability over that for laying hens alone. Likewise, any beef enterprise added to dairy will increase variability above that for dairy alone. This is also true for fed calves combined with yearlings or for turkeys added to broilers. However, with these exceptions, all enterprises will combine with others to reduce relative income variation.

Poultry enterprises generally help to reduce income variance when they are combined with non-poultry enterprises. Income variability is reduced because poultry returns tend to have higher income when other enterprises have lower income, and vice versa. This tendency was shown before by the correlation coefficients in tables 8 and 9.

Lowest relative variability of hogs combined with beef-cow herd number 1 comes with 0.3 of the cost resources used for hogs and 0.7 used for the beef-cow herd. In the case of hogs, beef-cow herd number 2, lowest relative variability comes with about 0.5 of resources used for hogs. The proportions also are about 0.5 for the turkey, beef-cow herd number 2 combination and for the hogs, choice calves combination. For a minimum relative variability of laying flock, choice calves, about 0.7 of resources should be used for the laying flock. Proportioning 0.8 of resources to the beef-cow herd gives a minimum C/V figure for beef-cow herd number 1 and choice calves. In combinations including only feeder cattle, the minimum C/V figure comes with 0.7 of resources used for calves in choice calves, 2-year-olds combinations and with all resources for calves in choice calves, yearlings combinations; the proportions are 0.5 to each enterprise for the 2-year-olds, yearlings combinations. In this last case, income is about the same whether yearlings or 2-year-olds are fed. Hence, one might always have some advantage in combining the two enterprises over a long period of time. He could reduce relative income variability (the coefficient of variation) by about 30 percent without a sacrifice in income.

YEAR-TO-YEAR CHANGES

The variance figures above on variability for different combinations provide the basis for determining the extent to which level of income and stability of income go hand-in-hand, or the quantitative sacrifices in one which must be made to increase the other. However, the year-to-year variation in income for different enterprise combinations is also of interest. For example, consider two enterprises which have the same coefficient of variation. One enterprise's income may change by a small, regular amount from year to year, but the other may have larger, more random year-to-year changes. The farmer would likely feel more uncertain about the second enterprise.

In table 11, the average change from year to year, divided by the mean, is given for all enterprise pairs. In this case the two enterprises are always the same size, one-half of the resources (both q and 1-q are 0.5) being given to each.

If year-to-year change, as a percent of the mean (column 5), is compared with the coefficient of variation (column 6), it is seen that an enterprise has about the same general rank under both measures. Hence, either measure might lead to about the same enterprise combination if the goal is to reduce variability of income.

The range of outcomes when the enterprises are combined presents the highest and lowest incomes of the 32 years for the "half-and-half" enterprise combinations. Farmers with low equity are especially interested in the most unfavorable outcomes of the past as a possible indication of the future. The combined range as a percent of the mean, column 4, is the range between the best and worst years, for the combination pair, divided by the average income. In column 3 the range of incomes for the two enterprises, taken independently, has been averaged. Hence, the highest or lowest figures of the range would not necessarily come in the same year. Column 3 would be appropriate only if the high and low years of the two enterprises did not counteract or reinforce each other. Of course, such is not the case as is shown by column 4. When column 4 is greater than column 3, it indicates that low and high years tend to come together for the two enterprises. Where column 4 is less than column 3, the high and low income years of the two enterprises tended to offset each other. For example, dairy and laying flock combined to reduce the range of outcomes by nearly one-half. Uncertainty is substantially reduced in such a case.

[11]For the hog, laying flock combination, a farmer starting with only the laying flock could increase both level of income and stability of income by shifting part of the resources to hogs until $q = 0.2$. Of course, finding the lowest relative variability of income in this way is accurate only to the nearest tenth place. Equation 4 of a preceding section can be used to find the exact value of q for minimum variability. For example, a q value of 0.623 gives minimum variance for the dairy, laying flock combination.

TABLE 11. YEAR-TO-YEAR CHANGES IN INCOME COMPARED TO RANGE AND COEFFICIENT OF VARIATION FOR RETURNS PER $100 ALL COSTS WITH EQUAL RESOURCE ALLOCATION BETWEEN ENTERPRISES (q AND 1-q EACH EQUAL 0.5).

Enterprise combination	Range of incomes with enterprises combined	Average range as percent of mean*	Range of "combined incomes" as percent of mean†	Year-to-year change for combined enterprises as percent of mean‡	Coefficient of variation§
(1)	(2)	(3)	(4)	(5)	(6)
Hogs, dairy	58.23–134.14	74.48	78.03	16.63	18.34
Hogs, laying flock	64.51–133.07	84.36	66.06	15.42	14.40
Dairy, laying flock	76.27–99.53	51.70	26.72	8.06	7.92
Hogs, turkeys	70.77–158.97	97.78	76.99	15.19	15.42
Dairy, turkeys	77.61–126.08	65.11	49.55	9.13	12.58
Laying flock, turkeys	79.06–153.48	74.98	71.33	13.19	17.18
Hogs, beef-cow herd No. 1	60.04–135.91	89.82	79.65	15.68	18.84
Dairy, beef-cow herd No. 1	61.10–102.40	57.16	52.59	9.84	15.28
Laying flock, beef-cow herd No. 1	64.08–103.61	67.04	46.49	9.67	10.22
Turkeys, beef-cow herd No. 1	68.04–124.96	80.45	59.41	11.58	14.85
Hogs, beef-cow herd No. 2	60.36–150.46	94.68	87.05	15.75	20.28
Dairy, beef-cow herd No. 2	62.52–116.94	62.02	62.71	11.45	17.53
Laying flock, beef-cow herd No. 2	78.58–118.16	71.90	42.43	8.63	10.71
Turkeys, beef-cow herd No. 2	73.50–132.51	85.31	56.71	10.72	14.74
Beef-cow herd No. 1, beef-cow herd No. 2	59.48–122.78	77.36	74.69	11.98	21.42
Hogs, good-choice calves	54.68–160.75	109.10	98.65	21.06	22.85
Dairy, good-choice calves	50.03–120.30	76.43	77.40	17.86	19.00
Laying flock, good-choice calves	68.08–116.52	86.30	49.79	14.01	12.37
Turkeys, good-choice calves	74.00–143.36	99.72	64.18	16.04	14.96
Beef-cow herd No. 1, good-choice calves	46.98–121.12	91.77	83.52	18.96	21.67
Beef-cow herd No. 2, good-choice calves	48.40–135.67	96.63	89.96	21.47	24.34
Hogs, 2-year-olds	43.85–152.79	129.70	100.19	25.00	22.97
Good-choice calves, yearlings	31.90–180.71	145.78	145.60	32.81	31.01
Two-year-olds, yearlings	20.73–153.71	166.40	128.59	26.72	28.89
Hogs, broilers	78.56–141.20	81.00	55.55	13.61	11.67
Dairy, broilers	80.69–107.91	48.34	28.35	7.34	7.42
Laying flock, broilers	75.84–125.46	58.21	48.39	10.10	11.85
Turkeys, broilers	82.70–149.12	71.62	58.62	10.58	15.94
Beef-cow herd No. 1, broilers	77.22–110.84	63.68	35.76	8.22	10.69
Beef-cow herd No. 2, broilers	79.12–124.72	68.54	44.60	8.16	10.81
Calves, broilers	78.50–127.65	82.94	46.25	14.96	12.43
Two-year-olds, broilers	67.34–153.50	103.56	86.16	17.34	18.99
Yearlings, broilers	74.49–161.16	117.69	86.67	18.95	16.56

* Computed by averaging the ranges of the two enterprises before they are combined and dividing by the average income of the two.
† Computed from the actual range of outcomes of the two enterprises after they have been combined and dividing by the average income of the two in combination.
‡ The year-to-year change, as percent of mean, when the enterprises are combined in 0.5 proportions.
§ Coefficient of variation (table 10) when enterprises combined in 0.5 proportions.

CHOICES IN LEVEL AND VARIABILITY OF INCOME FOR FEED RETURNS.

For short-run planning, level and variability of returns from feed are of prime interest to farmers. Hence, the figures in table 12 are provided to allow choices when feed returns, rather than all costs, are of prime concern. In some cases, relative variability is decreased even more than net income variability as resources are used for diversified enterprises. For example, hogs and dairy combine to reduce both absolute and relative variability of feed return; they did not do so for returns per $100 all cost. As before, the poultry enterprises combine with the other enterprises to substantially reduce income variability.

LEVEL AND VARIABILITY OF INCOME PER $100 OF ALL COSTS

To provide a more vivid illustration of the choices between level of income and variability of income, the data have been put in graphic form in the charts which follow. In fig. 1, variability of income, measured in terms of the standard deviation, is measured along the horizontal axis. Returns per $100 all cost (income) are measured on the vertical axis. To understand the choices indicated on the graph, follow this procedure: start from dairy alone (D) in the lower left corner. Then, examine the line leading to fed yearlings alone (B_5). The points on this line show all the combinations of *level of income* and *variability of income* which can be attained with var-

TABLE 12. LEVEL OF RETURNS PER $100 FEED OUTLAY, VARIANCE, STANDARD DEVIATION AND COEFFICIENT OF VARIATION FOR 10 TYPES OF LIVESTOCK AND POULTRY ENTERPRISES IN IOWA FOR THE PERIOD FROM 1917 TO 1948.*

