AN ESTIMATION OF THE COSTS ASSOCIATED WITH COMMERCIAL

BROILER PRODUCTION IN VIRGINIA

by

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AN ESTIMATION OF THE COSTS ASSOCIATED WITH COMMERCIAL BROILER PRODUCTION IN VIRGINIA

Competition in commercial broiler production, as in any industry, favors the efficient producer and, over a period of time, tends to force out of business those producers whose inefficient production methods result in relatively high production costs. Since individual producers can do very little to influence prices of either their output or inputs, this competition must be met by increased efficiency resulting in lower production costs if the producers are to realize a profitable margin on their broiler enterprise. To plan effectively, producers must have reliable information as to costs of production.[1] Also, feed dealers who are operating with the producers on a contract basis need reliable cost information if they are to formulate workable broiler contracts.

This study is based on the hypothesis that, under any given set of conditions as to input costs, there are specific combinations of input factors that will result in relatively lower production costs. Several studies of this nature have been made in the past, but due to

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[1]Earl O. Heady, "Choice of Functions in Estimating Input-Output Relationships," Proceedings, 51st Annual Meeting, Agricultural Economics and Rural Sociology Section, Association of Southern Agricultural Workers, 1954. In connection with this, Heady comments, "While agricultural economists have long sought to determine 'the cost of production,' we must say that 'there is no such thing.' Costs are different for each different size of enterprise or farm, or for each different technique. 'The costs,' computed as an average for a group or sample of farms, have very little use for decision making. Cost as a function of size or technique does, however, have application to a great number of farm situations."

the rapidly changing technological structure of the commercial broiler industry, their findings may not be applicable under present conditions.

The Background of the Problem

The production of broilers on a commercial basis is becoming of ever-increasing importance in many areas of Virginia. Total Virginia production of commercial broilers has grown from twelve million in 1940 to over 55 million in 1955,[1] an increase of almost 360 percent in only 16 years. Although broiler production is commercially important in several other areas, much of this increase has been centered in the Shenandoah Valley and the Eastern Shore--the two principal broiler producing areas of the state (Figure 1).

The situation in these areas of the state as to markets, climate, labor supply, credit, and lack of a more profitable alternative enterprise favors production of broilers as the major source of income on many farms and as a supplementary source of income on others. This has resulted in the rapid development of highly commercialized areas of broiler production with keen competition both within the areas and between the areas. In an effort to meet this competition, producers--and feed dealers who operate with producers on a contract basis--are seeking reliable current estimates of production costs.

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[1] Virginia Farm Statistics, Virginia Department of Agriculture, Bulletin 17, p. 77, 1957.