Value of q	Income	Variance	Std. dev.†	C/V‡	Income	Variance	Std. dev.†	C/V‡	Income	Variance	Std. dev.†	C/V‡
	Hogs, dairy				Hogs, laying flock				Dairy, laying flock			
1.0	156.83	2,405.2	49.0	31.2	156.83	2,405.2	49.0	31.2	151.06	1,240.4	35.2	23.3
0.9	156.25	2,146.3	46.3	29.6	153.79	1,913.7	43.7	28.4	148.60	975.7	31.2	21.0
0.8	155.67	1,919.0	43.8	28.1	150.76	1,497.6	38.7	25.6	146.14	761.9	27.6	18.8
0.7	155.10	1,723.4	41.5	26.7	147.72	1,157.0	34.0	23.0	143.68	599.0	24.4	17.0
0.6	154.52	1,559.4	39.4	25.5	144.68	891.8	29.8	20.6	141.22	487.0	22.0	15.6
0.5	153.94	1,427.1	37.7	24.5	141.65	702.0	26.4	18.7	138.76	426.0	20.6	14.8
0.4	153.36	1,326.4	36.4	23.7	138.61	587.7	24.2	17.4	136.30	415.9	20.3	14.9
0.3	152.79	1,257.4	35.4	23.2	135.58	548.8	23.4	17.2	133.84	456.7	21.3	15.9
0.2	152.21	1,220.1	34.9	22.9	132.54	585.4	24.1	18.2	131.38	548.5	23.4	17.8
0.1	151.63	1,214.4	34.8	22.9	129.50	697.3	26.4	20.3	128.93	691.1	26.2	20.3
0.0	151.06	1,240.4	35.2	23.3	126.47	884.7	29.7	23.5	126.47	884.7	29.7	23.5
	Hogs, turkeys				Dairy, turkeys				Laying flock, turkeys			
1.0	156.83	2,405.2	49.0	31.2	151.06	1,240.4	35.2	23.3	126.47	884.7	29.7	23.5
0.9	157.36	1,920.6	43.8	27.8	152.16	987.0	31.4	20.6	130.03	926.3	30.4	23.4
0.8	157.89	1,535.2	39.1	24.8	153.27	807.4	28.4	18.5	133.60	983.9	31.3	23.4
0.7	158.42	1,249.2	35.3	22.3	154.38	701.6	26.4	17.1	137.16	1,057.7	32.5	23.7
0.6	158.95	1,052.4	32.5	20.5	155.48	669.5	25.8	16.6	140.73	1,147.7	33.8	24.0
0.5	159.48	974.9	31.2	19.5	156.59	711.2	26.6	17.0	144.29	1,253.8	35.4	24.5
0.4	160.00	986.6	31.4	19.6	157.70	826.7	28.7	18.2	147.86	1,376.0	37.0	25.0
0.3	160.53	1,097.6	33.1	20.6	158.80	1,016.0	31.8	20.0	151.43	1,514.4	38.9	25.6
0.2	161.06	1,308.0	36.1	22.4	159.91	1,279.0	35.7	22.3	154.99	1,668.9	40.8	26.3
0.1	161.59	1,617.5	40.2	24.8	161.02	1,615.8	40.1	24.9	158.56	1,839.6	42.8	27.0
0.0	162.12	2,026.4	45.0	27.7	162.12	2,026.4	45.0	27.7	162.12	2,026.4	45.0	27.7
	Hogs, beef-cow herd No. 1				Dairy, beef-cow herd No. 1				Laying flock, beef-cow herd No. 1			
1.0	156.83	2,405.2	49.0	31.2	151.06	1,240.4	35.2	23.3	126.47	884.7	29.7	23.5
0.9	152.17	2,026.3	45.0	29.5	146.98	1,173.3	34.2	23.3	124.85	686.9	26.2	20.9
0.8	147.51	1,700.3	41.2	27.9	142.90	1,115.7	33.4	23.3	123.23	535.6	23.1	18.7
0.7	142.86	1,427.3	37.7	26.4	138.82	1,067.7	32.6	23.5	121.61	430.7	20.7	17.0
0.6	138.20	1,207.1	34.7	25.1	134.74	1,029.2	32.0	23.8	119.99	372.3	19.2	16.0
0.5	133.55	1,039.9	32.2	24.1	130.66	1,000.1	31.6	24.2	118.36	360.3	18.9	16.0
0.4	128.89	925.6	30.4	23.6	126.58	980.6	31.3	24.7	116.74	394.9	19.8	17.0
0.3	124.23	864.3	29.3	23.6	122.50	970.6	31.1	25.4	115.12	475.9	21.8	18.9
0.2	119.58	855.8	29.2	24.4	118.42	970.2	31.1	26.3	113.50	603.3	24.5	21.6
0.1	114.92	900.3	30.0	26.1	114.34	979.2	31.2	27.3	111.88	777.3	27.8	24.9
0.0	110.26	997.7	31.5	28.6	110.26	997.7	31.5	28.6	110.26	997.7	31.5	28.6
	Turkeys, beef-cow herd No. 1				Hogs, beef-cow herd No. 2				Dairy, beef-cow herd No. 2			
1.0	162.12	2,026.4	45.0	27.7	156.83	2,405.2	49.0	31.2	151.06	1,240.4	35.2	23.3
0.9	156.94	1,633.0	40.4	25.7	154.07	2,062.7	45.4	29.4	148.87	1,195.5	34.5	23.2
0.8	151.75	1,304.1	36.1	23.7	151.30	1,775.6	42.1	27.8	146.69	1,165.7	34.1	23.2
0.7	146.56	1,039.8	32.2	22.0	148.54	1,543.7	39.2	26.4	144.50	1,150.9	33.9	23.4
0.6	141.38	840.0	28.9	20.5	145.78	1,367.2	36.9	25.3	142.32	1,151.3	33.9	23.8
0.5	136.19	704.9	26.5	19.4	143.02	1,246.0	35.2	24.6	140.13	1,166.7	34.1	24.3
0.4	131.01	634.3	25.1	19.2	140.26	1,180.1	34.3	24.4	137.95	1,197.2	34.6	25.0
0.3	125.82	628.3	25.0	19.9	137.50	1,169.6	34.2	24.8	135.76	1,242.8	35.2	25.9
0.2	120.63	686.9	26.2	21.7	134.74	1,214.4	34.8	25.8	133.50	1,303.4	36.1	27.0
0.1	115.45	810.0	28.4	24.6	131.97	1,314.5	36.2	27.4	131.40	1,379.1	37.1	28.2
0.0	110.26	997.7	31.5	28.6	129.21	1,469.9	38.3	29.6	129.21	1,469.9	38.3	29.6
	Laying flock, beef-cow herd No. 2				Turkeys, beef-cow herd No. 2				Beef-cow herd No. 1, beef-cow herd No. 2			
1.0	126.47	884.7	29.7	23.5	162.12	2,026.4	45.0	27.7	110.26	997.7	31.5	28.6
0.9	126.74	638.6	25.2	19.9	158.83	1,597.5	39.9	25.1	112.16	975.6	31.2	27.8
0.8	127.03	460.1	21.4	16.8	155.54	1,251.5	35.3	22.7	114.05	968.9	31.1	27.2
0.7	127.29	349.4	18.6	14.6	152.25	988.5	31.4	20.6	115.95	977.6	31.2	26.9
0.6	127.57	306.3	17.5	13.7	148.96	808.5	28.4	19.0	117.84	1,001.7	31.6	26.8
0.5	127.84	331.0	18.1	14.2	145.67	711.3	26.6	18.3	119.74	1,041.2	32.2	26.9
0.4	128.11	423.4	20.5	16.0	142.38	697.2	26.4	18.5	121.63	1,096.1	33.1	27.2
0.3	128.39	583.5	24.1	18.8	139.09	765.9	27.6	19.8	123.53	1,166.4	34.1	27.6
0.2	128.66	811.3	28.4	22.1	135.79	917.7	30.2	22.3	125.42	1,252.2	35.3	28.2
0.1	128.94	1,106.7	33.2	25.8	132.50	1,152.3	33.9	25.6	127.32	1,353.4	36.7	28.8
0.0	129.21	1,469.9	38.3	29.6	129.21	1,469.9	38.3	29.6	129.21	1,469.9	38.3	29.6
	Hogs, good-choice calves				Dairy, good-choice calves				Laying flock, good-choice calves			
1.0	156.83	2,405.2	49.0	31.2	151.06	1,240.4	35.2	23.3	126.47	884.7	29.7	23.5
0.9	154.50	2,181.2	46.7	30.2	149.30	1,180.5	34.3	23.0	127.18	630.0	25.1	19.7
0.8	152.17	1,990.6	44.6	29.3	147.55	1,143.6	33.8	22.9	127.88	449.3	21.1	16.5
0.7	149.85	1,833.5	42.8	28.5	145.80	1,129.4	33.6	23.0	128.59	342.7	18.5	14.3
0.6	147.52	1,709.8	41.3	28.0	144.05	1,138.1	33.7	23.4	129.30	310.1	17.6	13.6
0.5	145.19	1,619.5	40.2	27.7	142.30	1,169.7	34.2	24.0	130.01	351.6	18.7	14.4
0.4	142.86	1,562.7	39.5	27.6	140.55	1,224.1	34.9	24.8	130.72	467.2	21.6	16.5
0.3	140.53	1,539.4	39.2	27.9	138.80	1,301.3	36.0	25.9	131.43	656.8	25.6	19.4
0.2	138.21	1,549.5	39.3	28.4	137.05	1,401.4	37.4	27.3	132.13	920.5	30.3	22.9
0.1	135.88	1,593.1	39.9	29.3	135.30	1,524.3	39.0	28.8	132.84	1,258.2	35.4	26.7
0.0	133.55	1,670.0	40.8	30.5	133.55	1,670.0	40.8	30.5	133.55	1,670.0	40.8	30.5
	Turkeys, good-choice calves				Beef-cow herd No. 1, good-choice calves				Beef-cow herd No. 2, good-choice calves			
1.0	162.12	2,026.4	45.0	27.7	110.26	997.7	31.5	28.6	129.21	1,469.9	38.3	29.6
0.9	159.27	1,580.2	39.7	24.9	112.59	945.2	30.7	27.3	129.65	1,405.7	37.4	28.9
0.8	156.41	1,225.2	35.0	22.3	114.92	919.2	30.3	26.3	130.08	1,360.2	36.8	28.3
0.7	153.55	961.4	31.0	20.1	117.25	919.9	30.3	25.8	130.51	1,333.4	36.5	27.9
0.6	150.69	788.9	28.0	18.6	119.58	947.2	30.7	25.7	130.95	1,325.4	36.4	27.8
0.5	147.84	707.7	26.6	17.9	121.91	1,001.2	31.6	25.9	131.38	1,336.0	36.5	27.8
0.4	144.98	717.6	26.7	18.4	124.24	1,081.7	32.8	26.4	131.82	1,365.4	36.9	28.0

TABLE 12. LEVEL OF RETURNS PER $100 FEED OUTLAY, VARIANCE, STANDARD DEVIATION AND COEFFICIENT OF VARIATION FOR 10 TYPES OF LIVESTOCK AND POULTRY ENTERPRISES IN IOWA FOR THE PERIOD FROM 1917 TO 1948.*—Continued.

Value of q	Income	Variance	Std. dev.†	C/V‡	Income	Variance	Std. dev.†	C/V‡	Income	Variance	Std. dev.†	C/V‡
	Turkeys, good-choice calves				Beef-cow herd No. 1, good-choice calves				Beef-cow herd No. 2, good-choice calves			
0.3	142.12	818.9	28.6	20.1	126.56	1,188.9	34.4	27.2	132.25	1,413.5	37.5	28.4
0.2	139.27	1,011.4	31.8	22.8	128.89	1,322.6	36.3	28.2	132.68	1,480.3	38.4	28.9
0.1	136.41	1,295.1	35.9	26.3	131.22	1,483.0	38.5	29.3	133.12	1,565.8	39.5	29.7
0.0	133.55	1,670.0	40.8	30.5	133.55	1,670.0	40.8	30.5	133.55	1,670.0	40.8	30.5
	Hogs, 2-year-olds				Dairy, 2-year-olds				Laying flock, 2-year-olds			
1.0	156.83	2,405.2	49.0	31.2	151.06	1,240.4	35.2	23.3	126.47	884.7	29.7	23.5
0.9	154.71	2,029.5	45.0	29.1	149.52	1,154.3	33.9	22.7	127.39	646.2	25.5	19.9
0.8	152.59	1,744.4	41.7	27.3	147.98	1,120.5	33.4	22.6	128.31	501.6	22.3	17.4
0.7	150.48	1,550.0	39.3	26.1	146.44	1,138.9	33.7	23.0	129.23	451.1	21.2	16.4
0.6	148.36	1,446.4	38.0	25.6	144.90	1,209.5	34.7	24.0	130.15	494.6	22.2	17.0
0.5	146.25	1,433.5	37.8	25.8	143.36	1,332.3	36.5	25.4	131.06	632.0	25.1	19.1
0.4	144.13	1,511.2	38.8	26.9	141.82	1,507.3	38.8	27.3	131.98	863.5	29.3	22.2
0.3	142.01	1,679.7	40.9	28.8	140.28	1,734.5	41.6	29.6	132.90	1,189.0	34.4	25.9
0.2	139.90	1,938.9	44.0	31.4	138.74	2,013.9	44.8	32.3	133.82	1,608.4	40.1	29.9
0.1	137.78	2,288.8	47.8	34.7	137.20	2,345.5	48.4	35.2	134.74	2,121.9	46.0	34.1
0.0	135.66	2,729.4	52.2	38.5	135.66	2,729.4	52.2	38.5	135.66	2,729.4	52.2	38.5
	Turkeys, 2-year-olds				Beef-cow herd No. 1, 2-year-olds				Beef-cow herd No. 2, 2-year-olds			
1.0	162.12	2,026.4	45.0	27.7	110.26	997.7	31.5	28.6	129.21	1,469.9	38.3	29.6
0.9	159.48	1,586.2	39.8	24.9	112.80	987.9	31.4	27.8	129.86	1,378.5	37.1	28.5
0.8	156.83	1,259.4	35.4	22.6	115.34	1,018.7	31.9	27.6	130.50	1,335.4	36.5	28.0
0.7	154.18	1,046.1	32.3	20.9	117.88	1,090.2	33.0	28.0	131.15	1,340.3	36.6	27.9
0.6	151.54	946.2	30.7	20.2	120.42	1,202.4	33.6	27.9	131.79	1,394.1	37.3	28.3
0.5	148.89	959.8	30.9	20.8	122.96	1,355.2	36.8	29.9	132.44	1,495.9	38.6	29.2
0.4	146.25	1,086.8	32.9	22.5	125.50	1,548.7	39.3	31.3	133.08	1,646.0	40.5	30.4
0.3	143.60	1,327.3	36.4	23.3	128.04	1,782.9	42.2	32.9	133.73	1,844.1	42.9	32.1
0.2	140.95	1,681.2	41.0	29.0	130.58	2,057.7	45.3	34.7	134.37	2,091.1	45.7	34.0
0.1	138.31	2,148.6	46.3	33.5	133.12	2,373.2	48.7	36.5	135.02	2,386.1	48.8	36.1
0.0	135.66	2,729.4	52.2	38.5	135.66	2,729.4	52.2	38.5	135.66	2,729.4	52.2	38.5
	Good-choice calves, 2-year-olds				Hogs, yearlings				Dairy, yearlings			
1.0	133.55	1,670.0	40.8	30.5	156.83	2,405.2	49.0	31.2	151.06	1,240.4	35.2	23.3
0.9	133.76	1,517.0	38.9	29.1	153.91	2,198.5	46.8	30.4	148.72	1,198.7	34.6	23.2
0.8	133.97	1,421.5	37.7	26.1	151.00	2,036.4	45.1	29.8	146.38	1,190.8	34.5	23.5
0.7	134.18	1,383.5	37.1	27.7	148.09	1,919.0	43.8	29.5	144.04	1,216.8	34.8	24.2
0.6	134.40	1,403.1	37.4	27.8	145.17	1,846.1	42.9	29.5	141.71	1,276.6	35.7	25.2
0.5	134.61	1,480.3	38.4	28.5	142.26	1,817.8	42.6	29.9	139.37	1,370.2	37.0	26.5
0.4	134.82	1,615.0	40.1	29.8	139.34	1,834.2	42.8	30.7	137.03	1,497.6	38.7	28.2
0.3	135.03	1,807.3	42.5	31.4	136.43	1,895.1	43.5	31.9	134.70	1,658.9	40.7	30.2
0.2	135.24	2,057.1	45.3	33.5	133.51	2,000.7	44.7	33.5	132.36	1,854.0	43.0	32.5
0.1	135.45	2,364.5	48.6	35.8	130.60	2,150.9	46.3	35.5	130.02	2,082.9	45.6	35.1
0.0	135.66	2,729.4	52.2	38.5	127.69	2,345.7	48.4	37.9	127.69	2,345.7	48.4	37.9
	Laying flock, yearlings				Turkeys, yearlings				Beef-cow herd No. 1, yearlings			
1.0	126.47	884.7	29.7	23.5	162.12	2,026.4	45.0	27.7	110.26	997.7	31.5	28.6
0.9	126.59	618.1	24.8	19.6	158.68	1,601.9	40.0	25.2	112.00	962.0	31.0	27.6
0.8	126.71	443.1	21.0	16.6	155.24	1,278.9	35.7	23.0	113.75	964.1	31.0	27.2
0.7	126.83	359.9	18.9	14.9	151.79	1,057.2	32.5	21.4	115.49	1,004.2	31.6	27.4
0.6	126.95	368.4	19.1	15.1	148.35	937.0	30.6	20.6	117.23	1,082.1	32.8	28.0
0.5	127.08	468.6	21.6	17.0	144.90	918.2	30.3	20.9	118.97	1,198.0	34.6	29.0
0.4	127.20	660.6	25.7	20.2	141.46	1,000.9	31.6	22.3	120.72	1,551.7	36.7	30.4
0.3	127.32	944.3	30.7	24.1	138.02	1,184.9	34.4	24.9	122.46	1,543.4	39.2	32.0
0.2	127.44	1,319.7	36.3	28.5	134.57	1,470.4	38.3	28.4	124.20	1,772.9	42.1	33.9
0.1	127.56	1,786.8	42.2	33.1	131.13	1,857.3	43.0	32.8	125.94	2,040.3	45.1	35.8
0.0	127.69	2,345.7	48.4	37.9	127.69	2,345.7	48.4	37.9	127.69	2,345.7	48.4	37.9
	Beef-cow herd No. 2, yearlings				Good-choice calves, yearlings				Fed 2-year-olds, yearlings			
1.0	129.21	1,469.9	38.3	29.6	133.55	1,670.0	40.8	30.5	135.66	2,729.4	52.2	38.5
0.9	129.06	1,424.4	37.7	29.2	132.97	1,683.8	41.0	30.8	134.86	2,355.1	48.5	35.9
0.8	128.91	1,408.4	37.5	29.1	132.38	1,709.5	41.3	31.2	134.07	2,055.4	45.3	33.8
0.7	128.75	1,422.0	37.7	29.2	131.79	1,747.2	41.8	31.7	133.27	1,830.3	42.7	32.1
0.6	128.60	1,465.1	38.2	29.7	131.21	1,796.8	42.3	32.3	132.47	1,680.0	40.9	30.9
0.5	128.45	1,537.9	39.2	30.5	130.62	1,858.4	43.1	33.0	131.67	1,604.3	40.0	30.4
0.4	128.30	1,640.3	40.5	31.5	130.03	1,932.0	43.9	33.8	130.88	1,603.2	40.0	30.5
0.3	128.14	1,772.2	42.0	32.8	129.45	2,017.5	44.9	34.6	130.08	1,676.8	40.9	31.4
0.2	127.99	1,933.8	43.9	34.3	128.86	2,114.9	45.9	35.6	129.28	1,825.1	42.7	33.0
0.1	127.84	2,124.9	46.0	36.0	128.27	2,224.3	47.1	36.7	128.48	2,048.1	45.2	35.2
0.0	127.69	2,345.7	48.4	37.9	127.69	2,345.7	48.4	37.9	127.69	2,345.7	48.4	37.0
	Hogs, broilers				Dairy, broilers				Laying flock, broilers			
1.0	156.83	2,405.2	49.0	31.2	151.06	1,240.4	35.2	23.3	126.47	884.7	29.7	23.5
0.9	157.10	1,874.8	43.2	27.5	151.91	972.3	31.1	20.5	129.78	824.2	28.7	22.1
0.8	157.37	1,425.8	37.7	23.9	152.75	753.2	27.4	17.9	133.08	774.4	27.8	20.9
0.7	157.65	1,058.2	32.5	20.6	153.60	583.2	24.1	15.7	136.39	735.5	27.1	19.8
0.6	157.92	772.1	27.7	17.5	154.45	462.2	21.4	13.9	139.70	707.4	26.5	19.0
0.5	158.19	567.5	23.8	15.0	155.30	390.2	19.7	12.7	143.01	690.1	26.2	18.3
0.4	158.46	444.3	21.0	13.3	156.15	367.2	19.1	12.2	146.32	683.6	26.1	17.8
0.3	158.74	402.5	20.0	12.6	157.00	393.3	19.8	12.6	149.63	687.9	26.2	17.5
0.2	159.01	442.2	21.0	13.2	157.85	468.5	21.6	13.7	152.94	705.1	26.5	17.3
0.1	159.28	563.3	23.7	14.9	158.70	592.6	24.3	15.3	156.24	729.1	27.0	17.2
0.0	159.55	765.9	27.6	17.3	159.55	765.9	27.6	17.3	159.55	765.9	27.6	17.3

TABLE 12. LEVEL OF RETURNS PER $100 FEED OUTLAY, VARIANCE, STANDARD DEVIATION AND COEFFICIENT OF VARIATION FOR 10 TYPES OF LIVESTOCK AND POULTRY ENTERPRISES IN IOWA FOR THE PERIOD FROM 1917 TO 1948.*—Continued.

Value of q	Income	Variance	Std. dev.†	C/V‡	Income	Variance	Std. dev.†	C/V‡	Income	Variance	Std. dev.†	C/V‡
	Turkeys, broilers				Beef-cow herd No. 1, broilers				Beef-cow herd No. 2, broilers			
1.0	162.12	2,026.4	45.0	27.7	110.26	997.7	31.5	28.6	129.21	1,469.9	38.3	29.6
0.9	161.87	1,819.9	42.6	26.3	115.19	803.6	28.3	24.6	132.25	1,136.4	33.7	25.4
0.8	161.61	1,631.2	40.3	24.9	120.12	647.5	25.4	21.1	135.28	861.4	29.3	21.6
0.7	161.35	1,460.4	38.2	23.6	125.05	529.4	23.0	18.4	138.31	644.8	25.3	18.3
0.6	161.09	1,307.5	36.1	22.4	129.98	449.3	21.1	16.3	141.35	486.7	22.0	15.6
0.5	160.84	1,172.5	34.2	21.2	134.91	407.1	20.1	14.9	144.38	387.0	19.6	13.6
0.4	160.58	1,055.4	32.4	20.2	139.84	402.9	20.0	14.3	147.42	345.8	18.5	12.6
0.3	160.32	956.2	30.9	19.2	144.77	436.7	20.8	14.4	150.45	363.1	19.0	12.6
0.2	160.07	874.9	29.5	18.4	149.69	508.4	22.5	15.0	153.48	438.9	20.9	13.6
0.1	159.81	811.4	28.4	17.8	154.62	618.1	24.8	16.0	156.52	573.1	23.9	15.2
0.0	159.55	765.9	27.6	17.3	159.55	765.9	27.6	17.3	159.55	765.9	27.6	17.3
	Good-choice calves, broilers				2-year-olds, broilers				Yearlings, broilers			
1.0	133.55	1,670.0	40.8	30.5	135.66	2,729.4	52.2	38.5	127.69	2,345.7	48.4	37.9
0.9	136.15	1,298.0	36.0	26.4	138.05	2,211.2	47.0	34.0	130.87	1,830.4	42.7	32.6
0.8	138.75	988.5	31.4	22.6	140.44	1,764.6	42.0	29.9	134.06	1,394.4	37.3	27.8
0.7	141.35	741.6	27.2	19.2	142.83	1,389.4	37.2	26.0	137.25	1,037.9	32.2	23.4
0.6	143.95	557.3	23.6	16.3	145.22	1,085.8	32.9	22.6	140.43	760.9	27.5	19.6
0.5	146.55	435.6	20.8	14.2	147.61	853.7	29.2	19.7	143.62	563.2	23.7	16.5
0.4	149.15	376.5	19.4	13.0	150.00	693.1	26.3	17.5	146.81	444.9	21.0	14.3
0.3	151.75	379.9	19.4	12.8	152.39	604.0	24.5	16.1	149.99	406.0	20.1	13.4
0.2	154.35	446.0	21.1	13.6	154.77	586.4	24.2	15.6	153.18	446.6	21.1	13.7
0.1	156.95	574.6	23.9	15.2	157.16	640.4	25.3	16.1	156.37	566.5	23.8	15.2
0.0	159.55	765.9	27.6	17.3	159.55	765.9	27.6	17.3	159.55	765.9	27.6	17.3

* The q value refers to the proportion of resources for the first-mentioned enterprise of the pair; 1-q refers to resources used for the second enterprise of the pair.

† Standard deviation.

‡ Coefficient of variation or standard deviation divided by income level.

ious combinations of the two enterprises. Each "end point" means specialization in the enterprise indicated by the letter; all points between the "end points" represent combinations of the two enterprises. This line shows that both returns and variability are increased as resources are shifted from dairy to fed yearlings. (Each dot on the curve represents a 10-percent shift of resource expenditure from one enterprise to the other.)

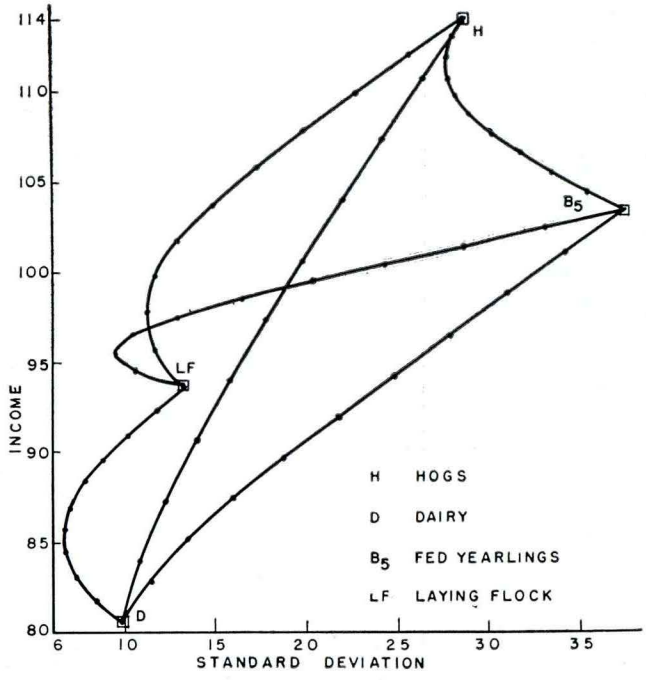

Fig. 1. Absolute variability and level of returns per $100 all costs for hogs, dairy, laying flock and yearlings.

The line leading from dairy to hogs also shows an increase in both income and variability as more hogs are added to the combination. The steeper slope of D to H indicates greater increases in income with less increase in variability than for the flatter slope of D to B_5.

When returns increase while variability decreases, it is called a "complementary" range. In going from dairy to laying flock (D to LF), variability decidedly decreases as income is increasing and demonstrates the "complementary" range. However, the point of minimum variability is soon reached. The point of minimum variability is attained at the point where the curve "bends," i.e., it is the point nearest the vertical axis. This point for the dairy, laying flock combination represents about 65 percent of the resources used for dairy and 35 percent used for the laying flock. Moving further along the line towards LF causes variability to increase. Income continues to increase until the point LF is reached, denoting use of all resources for the laying flock.

Line LF to B_5 represents the different combinations of laying flock and fed yearlings. A sharp "complementary" range (increase in income and decrease in variability) is evident. With only 20 percent of the resources used for fed yearlings, however, minimum variability is attained. The line curves back into the range of combinations where variability increases as income increases. The "flatness" of the last portion of the curve shows that variability is increasing relatively faster than income. The line for the laying flock and hogs also demonstrates a "complementary" range which soon turns back to a "competitive" range wherein choices must be made between level of income and stability of income.