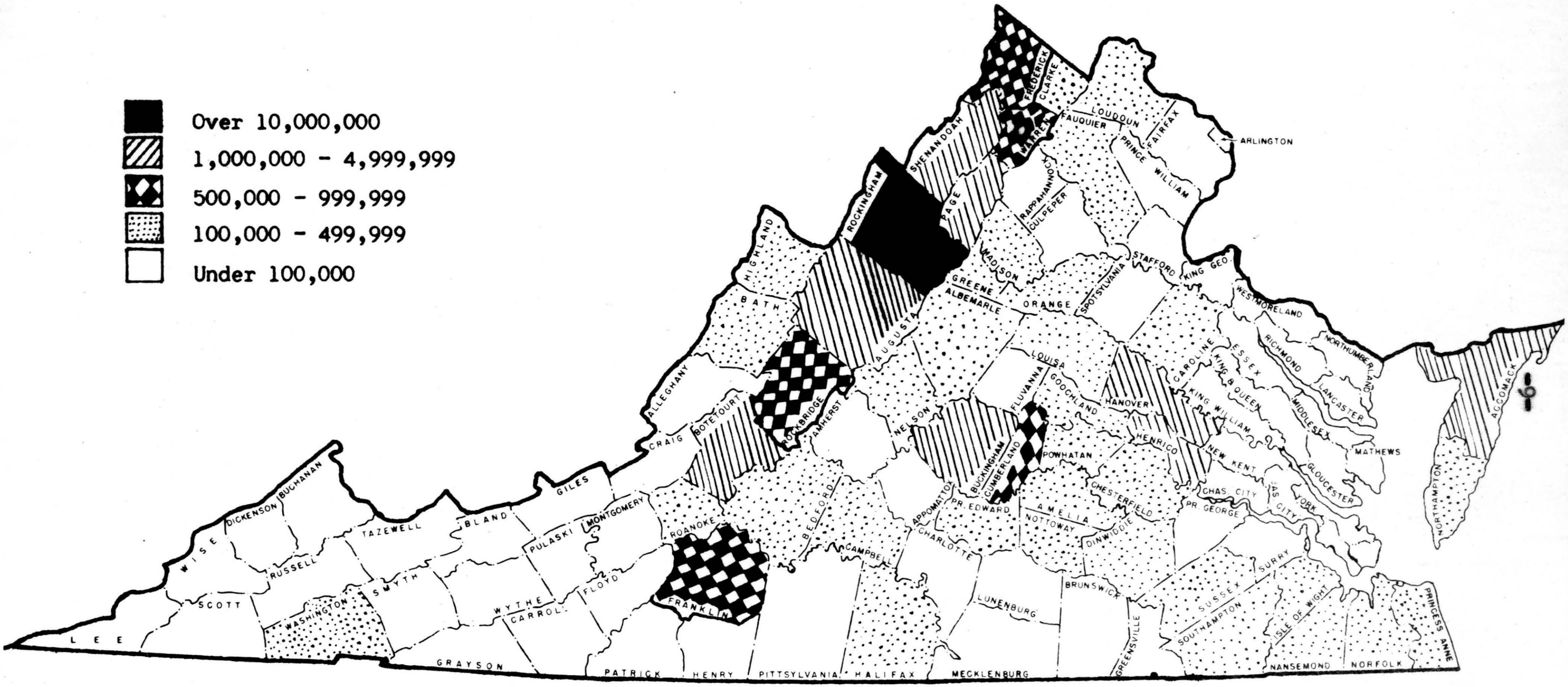

Figure 1. Number of Chickens Sold in 1954 by Counties.
Source: Virginia Farm Statistics, Bulletin 17, Virginia Department of Agriculture, 1957, p. 82.

Objectives of the Study

Rapid technological progress in commercial broiler production--feeding, breeding, and management--has rapidly caused the results of early studies of production costs to become obsolete and has brought about the need for current cost studies. The major objective of this study is to provide basic cost data relative to the production of commercial broilers in Virginia. This will be presented in the form of estimated costs of production for stated situations regarding chick prices, feed prices, and feed conversion ratios. A secondary objective is to determine the investment required for the production of commercial broilers under varying conditions of scale and physical facilities.

This information, coupled with input-output relationships under various conditions as determined by the study, will provide a basis for decision-making on the part of anyone who is either presently engaged in or contemplating entering commercial broiler production in Virginia. Feed dealers and broiler producers can make their own application of the information presented regarding costs versus returns, depending upon what conditions are expected to prevail for chick and feed prices and feed conversion ratios. This type of analysis should be of use to all dealers and all producers of the state since costs other than feed and chick costs should not vary greatly from one kind of feed to another, nor too much from one area of the state to another.[1]

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[1]James S. Plaxico, Good Broiler Management Pays, Virginia Agricultural Experiment Station, Bulletin 437, p. 12, June 1950.

Those factors which are expected to cause variation in costs will be investigated and discussed.

REVIEW OF LITERATURE

Since the mid-1930's when commercial broiler production began to gain national recognition as being an important part of the poultry industry, there have been several studies devoted to determining production costs. Christensen and Mighell observed in 1950 that "Production costs per unit in terms of feed, labor, and other items used in producing chickens and eggs, have been sharply reduced in the last 25 years, and particularly in the last 10 years, through widespread application of improved technology."[1] Data from several studies support this observation. Young, in an Indiana study, found that 4.7 pounds of feed were required to produce a pound of broiler meat in 1936-37,[2] while a slightly smaller feed conversion ratio of 4.4 was determined by Wilson and Smith in a 1938-39 Arkansas study.[3] When these results are compared with the feed efficiency of 3.0 reported by Parvin in 1953 from a Mississippi study,[4] it is apparent that there has been a significant change in technology in the broiler industry during the last two decades.

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[1]R. P. Christensen and R. L. Mighell, Competitive Position of Chicken and Egg Production in the United States, U. S. Department of Agriculture, Bulletin 1018, p. 26, 1950.

[2]E. C. Young, An Economic Study of the Broiler Industry in Western Indiana, Indiana Agricultural Experiment Station, Bulletin 441, p. 7, 1939.

[3]W. T. Wilson and R. M. Smith, Broiler Production and Marketing in Northwestern Arkansas, Arkansas Agricultural Experiment Station, Bulletin 412, p. 6, 1941.

[4]D. W. Parvin, Investment, Cost and Returns to Broiler Production, Mississippi Agricultural Experiment Station, Bulletin 524, p. 7, 1954.

Changes in technology have also drastically affected the amount of labor required in producing broilers. A 1946-47 Virginia study by Plaxico showed that the average labor requirement per 1,000 birds started was 167 hours.[1] A second Virginia study by Plaxico indicated that labor requirements in the Shenandoah Valley had been reduced to 98.77 hours per 1,000 birds started by 1948.[2]

The results of these studies agree with those determined by studies of a similar nature in other states. Johnson, Gordeuk, and Robertson found the average number of hours of labor required per thousand birds to be 89 in a 1946-48 Indiana study.[3] In two Delaware studies, Bausman reported that 96 hours of labor were required per 1,000 broilers in 1946,[4] while McAllister and Bausman reported a labor requirement of 73 hours per 1,000 broilers in 1948-49.[5] However, these results are in contrast to a figure of 49 hours of labor per 1,000 birds started reported by Parvin in a 1953 Mississippi study.[6]

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[1] James S. Plaxico, Broiler Costs and Returns Related to Management Practices, Rockingham County, Virginia, 1946-47, Virginia Agricultural Experiment Station, Bulletin 426, p. 28, 1949.

[2] Plaxico, Good Broiler Management Pays, op. cit., p. 20.

[3] H. A. Johnson, Alexander Gordeuk, and L. S. Robertson, Profitable Broiler Production in Indiana, Purdue University Agricultural Experiment Station, Bulletin 539, p. 22, 1950.

[4] R. O. Bausman, Influence of Management Practices on Cost of Producing Broilers in Delaware, University of Delaware Agricultural Experiment Station, Bulletin 270, p. 19, 1947.

[5] W. F. McAllister and R. O. Bausman, Influence of Management Practices on Cost of Producing Broilers in Delaware, University of Delaware Agricultural Experiment Station, Bulletin 282, p. 19, 1950.

[6] Parvin, op. cit., p. 6.

While improved technology has brought about definite changes in the feed conversion ratio and labor requirements for broiler production, less change has been evident in chick cost. A Delaware study by McAllister and Bausman showed an extreme variation in chick cost per bird sold from 10.4 cents in 1946 to 18.7 cents in 1948-49, but they explain this variation as being due to greater mortality in the 1948-49 period as well as to higher chick prices.[1] Plaxico reported much less variation in a Virginia study with a chick cost per bird sold at 16 cents in 1946-47 and 16.2 cents in 1947-48.[2] Johnson, *et al.*, reported a chick cost of 16.6 cents per bird sold in a 1946-48 study conducted in Southern Indiana,[3] while five years later, Parvin found a 15.6 cents chick cost per bird started in a 1953 Mississippi study.[4]

Reports from several state experiment stations agree that the size of flock has a significant effect on the costs of broiler production although there is some disagreement as to the reasons for this. A Delaware study by Bausman indicates that each increase of 1,000 broilers in the size of flock decreased the average cost of production at the rate of 0.2 of a cent per pound.[5] In a more recent study by McAllister and Bausman, this decrease in production costs for larger

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[1] *Ibid.*, p. 9.

[2] Plaxico, *Good Broiler Management Pays*, *op. cit.*, p. 13.