In fig. 2, level of returns and *relative* income variability (the coefficient of variation) are plotted for the same enterprises as in fig. 1. Farmers are probably

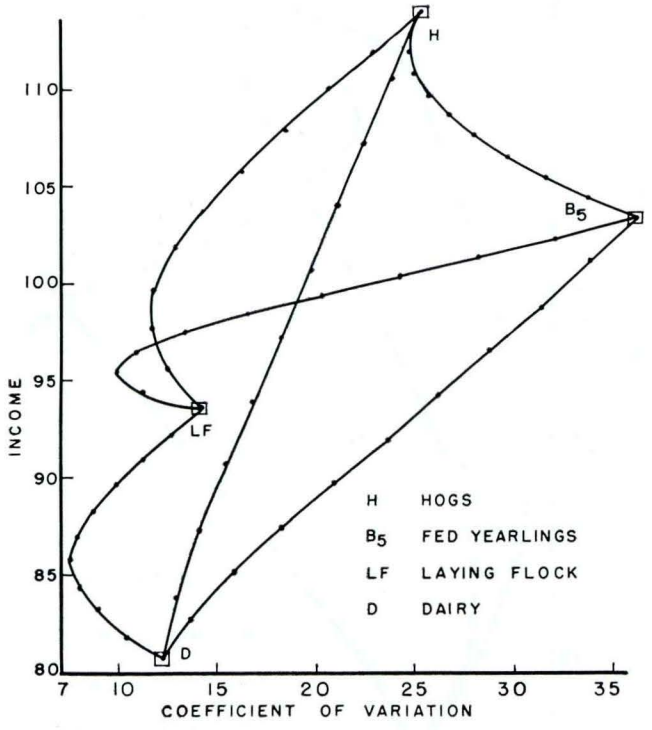

Fig. 2. Relative variability and level of returns per $100 all costs for hogs, dairy, laying flock and yearlings.

most concerned about variation in income relative to its level; consequently, the remaining graphs presented in this study deal only with relative income variability. Hogs, broilers, commercial beef-cow herd and fed 2-year-olds are compared in fig. 3. Complementary ranges exist between all these pairs although it is very slight between 2-year-old feeders and the beef-cow herd. A long complementary range occurs when resources are shifted from 2-year-olds alone to use of 90 percent of resources for broilers; the complementary range is quite long for beef-cow herd number 1 and broilers, and for 2-year-old steers and hogs.

Turkeys, hogs, dairy and beef-cow herd number 2 are compared in fig. 4. No complementary range occurs between the dairy and hog enterprises or between dairy and beef-cow herd number 2. The other enterprise pairs show pronounced complementarity of income level and relative income stability through part of the possible resource combinations. Varying degrees of complementarity are shown by all four enterprise pairs in fig. 5, except between broilers and turkeys and between dairy and fed beef calves. A sharp reduction in relative variability is shown for turkeys and calves when they are combined in about equal parts, as compared to specialization in either one alone.

LEVEL AND VARIABILITY OF INCOME PER $100 FEED COSTS

Income and relative variance of returns per $100 feed outlay are given in fig. 6 for the same enterprises presented in fig. 2. The two cases are similar in respect to choices between level and variability of income. However, the levels of income themselves are altered. For example, the dairy enterprise advanced to second place in returns per $100 feed outlay. This change is due to the fact that labor and equipment costs do not enter in feed returns. In fig. 7, complementarity of level and stability of income is shown in every instance of hogs with broilers, 2-year-olds and beef-cow herd number 2. Generally, the relationships for level and variability of feed returns are the same for the enterprise pairs as for level and variability of return per $100 of all costs.

MARGINAL VARIANCE OF INCOME PER $100 ALL COSTS

The relationship of stability and level of income in the use of resources (i.e., the slopes of the curves) can be presented in tabular form. Data in table 13 show the rate of change in income variability, as measured by variance, which accompanies each unit change in q (or proportion of resources allocated to the first of the pair.) This change is called the marginal variance. These rates of change correspond to the slopes of the curves in the preceding illustrations. Computation of table 13 follows equation 2 of a preceding section. Each successive unit increase in q for the hogs, dairy combination results in a larger addition to variance. Starting from a q of 0.1 (10 percent of the resources devoted to hogs), a unit change in q results in a marginal variance of 270.4; with a q of 0.2, marginal variance is increased to 386.4. In other words, variability increases at an almost constant rate for each successive unit change in use of resources for hogs and dairy.

The sign of the marginal variance is negative when a shift in use of resources increases income and decreases variability. (This corresponds to the "complementary" range in the preceding graphs.) Negative marginal var-

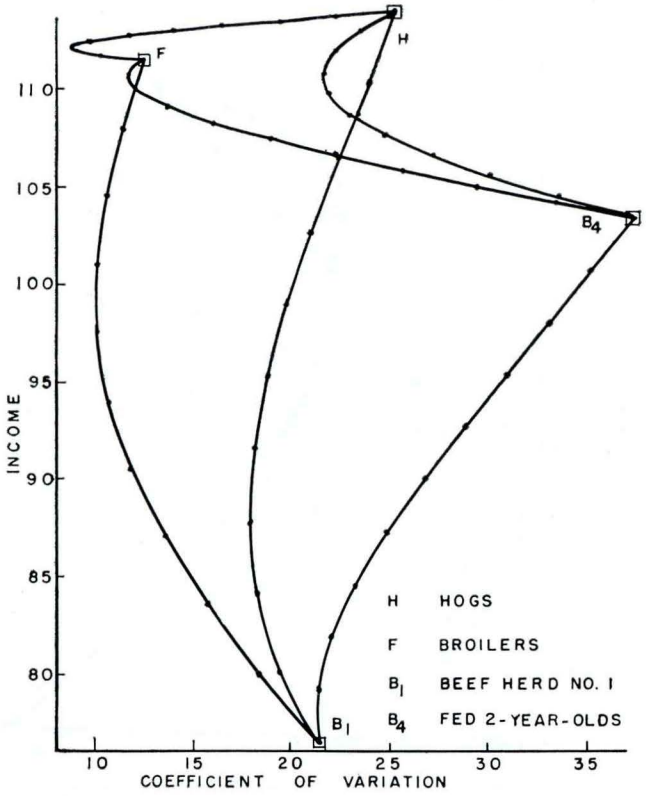

Fig. 3. Relative variability and level of returns per $100 all costs for hogs, commercial beef-cow herd, broilers and 2-year-old steers.

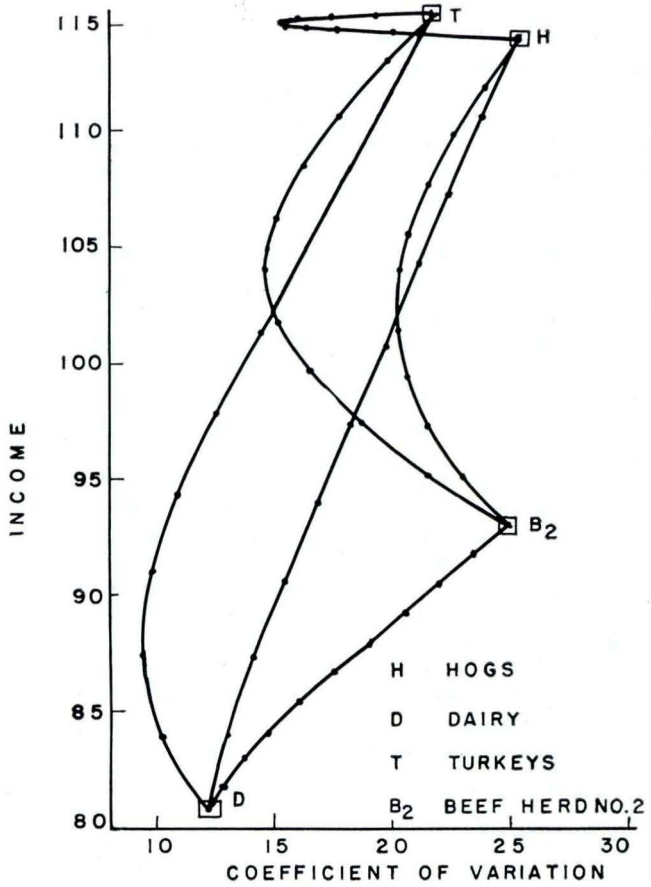

Fig. 4. Relative variability and level of returns per $100 all costs for hogs, dairy, turkeys and beef-cow herd No. 2.

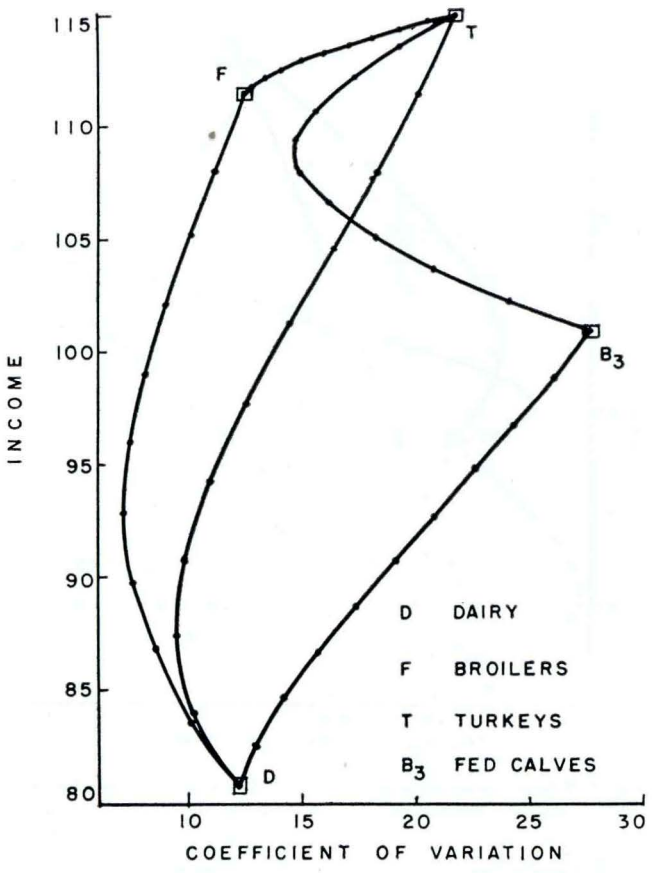

Fig. 5. Relative variability and level of returns per $100 all costs for turkeys, broilers, dairy and fed calves.

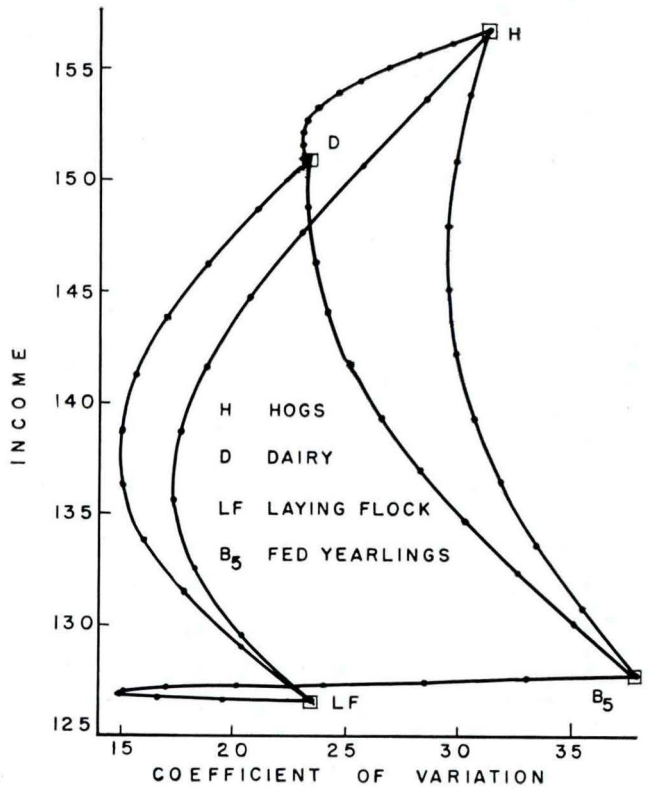

Fig. 6. Relative variability and level of returns per $100 feed outlay for hogs, dairy, laying flock and fed yearlings.