[3] Johnson, Gordeuk, Robertson, *op. cit.*, p. 9.

[4] Parvin, *op. cit.*, p. 8.

[5] Bausman, *op. cit.*, p. 13.

flocks is explained as being the result of greater feed efficiency due to better feed management among the larger operators.[1]

Increased labor efficiency is given as the reason for an average decrease in the cost of production of 1.5 cents per pound for each increase of 1,000 birds per flock in a Virginia study by Plaxico in 1946-47.[2] In a later study, he indicated that labor requirements tended to level off as the size of lots reached about 4,000 birds and that there was no decrease in cost of production as the size of lots increased beyond the 4,000 level.[3] Johnson, et al., in their study in Southern Indiana, indicated a substantial decrease in production costs as flock size increased up to 21,500 birds due to more efficient use of labor and buildings in larger flocks.[4] However, they feel that the amount of family labor available to the producer is the practical limiting factor in determining the size of flock.

Several other phases of broiler production costs have been explored. Plaxico concluded that the time of the year that birds were produced had no significant effect on costs other than for fuel.[5] Judge and Fellows presented experimental data to show that sex of chicks

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[1]McAllister and Bausman, op. cit., p. 12.

[2]Plaxico, Broiler Costs and Returns Related to Management Practices, Rockingham County, Virginia, 1946-47, op. cit., p. 18.

[3]Plaxico, Good Broiler Management Pays, op. cit., p. 19.

[4]Johnson, Gordeuk, Robertson, op. cit., pp. 8-9.

[5]James L. Plaxico, "Monthly Variations in Prices and the Cost of Production of Broilers," Virginia Farm Economics, No. 138, p. 8, May 1954.

was an important consideration from the standpoint of costs and subsequent maximization of profit.[1] Smith and McDaniel, in a Delaware study in 1952, concluded that floor space per bird influenced cost of production by affecting mortality and pounds of broilers produced.[2]

Thus far, we have examined only detailed items of costs from broiler production studies. These combine to give an estimation of total cost of production which is perhaps the most important single statistic from the producer's standpoint. Results from several studies show that this total cost of production does not vary so widely as do the various items of cost making up the total. However, the application of improved technology has reduced this total cost, particularly in the last ten years. Plaxico reported a total cost of 31.5 cents per pound of broiler sold in 1946[3] which is comparable to the 31.7 cents per pound sold reported by McAllister and Bausman in 1948[4] and the 32.4 cents per pound sold reported by Plaxico in 1949.[5]

In 1953, Judge and Fellows used 1952 experimental data to estimate total costs for the production of broilers as ranging from 20.8 cents

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[1]George G. Judge and Irving F. Fellows, Economic Interpretations of Broiler Production Problems, Storrs (Connecticut) Agricultural Experiment Station, Bulletin 302, p. 25, 1953.

[2]R. C. Smith and William E. McDaniel, Floor Space Affects Broiler Profits, University of Delaware Agricultural Experiment Station, Circular 25, p. 1, 1952.

[3]Plaxico, Broiler Costs and Returns Related to Management Practices, Rockingham County, Virginia, 1946-47, op. cit., p. 37.

[4]McAllister and Bausman, op. cit., p. 9.

[5]Plaxico, Good Broiler Management Pays, op. cit., p. 13.

to 24.0 cents per pound of meat sold, varying according to the age at sale.[1] Their estimates were strengthened by Parvin's Mississippi study which showed an average total cost of 25.5 cents per pound sold in 1953.[2]

Many of the studies reviewed used some type of statistical analysis in estimating production relationships under various conditions. McAllister and Bausman used a linear function in estimating the influence of various production factors on the cost of producing broilers.[3] Parvin estimated the relationship of size of brood to the daily chore labor requirements by use of a simple linear regression technique.[4]

Judge and Fellows, using experimental cost of production data, estimated various input-output relationships with the equation:

$$Y = \beta_o + \beta_1 X + \beta_2 X^2$$

where Y = output

X = input

$\beta_o, \beta_1, \beta_2$ = constants to be estimated.[5]

Heady seemed to favor this type of quadratic least-squares equation over linear functions such as those mentioned above since it

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[1]Judge and Fellows, *op. cit.*, p. 25.