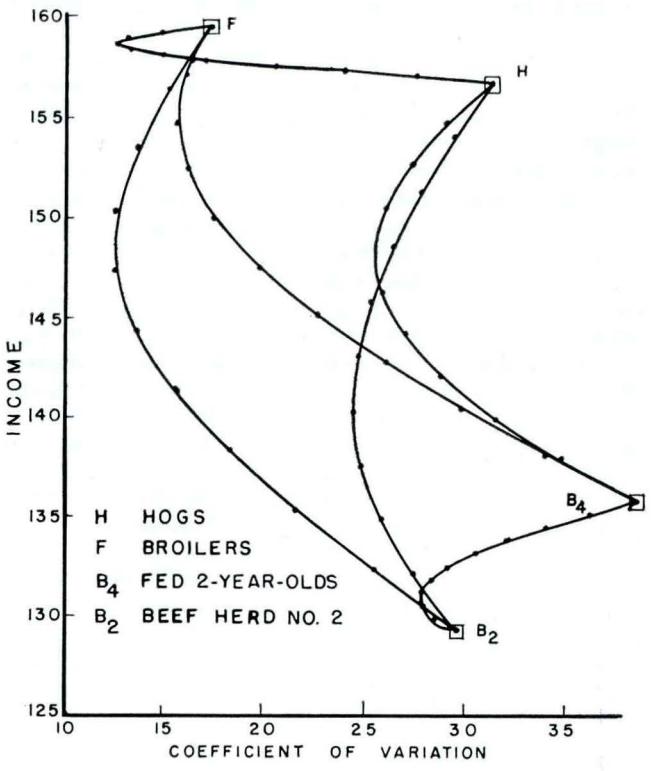

Fig. 7. Relative variability and level of returns per $100 feed outlay for hogs, broilers, 2-year-olds and beef-cow herd No. 2.

TABLE 13. RATE OF CHANGE OR MARGINAL VARIANCE QUANTITIES OF RETURNS PER $100 ALL COSTS FOR SPECIFIED LIVESTOCK ENTERPRISE PAIRS.*

Value of q	Hogs, dairy	Hogs, lay. f.	Dairy, lay. f.	Hogs, turks.	Dairy, turks.	Lay. f., turks.	Hogs, beef No. 1	Dairy, beef No. 1	Lay. f., beef No. 1	Turks., beef No. 1
0.9	1,198.4	1,550.0	203.3	1,536.8	141.8	-193.6	1,291.2	-48.9	378.9	1,145.3
0.8	1,082.4	1,326.0	132.4	1,203.3	-26.5	-257.9	1,108.4	-80.2	260.7	948.1
0.7	966.4	1,102.0	61.5	870.0	-194.7	-322.2	925.7	-111.5	142.6	751.1
0.6	850.3	878.0	-9.4	536.3	-362.9	-386.6	742.9	-142.8	24.3	564.0
0.5	734.3	654.0	-80.3	203.2	-531.1	-450.8	560.2	-174.1	93.8	357.0
0.4	618.3	430.1	-151.1	-130.1	-699.3	-515.1	377.4	-205.5	-212.1	159.9
0.3	502.4	206.2	-222.1	-463.5	-867.6	-579.5	194.8	-236.8	-330.3	-37.1
0.2	386.4	-17.8	-293.0	-796.8	-1,035.8	-643.8	12.1	-268.1	-448.4	-234.1
0.1	270.4	-241.8	-363.9	-1,130.3	-1,204.1	-708.1	-170.7	-299.4	-566.6	-431.3

Value of q	Hogs, beef No. 2	Dairy, beef No. 2	Lay. f., beef No. 2	Turks., beef No. 2	Beef No. 1, beef No. 2	Hogs, gd. calves	Dairy, calves	Lay. f., calves	Turks., calves	Beef No. 1, calves
0.9	1,072.0	-168.1	462.2	1,201.4	-29.1	696.7	-232.7	464.9	1,263.7	-11.7
0.8	877.1	-236.6	256.3	923.3	-88.9	534.4	-346.2	197.2	908.9	-136.9
0.7	682.0	-305.1	50.1	645.2	-148.6	372.1	-459.7	-70.7	554.0	-262.2
0.6	487.0	-373.7	-156.0	366.9	-208.4	209.9	-573.2	-338.6	199.2	-387.3
0.5	292.0	-442.3	-362.0	88.8	-268.2	47.6	-686.7	-606.4	-155.6	-512.6
0.4	97.1	-510.8	-568.0	-189.2	-327.8	-114.7	-800.2	-874.3	-510.4	-637.8
0.3	-97.8	-579.5	-774.1	-467.5	-387.7	-276.8	-913.8	-1,142.2	-865.2	-763.0
0.2	-292.9	-648.0	-980.3	-745.6	-447.4	-439.1	-1,027.3	-1,410.1	-1,220.1	-888.3
0.1	-487.9	-716.6	-1,186.3	-1,023.8	-507.3	-601.5	-1,140.9	-1,677.9	-1,575.0	-1,013.6

Value of q	Beef No. 2, calves	Hogs, 2-yr.-olds	Dairy, 2-yr.-olds	Lay. f., 2-yr.-olds	Turks., 2-yr.-olds	Beef No. 1, 2-yr.-olds	Beef No. 2, 2-yr.-olds	Calves, 2-yr.-olds,
0.9	85.2	1,060.8	-319.1	309.5	1,165.4	-265.5	-15.0	549.4
0.8	2.8	628.7	-589.6	-98.1	656.4	-506.0	-251.1	233.4
0.7	-79.6	196.8	-860.2	-505.8	147.5	-746.4	-487.1	-82.7
0.6	-162.0	-235.1	-1,130.8	-913.5	-361.4	-986.8	-723.2	-398.6
0.5	-244.4	-667.1	-1,401.4	-1,321.1	-870.3	-1,227.3	-959.1	-714.7
0.4	-326.9	-1,099.1	-1,672.0	-1,728.8	-1,379.2	-1,467.7	-1,195.1	-1,030.8
0.3	-409.3	-1,530.9	-1,942.7	-2,136.5	-1,888.1	-1,708.2	-1,431.2	-1,346.7
0.2	-491.7	-1,962.9	-2,213.3	-2,544.2	-2,397.0	-1,948.6	-1,667.2	-1,662.8
0.1	-574.1	-2,394.9	-2,483.8	-2,951.8	-2,906.0	-2,189.1	-1,903.2	-1,978.7

Value of q	Hogs, yearlings	Dairy, yearlings	Lay. f., yearlings	Turks., yearlings	Beef No. 1, yearlings	Beef No. 2, yearlings	Calves, yearlings	2-yr.-olds, yearlings
0.9	386.9	-420.6	432.1	1,046.9	-224.8	-176.1	-333.2	1,883.1
0.8	70.5	-643.7	15.9	589.7	-453.4	-349.7	-406.5	1,434.4
0.7	-145.9	-866.8	-400.3	132.6	-681.8	-523.4	-479.8	985.8
0.6	-362.2	-1,089.8	-816.5	-324.7	-910.3	-697.0	-552.9	537.1
0.5	-578.6	-1,312.9	-1,232.6	-781.8	-1,138.8	-870.6	-626.2	88.5
0.4	-795.0	-1,536.0	-1,648.8	-1,238.9	-1,367.2	-1,044.3	-699.5	-360.1
0.3	-1,011.2	-1,759.1	-2,065.0	-1,696.2	-1,595.8	-1,217.9	-772.6	-808.8
0.2	-1,227.5	-1,982.1	-2,481.1	-2,153.2	-1,824.1	-1,391.5	-845.8	-1,257.3
0.1	-1,443.9	-2,205.2	-2,897.3	-2,610.4	-2,052.7	-1,565.0	-919.0	-1,706.0

Value of q	Hogs, broilers	Dairy, broilers	Lay. f., broilers	Turks., broilers	Beef No. 1, broilers
0.9	1,719.2	201.9	100.7	700.8	494.2
0.8	1,449.4	127.8	72.0	634.7	390.5
0.7	1,179.4	53.6	43.1	568.6	286.8
0.6	909.4	-20.6	14.3	502.4	183.1
0.5	639.6	-94.7	-14.4	436.4	79.4
0.4	369.7	-168.9	-43.3	370.3	-24.3
0.3	99.8	-243.2	-72.1	304.1	-128.1
0.2	-170.0	-317.3	-100.9	238.1	-231.7
0.1	-440.0	-391.5	-129.7	171.9	-335.5

Value of q	Beef No. 2, broilers	Calves, broilers	2-yr.-olds, broilers	Yearlings, broilers
0.9	1,123.6	1,591.3	2,675.6	2,764.4
0.8	929.6	1,341.5	2,333.4	2,377.9
0.7	735.5	1,091.6	1,991.1	1,991.4
0.6	541.5	841.8	1,648.9	1,604.7
0.5	347.6	592.0	1,306.7	1,218.2
0.4	153.5	342.1	964.9	831.6
0.3	-40.5	-92.3	622.2	444.9
0.2	-234.5	-157.5	280.0	58.4
0.1	-428.5	-407.3	-62.3	-328.2

*The value of q refers to the proportion of resources devoted to the first-mentioned enterprise of each pair.

iances occur for most livestock pairs over some range of q values. Usually, however, a point is reached where further increases in q result in an increase in variance, and the marginal variance becomes positive.

MARGINAL VARIANCE OF INCOME PER $100 FEED COSTS

Data in table 14 indicate the rate of change in the variability of returns per $100 feed outlay which accompanies each unit change in q. These figures again follow those for returns per $100 all cost except that income levels are altered, and complementarity of income and stability is often greater. For example, in the hogs, dairy combination, a q value of 0.1 has a negative marginal variance for returns from feed; it was positive for returns per $100 all cost.

VALUE OF q FOR MINIMUM VARIANCE

It is possible to specify the exact proportion of resource for each enterprise in order to obtain minimum variability of income. These values of q are computed from the preceding equation 3 and are given in table 15 for returns per $100 of all costs. For the hogs, dairy combination, all resources must be devoted to dairy to minimize income variability. (This is shown by a q value of 0.0.) For hogs and laying flock, a q value of about 0.21 minimizes variance. Hogs always receive less than one-half of the resources except when combined with fed 2-year-olds and yearlings. This is because the other enterprises have lower variances (except for 2-year-olds and yearlings).

Values of q which minimize variance correspond to the vertical or "turning point" of the curves presented in figs. 1-7. At the point where the curve "turns," the rate of change is zero and denotes a marginal variance of zero. In cases where competition alone exists between

two enterprises, variability is at a minimum at one end of the curve where all resources are devoted to the least variable enterprise.

Minimum variance values of q for income per $100 feed costs are presented in table 16. These are quite similar to the figures in table 15 for income per $100 of all costs. However, a few exceptions exist. A q value of 0.13 minimizes feed return variability for hogs, dairy, as compared to a q value of 0.0 for returns per $100 all cost. The beef enterprises also can be combined with dairy to reduce variability of returns per $100 of feed costs. In the case of pairs of poultry enterprises, turkeys

TABLE 14. RATE OF CHANGE OR MARGINAL VARIANCE QUANTITIES OF RETURNS PER $100 FEED OUTLAY FOR SPECIFIED LIVESTOCK ENTERPRISE PAIRS.*

Value of q	Hogs, dairy	Hogs, lay f.	Dairy, lay f.	Hogs, turks.	Dairy, turks.	Lay f., turks.	Hogs, beef No. 1	Dairy, beef No. 1	Lay f., beef No. 1	Turks., beef No. 1
0.9	2,431.2	4,537.9	2,392.6	4,349.9	2,164.9	-495.9	3,524.5	623.1	1,745.9	3,611.6
0.8	2,114.5	3,783.5	1,883.4	3,357.1	1,427.2	-657.3	2,995.2	582.0	1,281.3	2,965.9
0.7	1,794.0	3,029.2	1,374.1	2,364.3	689.4	-818.8	2,466.0	432.9	816.4	2,320.1
0.6	1,481.4	2,274.8	864.9	1,371.5	-48.3	-980.3	1,936.7	337.8	351.7	1,674.5
0.5	1,164.9	1,520.5	355.6	378.8	-786.1	-1,141.7	1,407.5	242.6	-113.0	1,028.7
0.4	848.3	766.2	-153.6	-614.0	-1,523.9	-1,303.2	878.3	147.5	-577.7	383.0
0.3	531.7	11.8	-662.8	-1,606.6	-2,261.4	-1,464.5	349.0	52.4	-1,042.4	-262.8
0.2	215.1	-742.6	-1,172.1	-2,599.5	-2,999.2	-1,626.0	-180.2	-42.6	-1,507.2	-908.5
0.1	-101.5	-1,496.9	-1,681.3	-3,592.2	-3,736.9	-1,787.4	-709.5	-137.8	-1,971.9	-1,473.3

Value of q	Hogs, beef No. 2	Dairy, beef No. 2	Lay f., beef No. 2	Turks., beef No. 2	Beef No. 1, beef No. 2	Hogs, calves	Dairy, calves	Lay f., calves	Turks., calves	Beef No. 1, calves
0.9	3,148.4	373.6	2,123.0	3,874.3	144.3	2,073.1	484.2	2,177.2	4,006.2	392.5
0.8	2,595.1	222.8	1,446.0	3,048.8	-9.9	1,738.6	255.7	1,436.6	3,093.7	126.3
0.7	2,041.8	72.0	768.9	2,215.4	-163.9	1,404.1	27.2	695.9	2,181.2	-140.0
0.6	1,488.5	-78.8	91.8	1,386.0	-318.1	1,069.6	-201.3	-44.8	1,268.8	-406.2
0.5	935.3	-229.6	-585.2	556.5	-472.2	735.2	-429.7	-785.3	356.4	-672.3
0.4	382.0	-380.4	-1,262.3	-273.0	-626.4	400.7	-658.1	-1,525.9	-556.0	-938.5
0.3	-171.2	-531.1	-1,939.3	-1,102.5	-780.5	66.3	-886.5	-2,266.5	-1,468.5	-1,204.6
0.2	-724.6	-681.9	-2,616.4	-1,931.9	-934.6	-268.3	-1,115.0	-3,007.2	-2,381.0	-1,471.0
0.1	-1,277.8	-832.7	-3,293.4	-2,761.4	-1,088.7	-602.7	-1,343.5	-3,747.8	-3,293.5	-1,737.1

Value of q	Beef No. 2, calves	Hogs, 2-yr.-olds	Dairy, 2-yr.-olds	Lay. f., 2-yr.-olds	Turks., 2-yr.-olds	Beef No. 1, 2-yr.-olds	Beef No. 2, 2-yr.-olds	Calves, 2-yr.-olds
0.9	548.6	3,304.2	599.5	1,915.5	3,834.9	-105.0	672.6	1,242.9
0.8	361.5	2,397.0	77.3	975.5	1,600.6	-511.7	189.6	667.4
0.7	174.2	1,490.0	-444.8	35.4	1,565.9	-918.4	-293.5	91.7
0.6	-12.9	582.8	-423.2	-904.7	431.5	-1,325.1	-776.5	-124.8
0.5	-200.1	-324.1	-1,489.0	-1,844.6	-702.9	-1,731.6	-1,259.4	-1,059.3
0.4	-387.3	-1,231.2	-2,011.1	-2,784.7	-837.4	-2,138.3	-1,742.4	-1,634.9
0.3	-574.4	-2,138.3	-2,533.2	-3,724.7	-2,971.9	-2,544.9	-2,225.4	-2,210.4
0.2	-761.7	-3,045.4	-3,055.3	-4,664.8	-4,106.4	-2,951.7	-2,708.5	-2,786.1
0.1	-948.8	-3,952.5	-3,577.5	-5,604.8	-5,240.9	-3,358.3	-3,191.5	-3,361.6

Value of q	Hogs, yearlings	Dairy, yearlings	Lay. f., yearlings	Turks. yearlings	Beef No. 1, yearlings	Beef No. 2, yearlings	Calves, yearlings	2-yr.-olds, yearlings
0.9	1,843.9	247.8	2,208.1	3,737.7	168.0	307.9	-197.4	3,370.2
0.8	1,397.7	-90.5	1,290.8	2,723.4	-211.1	12.0	-317.0	2,623.5
0.7	951.8	-428.8	373.6	1,709.2	-589.9	-283.9	-436.5	1,877.0
0.6	505.6	-767.1	-543.8	695.0	-969.0	-354.6	-556.1	1,130.3
0.5	59.6	-1,105.3	-1,460.9	-319.2	-1,347.9	-875.7	-675.1	383.7
0.4	-386.6	-1,443.6	-3,462.8	-1,333.5	-1,727.0	-1,171.7	-795.2	-362.9
0.3	-832.6	-1,781.7	-3,837.7	-2,347.7	-2,105.9	-1,467.5	-914.7	-1,109.5
0.2	-1,278.6	-2,120.0	-4,212.6	-3,361.9	-2,484.8	-1,763.4	-1,034.2	-1,856.0
0.1	-1,724.7	-2,458.3	-4,587.6	-4,376.2	-2,863.8	-2,059.3	-1,153.8	-2,602.7

Value of q	Hogs, broilers	Dairy, broilers	Lay. f., broilers	Turks., broilers	Beef No. 1, broilers
0.9	4,897.2	1,795.7	551.6	1,976.0	1,750.9
0.8	5,082.7	1,376.5	443.4	1,797.1	1,398.1
0.7	3,268.3	957.4	335.3	1,618.3	991.4
0.6	2,453.8	538.1	227.0	1,439.5	611.6
0.5	1,639.4	118.9	118.9	1,260.6	231.9
0.4	824.9	-656.7	10.7	1,081.7	-147.9
0.3	10.5	-897.7	-97.5	902.8	-527.6
0.2	-804.0	-1,138.7	-205.6	724.0	-707.4
0.1	-1,618.4	-1,379.8	-313.8	545.1	-1,287.1

Value of q	Beef No. 2, broilers	Calves, broilers	2-yr.-olds, broilers	Yearlings, broilers
0.9	3,042.9	3,407.8	4,824.2	4,756.1
0.8	2,458.2	2,781.9	4,109.0	3,961.9
0.7	1,873.5	2,156.0	3,393.9	3,168.0
0.6	1,288.8	1,530.1	2,678.7	2,373.0
0.5	704.1	904.2	1,963.5	1,579.8
0.4	119.4	278.3	1,248.4	785.8
0.3	-465.3	-347.6	533.2	-8.4
0.2	-1,050.0	-973.5	-181.9	-802.3
0.1	-1,634.7	-1,599.4	-897.1	-1,596.5

*The value of q refers to the proportion of resources devoted to the first-mentioned enterprise of each pair.

TABLE 15. VALUES OF q OR COMBINATIONS OF LIVESTOCK ENTERPRISES WHICH MINIMIZE VARIANCE OF RETURNS PER $100 ALL COSTS. THE VALUES OF q REFER TO THE PROPORTION OF RESOURCES DEVOTED TO THE ENTERPRISES LISTED ALONG THE TOP OF THE TABLE.

Livestock enterprise	Hogs	Dairy	Laying flock	Turkeys	Beef-cow herd No. 1	Beef-cow herd No. 2	Good-choice calves	Fed 2-year-olds	Yearlings	Broilers
Hogs	—									
Dairy	0.0	—								
Laying flock	0.2080	0.6132	—							
Turkeys	0.4390	0.8157	1.0	—						
Beef-cow herd No. 1	0.1934	1.0	0.5794	0.3188	—					
Beef-cow herd No. 2	0.3502	1.0	0.6757	0.4681	0.9487	—				
Good-choice calves	0.4706	1.0	0.7264	0.5439	0.9093	0.7966	—			
Fed 2-year-olds	0.6544	1.0	0.8241	0.6710	1.0	0.9064	0.7262	—		
Yearlings	0.7674	1.0	0.7962	0.6710	0.9984	1.0	1.0	0.4803	—	
Broilers	0.2630	0.6277	0.5503	0.0	0.4235	0.3209	0.2631	0.1182	0.1849	—

again fail to reduce variance when combined with broiler or laying flock.

THREE AND FOUR ENTERPRISE COMBINATIONS

The farmer need not restrict diversification, to lower income variability, to two enterprises. He may use several. Hence, combinations extending beyond two enterprises are examined in this section.

In table 17, hogs are combined with other enterprises in three different ways for returns per $100 of all costs. First, both laying flock and dairy enterprises are added such that the resources not used by the hog enterprise are divided equally between the other two enterprises.[12] Compared to the two enterprise combinations of hogs, laying flock in table 10, relative income variability is slightly reduced at low values of q. Little effect is shown at higher q values. Therefore, adding the third enterprise, dairying, helps very little in reducing income variability.

It should be remembered, however, that this statement applies only when the two "added" enterprises are combined in fixed proportions with each receiving a proportion of resources equal to (1-q)/2. A different optimum (in the sense of the value of q to minimize variance) would exist if the "added" enterprises were allowed to use varying relative proportions of total resources.

Two-year-olds and a laying flock are combined with hogs in table 17 under the same arrangement (i.e., resources not used for hogs are divided equally between 2-year-olds and the laying flock). This diversification pattern increases relative variability of income for all values of q, over that for the hog, laying flock pair. For all values of q, income variability is not reduced by adding a third, highly variable enterprise to a fairly stable pair of enterprises. Of course, if hogs and 2-year-olds

[12] The equation which expresses total variance under the combination of enterprises A, B and C is:

$$\sigma^2_T = q^2\,\sigma^2_A + \left(\frac{1-q}{2}\right)^2\sigma^2_B + \left(\frac{1-q}{2}\right)^2\sigma^2_C + 2\,\rho_{AB}\,q\left(\frac{1-q}{2}\right)\sigma_A\,\sigma_B + 2\rho_{AC}\,q\left(\frac{1-q}{2}\right)\sigma_A\,\sigma_C + 2\,\rho_{BC}\left(\frac{1-q}{2}\right)\left(\frac{1-q}{2}\right)\sigma_B\,\sigma_C$$

TABLE 16. VALUES OF q OR COMBINATION OF LIVESTOCK ENTERPRISES WHICH MINIMIZE VARIANCE OF RETURNS PER $100 FEED OUTLAY. THE VALUES OF q REFER TO THE PROPORTION OF RESOURCES DEVOTED TO THE ENTERPRISES LISTED ALONG THE TOP OF THE TABLE.

Livestock enterprise	Hogs	Dairy	Laying flock	Turkeys	Beef-cow herd No. 1	Beef-cow herd No. 2	Good-choice calves	Fed 2-year-olds	Yearlings	Broilers
Hogs	—									
Dairy	0.1320	—								
Laying flock	0.2985	0.4302	—							
Turkeys	0.4619	0.6066	1.0	—						
Beef-cow herd No. 1	0.2341	0.2450	0.5243	0.3407	—					
Beef-cow herd No. 2	0.3309	0.6522	0.5864	0.4329	0.8063	—				
Good-choice calves	0.2802	0.6881	0.6060	0.4610	0.7525	0.6069	—			
Fed 2-year-olds	0.5357	0.7852	0.6962	0.5620	0.9258	0.7608	0.6840	—		
Yearlings	0.4866	0.8268	0.6593	0.5315	0.8557	0.7959	1.0	0.4485	—	
Broilers	0.2987	0.4032	0.3901	0.0	0.4389	0.3796	0.3555	0.2255	0.3011	—

TABLE 17. LEVEL OF INCOME, VARIANCE, STANDARD DEVIATION AND COEFFICIENT OF VARIATION FOR RETURNS PER $100 ALL COSTS FOR THREE AND FOUR ENTERPRISE COMBINATIONS.*

Value of q	Income	Variance	Std. Dev.	C/V	Income	Variance	Std. Dev.	C/V
	Hogs, laying flock and dairy†				Hogs, 2-year-olds and laying flock†			
1.0	114.01	830.4	28.8	25.3	114.01	830.4	28.8	25.3
0.9	111.32	683.6	26.2	23.5	112.46	678.4	26.0	23.2
0.8	108.62	552.1	23.5	21.4	110.91	549.0	23.4	21.1
0.7	105.92	435.7	20.9	19.7	109.36	442.2	21.0	19.2
0.6	103.23	334.6	18.3	17.7	107.81	357.9	18.9	17.6
0.5	100.54	248.7	15.8	15.7	106.26	296.3	17.2	16.2
0.4	97.84	178.0	13.3	13.6	104.71	257.3	16.0	15.3
0.3	95.14	122.6	11.1	11.6	103.16	240.9	15.5	15.0
0.2	92.45	82.4	9.1	9.8	101.61	247.1	15.7	15.5
0.1	89.76	57.4	7.6	8.4	100.06	275.9	16.6	16.6
0.0	87.06	47.6	6.9	7.9	98.51	327.4	18.1	18.4
	Hogs, laying flock and 2-year-olds‡				Hogs, laying flock and dairy‡			
1.0	114.01	830.4	28.8	25.3	114.01	830.4	28.8	25.3
0.9	112.30	672.5	25.0	23.1	111.53	677.0	26.0	23.3
0.8	110.58	534.9	23.1	20.9	109.05	540.7	23.3	21.3
0.7	108.86	417.6	20.4	18.8	106.58	421.7	20.5	19.3
0.6	107.15	320.5	17.9	16.7	104.10	319.9	17.9	17.2
0.5	105.44	243.7	15.6	14.8	101.62	235.4	15.3	15.1
0.4	103.72	187.2	13.7	13.2	99.14	168.0	13.0	13.1
0.3	102.00	150.9	12.3	12.0	96.66	117.9	10.9	11.2
0.2	100.29	134.9	11.6	11.6	94.19	85.0	9.2	9.8
0.1	98.58	139.2	11.8	12.0	91.71	69.3	8.3	9.1
0.0	96.86	163.8	12.8	13.2	89.23	70.8	8.4	9.4
	Hogs, dairy, laying flock, broilers†				Hogs, 2-year-olds, laying flock, broilers†			
1.0	114.01	830.4	28.8	25.3	114.01	830.4	28.8	25.3
0.9	112.13	670.4	25.9	23.1	112.89	666.34	25.8	22.9
0.8	110.25	528.7	23.0	20.9	111.78	524.5	22.9	20.5
0.7	108.37	405.5	20.1	18.6	110.66	404.8	20.1	18.2
0.6	106.49	300.6	17.3	16.3	109.54	307.3	17.5	16.0
0.5	104.61	214.2	14.6	14.0	108.42	232.1	15.2	14.0
0.4	102.73	146.1	12.1	11.8	107.31	179.0	13.4	12.5
0.3	100.85	96.4	9.8	9.7	106.19	148.2	12.2	11.5
0.2	98.97	65.2	8.1	8.2	105.07	139.6	11.8	11.2
0.1	97.09	52.3	7.2	7.4	103.96	153.2	12.4	11.9
0.0	95.21	57.8	7.6	8.0	102.84	189.0	13.7	13.4

* Value of q refers to proportion of resources devoted to the first-mentioned enterprise.
† Remaining resources (1-q) are proportioned equally to the remaining enterprises.
‡ Remaining resources (1-q) are divided such that two-thirds are allocated to the second and one-third to the third enterprise.

are considered as the original pair, then the addition of a stable enterprise such as the laying flock reduces income variability.

The laying flock and 2-year-old enterprises are again combined with hogs in table 17. In this case, 2-year-olds received only one-third of the resources shifted away from hogs, and the laying flock received two-thirds.[13] (The laying flock enterprise is "twice as large" as the steer enterprise.) Since the stable enterprise, laying flock, has more weight, income variability is reduced more than in the previous example.

Hogs, laying flock and dairy are also combined under the same procedure in table 17. Here dairying gets one-third while the laying flock gets two-thirds of the resources not used for hogs. Income variability is about the same here as when dairy and the laying flock each received one-half the remaining resources, since both dairy and laying flock are stable enterprises.

Income variability has also been computed for four-enterprise combinations.[14] In table 17, a fourth enterprise, broilers, has been combined with hogs, dairy and laying flock. A slight reduction of income variability over the three-enterprise case does occur for most q values. However, it is doubtful if the reduction in itself would be enough to cause a farmer to add the fourth enterprise. Broilers have also been added to the hog, 2-year-olds, laying flock combination. In this case, reduction in income variability is greater than for the previous four-enterprise case. However, even then, many two and three enterprise combinations have less variability than these four-enterprise combinations. For example, removal of the 2-year-olds from the preceding three-enterprise combination (the one including hogs, laying flock and 2-year-olds) has more effect in reducing variability than adding the broiler enterprise to make a four-enterprise combination.

Other three-enterprise and four-enterprise combinations are presented in table 18. In general, it is concluded that three and four enterprise combinations are not very effective in reducing income variability below that for pairs of stable enterprises. However, when the farmer has only several variable enterprises, the transfer of one-fourth or more resources to a stable poultry or dairy enterprise will reduce variability. Even here, variability would usually be reduced just as well if the farmer combined only one variable enterprise with a more stable one.

[13] The variance equation to represent this allocation of resources is:

$$\sigma^2_T = q^2\,\sigma^2_A + \left[\frac{2(1-q)}{3}\right]^2\sigma^2_B + \left[\frac{(1-q)}{3}\right]^2\sigma^2_C + 2\,\rho_{AB}\,q\left[\frac{2(1-q)}{3}\right]\sigma_A\,\sigma_B + 2\rho_{AC}\,q\left[\frac{(1-q)}{3}\right]\sigma_A\,\sigma_C + 2\rho_{BC}\left[\frac{2(1-q)}{3}\right]\left[\frac{(1-q)}{3}\right]\sigma_B\,\sigma_C$$

[14] The variance equation to represent this allocation is:

$$\sigma^2_T = q^2\,\sigma^2_A + \left(\frac{1-q}{3}\right)^2\sigma^2_B + \left(\frac{1-q}{3}\right)^2\sigma^2_C + \left(\frac{1-q}{3}\right)^2\sigma^2_D + 2\rho_{AB}\,q\left(\frac{1-q}{3}\right)\sigma_A\,\sigma_B + 2\rho_{AC}\,q\left(\frac{1-q}{3}\right)\sigma_A\,\sigma_C + 2\rho_{AD}\,q\left(\frac{1-q}{3}\right)\sigma_A\,\sigma_D + 2\,\rho_{BC}\left(\frac{1-q}{3}\right)^2\sigma_B\,\sigma_C + 2\rho_{BD}\left(\frac{1-q}{3}\right)^2\sigma_B\,\sigma_D + 2\rho_{CD}\left(\frac{1-q}{3}\right)\sigma_C\,\sigma_D$$

TABLE 18. LEVEL OF INCOME, VARIANCE, STANDARD DEVIATION AND COEFFICIENT OF VARIATION FOR RETURNS PER $100 ALL COSTS FOR THREE AND FOUR ENTERPRISE COMBINATIONS.*

Value of q	Income	Variance	Std. dev.	C/V	Income	Variance	Std. dev.	C/V
	2-year-olds, hogs and laying flock†				Yearlings, laying flock and dairy†			
1.0	103.45	1,497.5	38.7	37.4	103.38	1,409.0	37.5	36.3
0.9	103.48	1,206.4	34.7	33.6	101.75	1,137.0	33.7	33.1
0.8	103.52	950.8	30.8	29.8	100.12	895.2	29.9	29.9
0.7	103.55	733.3	27.1	26.2	98.48	683.6	26.1	26.6
0.6	103.59	551.3	23.5	22.7	96.85	502.1	22.4	23.1
0.5	103.62	405.7	20.1	19.4	95.22	350.9	18.7	19.7
0.4	103.65	296.5	17.2	16.6	93.59	229.9	15.2	16.2
0.3	103.69	223.6	15.0	14.4	91.96	139.0	11.8	12.8
0.2	103.72	187.2	13.7	13.2	90.32	78.4	8.9	9.8
0.1	103.76	187.1	13.7	13.2	88.69	47.9	6.9	7.8
0.0	103.79	223.4	14.9	14.4	87.06	47.6	6.9	7.9
	Yearlings, hogs and dairy†				Dairy, hogs and laying flock†			
1.0	103.38	1,409.0	37.5	36.3	80.55	96.1	9.8	12.2
0.9	102.77	1,214.1	34.8	33.9	82.87	92.0	9.6	11.6
0.8	102.16	1,038.3	32.2	31.5	85.20	92.5	9.6	11.3
0.7	101.55	881.5	29.7	29.2	87.52	95.0	9.7	11.1
0.6	100.94	743.8	27.3	27.0	89.85	102.1	10.1	11.2
0.5	100.33	625.2	25.0	24.9	92.17	112.9	10.6	11.5
0.4	99.72	525.7	22.9	23.0	94.49	127.6	11.3	12.0
0.3	99.11	445.2	21.1	21.3	96.82	145.9	12.1	12.5
0.2	98.50	383.8	19.6	19.9	99.14	168.0	13.0	13.1
0.1	97.89	341.5	18.5	18.9	101.47	193.8	13.9	13.7
0.0	97.28	318.3	17.8	18.3	103.79	223.4	14.9	14.4
	Dairy, hogs and yearlings†				Dairy, yearlings and laying flock†			
1.0	80.55	96.1	9.8	12.2	80.55	96.1	9.8	12.2
0.9	83.36	119.4	10.9	13.1	82.34	94.4	9.7	11.8
0.8	86.18	154.4	12.4	14.4	84.14	97.0	9.8	11.7
0.7	89.00	200.8	14.2	15.9	85.93	103.9	10.2	11.9
0.6	91.81	258.8	16.1	17.5	87.72	115.1	10.7	12.2
0.5	94.62	328.4	18.1	19.2	89.52	130.6	11.4	12.8
0.4	97.44	409.5	20.2	20.8	91.31	150.4	12.3	13.4
0.3	100.26	502.1	22.4	22.4	93.10	174.4	13.4	14.4
0.2	103.07	606.3	24.6	23.9	94.89	202.8	14.2	15.0
0.1	105.88	722.0	26.9	25.4	96.69	235.5	15.3	15.9
0.0	108.70	849.3	29.1	26.8	98.48	272.4	16.5	16.8
	Dairy, laying flock and broilers†				Beef-cow herd No. 1, yearlings and hogs†			
1.0	80.55	96.1	9.8	12.2	76.51	270.2	16.4	21.5
0.9	82.75	71.8	8.5	10.2	79.73	259.9	16.1	20.2
0.8	84.95	54.1	7.4	8.7	82.95	264.8	16.3	19.6
0.7	87.15	42.9	6.6	7.5	86.17	284.8	16.9	19.6
0.6	89.35	38.3	6.2	6.9	89.39	320.0	17.9	20.0
0.5	91.54	40.2	6.3	6.9	92.60	370.3	19.2	20.8
0.4	93.74	48.6	7.0	7.4	95.82	435.8	20.9	21.8
0.3	95.94	63.5	8.0	8.3	99.04	516.5	22.7	23.0

TABLE 18. LEVEL OF INCOME, VARIANCE, STANDARD DEVIATION AND COEFFICIENT OF VARIATION FOR RETURNS PER $100 ALL COSTS FOR THREE AND FOUR ENTERPRISE COMBINATIONS.*—Continued.

Value of q	Income	Variance	Std. dev.	C/V	Income	Variance	Std. dev.	C/V
	Dairy, laying flock and broilers†				Beef-cow herd No. 1, yearlings and hogs†			
0.2	98.14	85.0	9.2	9.4	102.26	612.3	24.7	24.2
0.1	100.34	113.0	10.6	10.6	105.48	723.2	26.9	25.5
0.0	102.54	147.6	12.1	11.9	108.70	849.3	29.1	26.8
	Beef-cow herd No. 1, dairy and hogs†				Turkeys, laying flock and broilers†			
1.0	76.51	270.2	16.4	21.5	115.11	627.2	25.0	21.8
0.9	78.59	239.9	15.5	19.7	113.85	553.2	23.5	20.7
0.8	80.66	217.4	14.7	18.3	112.60	484.9	22.0	19.6
0.7	82.74	202.7	14.2	17.2	111.34	422.4	20.6	18.5
0.6	84.82	195.8	14.0	16.5	110.08	365.7	19.1	17.4
0.5	86.90	196.7	14.0	16.1	108.82	314.9	17.7	16.3
0.4	88.97	205.4	14.3	16.1	107.57	269.8	16.4	15.3
0.3	91.05	221.9	14.9	16.4	106.31	230.6	15.2	14.3
0.2	93.13	246.2	15.7	16.9	105.05	197.1	14.0	13.4
0.1	95.20	278.3	16.7	17.5	103.80	169.4	13.0	12.5
0.0	97.28	318.3	17.8	18.3	102.54	147.6	12.1	11.9
	2-year-olds, yearlings and calves†				Calves, turkeys and broilers†			
1.0	103.45	1,497.5	38.7	37.4	101.02	782.8	28.0	27.7
0.9	103.32	1,284.4	35.8	34.7	102.25	608.5	24.7	24.1
0.8	103.20	1,107.7	33.3	32.3	103.48	462.9	21.5	20.8
0.7	103.08	967.3	31.1	30.2	104.71	345.8	18.6	17.8
0.6	102.95	863.4	29.4	28.5	105.94	257.3	16.0	15.1
0.5	102.82	795.9	28.2	27.4	107.16	197.4	14.0	13.1
0.4	102.70	764.8	27.7	26.9	108.39	166.0	12.9	11.9
0.3	102.58	770.1	27.8	27.1	109.62	163.2	12.8	11.7
0.2	102.45	811.8	28.5	27.8	110.85	189.0	13.7	12.4
0.1	102.32	889.9	29.8	29.2	112.08	243.4	15.6	13.9
0.0	102.20	1,004.4	31.7	31.0	113.31	326.4	18.1	15.9
	Broilers, laying flock and calves†				Dairy, yearlings and hogs‡			
1.0	111.50	190.8	13.8	12.4	80.55	96.1	9.8	12.2
0.9	110.08	153.7	12.4	11.3	83.19	121.3	11.0	13.2
0.8	108.66	123.7	11.1	10.2	85.82	160.6	12.7	14.8
0.7	107.24	101.1	10.1	9.4	88.46	213.0	14.6	16.5
0.6	105.82	85.6	9.3	8.7	91.10	280.8	16.8	18.4
0.5	104.40	77.4	8.8	8.4	93.74	361.8	19.0	20.3
0.4	102.98	76.4	8.7	8.5	96.37	465.7	21.4	22.2
0.3	101.56	82.6	9.1	9.0	99.01	565.6	23.8	24.0
0.2	100.14	88.1	9.4	9.4	101.65	688.3	26.2	25.8
0.1	98.72	116.8	10.8	11.0	104.28	825.1	28.7	27.5
0.0	97.30	144.8	12.0	12.4	106.92	975.7	31.2	29.2
	Dairy, hogs and yearlings‡				Hogs, 2-year-olds and laying flock‡			
1.0	80.55	96.1	9.8	12.2	114.01	830.4	28.8	25.3
0.9	83.54	118.1	10.9	13.0	112.62	685.4	26.2	23.2
0.8	86.53	150.5	12.3	14.2	111.24	567.6	23.8	21.4
0.7	89.53	193.3	13.9	15.5	109.86	476.9	21.8	19.9
0.6	92.52	246.5	15.7	17.0	108.47	413.5	20.3	18.8
0.5	95.51	310.0	17.6	18.4	107.08	377.3	19.4	18.1
0.4	98.50	383.8	19.6	19.9	105.70	368.2	19.2	18.2
0.3	101.49	468.0	21.6	21.3	104.32	386.4	19.7	18.8
0.2	104.49	562.6	23.7	22.7	102.93	431.8	20.8	20.2
0.1	107.48	667.6	25.8	24.0	101.54	504.4	22.5	22.1
0.0	110.47	782.9	28.0	25.3	100.16	604.2	24.6	24.5
	Calves, turkeys and broilers‡				Calves, broilers and turkeys‡			
1.0	101.02	782.8	28.0	27.7	101.02	782.8	28.0	27.7
0.9	102.31	608.0	24.7	24.1	102.19	609.3	24.7	24.2
0.8	103.60	463.8	21.5	20.8	103.36	462.7	21.5	20.8
0.7	104.89	350.1	18.7	17.8	104.52	343.2	18.5	17.7
0.6	106.18	266.8	16.3	15.4	105.69	250.7	15.8	15.0
0.5	107.46	214.1	14.6	13.6	106.86	185.2	13.6	12.7
0.4	108.75	191.9	13.9	12.7	108.03	146.7	12.1	11.2
0.3	110.04	200.3	14.2	12.9	109.20	135.2	11.6	10.7
0.2	111.33	239.1	15.5	13.9	110.36	150.7	12.3	11.1
0.1	112.62	308.5	17.6	15.6	111.53	193.3	13.9	12.5
0.0	113.91	408.3	20.2	17.7	112.70	262.9	16.2	14.4
	Hogs, dairy, laying flock, 2-year-olds†				Hogs, laying flock, turkeys, broilers†			
1.0	114.01	830.4	28.8	25.3	114.01	830.4	28.8	25.3
0.9	111.86	686.4	26.2	23.4	113.28	655.6	25.6	22.6
0.8	109.71	559.8	23.7	21.6	112.55	506.5	22.5	20.0
0.7	107.56	450.7	21.2	19.7	111.83	383.2	19.6	17.5
0.6	105.41	358.9	18.9	18.0	111.10	285.8	16.9	15.2
0.5	103.26	284.5	16.9	16.3	110.37	214.2	14.6	13.3
0.4	101.12	227.5	15.1	14.9	109.64	168.3	13.0	11.8
0.3	98.97	187.9	13.7	13.9	108.91	148.3	12.2	11.2
0.2	96.82	165.8	12.9	13.3	108.19	154.1	12.4	11.5
0.1	94.67	161.0	12.7	13.4	107.46	185.6	13.6	12.7
0.0	92.52	173.7	13.2	14.2	106.73	243.0	15.6	14.6
	Dairy, yearlings, hogs, laying flock†				Dairy, yearlings, hogs, beef-cow herd No. 1†			
1.0	80.55	96.1	9.8	12.2	80.55	96.1	9.8	12.2
0.9	82.86	100.7	10.0	12.1	82.29	111.1	10.5	12.8
0.8	85.17	109.5	10.5	12.3	84.03	131.4	11.5	13.6
0.7	87.48	122.5	11.1	12.7	85.78	157.2	12.5	14.6
0.6	89.79	139.6	11.8	13.2	87.52	188.3	13.7	15.7
0.5	92.10	160.9	12.7	13.8	89.26	224.8	15.0	16.8
0.4	94.41	186.3	13.6	14.5	91.00	266.7	16.3	18.0
0.3	96.72	215.8	14.7	15.2	92.74	313.9	17.7	19.1
0.2	99.03	249.5	15.8	16.0	94.49	366.5	19.1	20.3
0.1	101.34	287.4	17.0	16.7	96.23	424.6	20.6	21.4
0.0	103.65	329.4	18.2	17.5	97.97	487.9	22.1	22.6
	Dairy, laying flock, beef-cow herd No. 1, broilers†				Dairy, laying flock, yearlings, 2-year-olds†			
1.0	80.55	96.1	9.8	12.2	80.55	96.1	9.8	12.2
0.9	81.88	79.9	8.9	10.9	82.51	97.5	9.9	12.0
0.8	83.21	66.7	8.2	9.8	84.47	103.5	10.2	12.0
0.7	84.54	56.7	7.5	8.9	86.42	114.3	10.7	12.4
0.6	85.87	49.8	7.1	8.2	88.38	129.8	11.4	12.9
0.5	87.20	46.0	6.8	7.8	90.34	149.9	12.2	13.6
0.4	88.54	45.2	6.7	7.6	92.30	174.7	13.2	14.3
0.3	89.87	47.6	6.9	7.7	94.26	204.1	14.3	15.2

TABLE 18. LEVEL OF INCOME, VARIANCE, STANDARD DEVIATION AND COEFFICIENT OF VARIATION FOR RETURNS PER $100 ALL COSTS FOR THREE AND FOUR ENTERPRISE COMBINATIONS.*—Continued.

Value of q	Income	Variance	Std. dev.	C/V	Income	Variance	Std. dev.	C/V
	Dairy, laying flock, beef-cow herd No. 1, broilers†				Dairy, laying flock, yearlings, 2-year-olds†			
0.2	91.20	53.0	7.3	8.0	96.21	238.3	15.4	16.1
0.1	92.53	61.6	7.8	8.5	98.17	277.2	16.6	17.0
0.0	93.86	73.2	8.6	9.1	100.13	320.7	17.9	17.9
	2-year-olds, yearlings, calves, beef-cow herd No. 1†				2-year-olds, yearlings, calves, laying flock†			
1.0	103.45	1,497.5	38.7	37.4	103.45	1,497.5	38.7	37.4
0.9	102.47	1,276.7	35.7	34.9	103.04	1,246.6	35.3	34.3
0.8	101.49	1,084.6	32.9	32.5	102.62	1,026.4	32.0	31.2
0.7	100.51	921.3	30.4	30.2	102.21	836.9	28.9	28.3
0.6	99.53	786.8	28.1	28.2	101.80	678.0	26.0	25.6
0.5	98.54	681.0	26.1	26.5	101.38	549.8	23.4	23.1
0.4	97.56	604.0	24.6	25.2	100.97	452.2	21.3	21.1
0.3	96.58	555.7	23.6	24.4	100.56	385.4	19.6	19.5
0.2	95.60	536.2	23.2	24.2	100.15	349.1	18.7	18.7
0.1	94.62	545.5	23.4	24.7	99.73	343.6	18.5	18.6
0.0	93.64	583.5	24.2	25.8	99.32	368.7	19.2	19.3

* Value of q refers to proportion of resources devoted to the first-mentioned enterprise.

† Remaining resources (1-q) are proportioned equally to the remaining enterprises.

‡ Remaining resources are divided such that two-thirds are allocated to the second and one-third to the third enterprise.

APPENDIX

Livestock and Poultry Enterprise Systems Used In Computing Costs and Returns

Estimates of physical production coefficients for computing costs and returns from the various livestock systems were obtained from published and unpublished results of studies conducted at the Iowa Agricultural Experiment Station, the United States Department of Agriculture and several other agricultural experiment stations. In some cases the various sources differed in estimates of input requirements; the estimates used were the ones which in the judgment of the authors were most representative of present Corn Belt conditions. A brief description of the enterprise systems follows:

The dairy-cow feeding system considered in this study was originally synthesized by Staniforth.[1] A relatively low level of production of 192 pounds of butterfat per cow was used to approximate average Iowa conditions. As a consequence, returns per $100 all costs are fairly low. Feed allowances per cow were 36.9 bushels of corn, 110 pounds of cottonseed meal, 2.57 tons of alfalfa hay and 1.25 acres pasture. An annual labor charge per cow for 14.64 days' labor was made.

Costs and returns from five distinct beef-cattle systems were utilized from budgets constructed by Olson.[2] One system involved the purchase of good to choice calves weighing about 440 pounds in October, wintering them and then feeding them out in drylot for sale as choice cattle in August at a weight of 1,000 pounds. Allowances for 63 bushels of corn, 0.70 ton of hay, 260 pounds of protein supplement and 1.74 days' labor were made per steer calf.

For the yearling steer system, choice yearling feeders weighing an average of 610 pounds were purchased in November. They were wintered to gain about 1 pound per day. In May the steers were placed in drylot and fed to a choice finish at a weight of 1,060 pounds. Annual expenses per steer included 53.71 bushels of corn, 1.50 tons of hay, 148 pounds of protein supplement and 1.53 days of labor.

Choice 2-year-old steers weighing 800 pounds were purchased in August for the 2-year-old feeding system. They were pastured about a month in the fall, then put in drylot and finished to choice grade cattle of 1,150 pounds in January. An annual allotment of 48 bushels of corn, 0.48 ton of hay, 170 pounds of protein supplement and 1.26 days of labor was made per steer.

Two systems of handling beef cows were considered. The difference between the systems was in the disposition of the calf crop. Under the beef-cow herd No. 1 system, the calves were sold each fall at a weight of 400 pounds as good to choice feeder calves. Feed requirements per cow were estimated at 6.7 bushels of corn, 1.15 tons of hay and 1.6 acres of pasture. Days of labor expended per cow were estimated at 1.5 days per year.

Under the system of beef-cow herd No. 2, the calves were wintered through the first winter, pastured the following summer and fall, wintered through the second winter and grazed through part of the following summer. They were then fed out in drylot from July to October and sold as good grade cattle weighing about 1,200 pounds. Costs for maintaining the herd were similar to beef-cow herd No. 1. Feed requirements per feeder were estimated at 18.75 bushels of corn, 2.16 tons of hay, 1.88 acres of pasture and 105 pounds of protein supplement.

Feed allowances for the hog system included 13.5 bushels of corn per pig plus 5 bushels of corn for the sow per pig. Protein supplement allowance per pig was 59 pounds (including sow). An annual labor input of 0.59 day per pig was estimated.

Costs and returns for three poultry enterprises were computed. For the laying flock, replacement cost of pullets was found by computing the cost of the growing flock for each year. Feed requirements for 100 replacement pullets were estimated at 3,032 pounds of a simple mash mixture. A labor allowance of 5.52 days was made per 100 pullets. An annual labor input of 13.1 days and a feed allowance of 9,271 pounds of grain and mash were made per 100 layers. A conservative production of 171 eggs per hen per year was used to make the budget comparable to the Iowa average level used in the dairy budget.

For the turkey enterprise, 100 cwt. of grain and mash were allowed per 100 marketed turkeys. An estimate of 10 days' labor per year was made per 100 poults. Average weight of turkeys at marketing time was assumed to be 18 pounds.

Feed inputs for the broiler enterprise were estimated at 15.54 pounds per bird to obtain a marketing weight of 3.5 pounds. An annual labor charge of 15 days per 1,000 salable birds was levied against the enterprise.

[1] S. D. Staniforth. Basic data from: Analysis of the effect of uncertainty in crop production. Unpublished Ph.D. Thesis. Iowa State College Library, Ames, Iowa. 1950.

[2] R. O. Olson. Economics of feed utilization with special emphasis on risk and uncertainty. Unpublished Ph.D. Thesis. Iowa State College Library, Ames, Iowa. 1950. (Unpublished basic data.)