[2]Parvin, *op. cit.*, p. 8.

[3]McAllister and Bausman, *op. cit.*, pp. 13-15.

[4]Parvin, *op. cit.*, p. 16.

[5]Judge and Fellows, *op. cit.*, p. 10.

does not assume constant ratios of response.[1] However, if the squared term does not account for a significant proportion of the variance, it may be deleted, giving a simple linear equation.[2]

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[1]Heady, "Choice of Functions in Estimating Input-Output Relationships," op. cit., p. 5.

[2]Ibid., p. 5.

SOURCE OF DATA

Three feed dealers, two in Harrisonburg and one in Stuarts Draft, who were contracting for the production of broilers were selected because they represented three competing brands of feed and were willing to cooperate in the study. A complete list of their contract broiler producers, together with usual size of batch,[1] was obtained from these three dealers. All producers whose home addresses indicated that they were residents of West Virginia were eliminated from the lists. The remaining producers were stratified on the basis of size of operation, and a 20 percent sample was selected at random within each stratum.[2] The same method was used to select an alternate sample of the same size since difficulty was anticipated in

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[1]Producers often raise two or more groups of broilers during the year. Each separate group, or brood, is referred to as a batch in this study.

[2]Producers were stratified into four levels and a sample drawn from each stratum as follows:

Usual size of batch	Number selected in sample
500 - 2499	43
2500 - 4999	45
5000 - 7499	48
7500 and over	42
Total number in sample	178

George W. Snedecor, Statistical Methods Applied to Experiments in Agriculture and Biology, Iowa State College Press, Ames, Iowa, 1956. See William G. Cochran's discussion of the theoretical advantage of a stratified random sample in Chapter 17 of Snedecor's book.

contacting all producers selected in the original sample.[1]

Producers thus selected were visited by enumerators who secured data on building and equipment investment, labor utilization and various items of farm cost relative to the production of broilers.[2] If, after two farm visits by an enumerator, the producer's sample data schedule could not be completed, a schedule was taken on a producer from the same size stratum of the alternate sample. In addition, data schedules were secured from as many of the other producers selected in the alternate sample as time permitted. This was done in order to insure a sample of sufficient size after incomplete or otherwise unusable schedules were discarded. By this means, the expenditure of time and funds for a second visit to the area was avoided.

Through the cooperation of the three feed dealers included in the study, photographic copies were made of their broiler contract summaries for all birds started from July 1, 1954, through June 30, 1955,

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[1]It was felt that this procedure was superior to attempting to select an over-all random sample of all producers since:

(1) Calculations were to be made for specific feed and chick prices and for given feed conversion ratios.
(2) Calculations were to be made for specific types of buildings and specific types of equipment, and the type of feed or dealer should have little effect on these.
(3) Miscellaneous items of cost form only a small proportion of the total cost. Thus, differences between dealers, if any exist, would have very little effect on the total cost.
(4) Much less time would be required to collect the data.
(5) Fewer dealers would have to be depended upon for cooperation in the study.

[2]See Appendix Exhibit 1 for a sample of the schedule used in collecting information from producers.

the time period covered by this study.[1] This information together with the data gathered from the producer schedules provided a complete record of production costs for each batch of broilers started within this period.

A total of 213 producer schedules and dealer record summaries on more than two thousand separate batches of broilers were collected in this manner. Those schedules which could not be used were discarded. The remaining 184 producer schedules and the dealer record summaries for the 641 batches of broilers that those 184 producers had started during the period July 1, 1954, through June 30, 1955, were retained for use in the analysis. These included producers from the counties of Rockingham, Augusta, Rockbridge, Highland, and Shenandoah (Figure 2).

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[1]See Appendix Exhibit 2 for a sample of the dealer contract summaries. This method of collecting data was used since:

(1) It minimized the chance of error in copying data.
(2) Less time in the field on the part of research personnel was required in order to secure the desired data.
(3) Complete records were thus made available in permanent form.

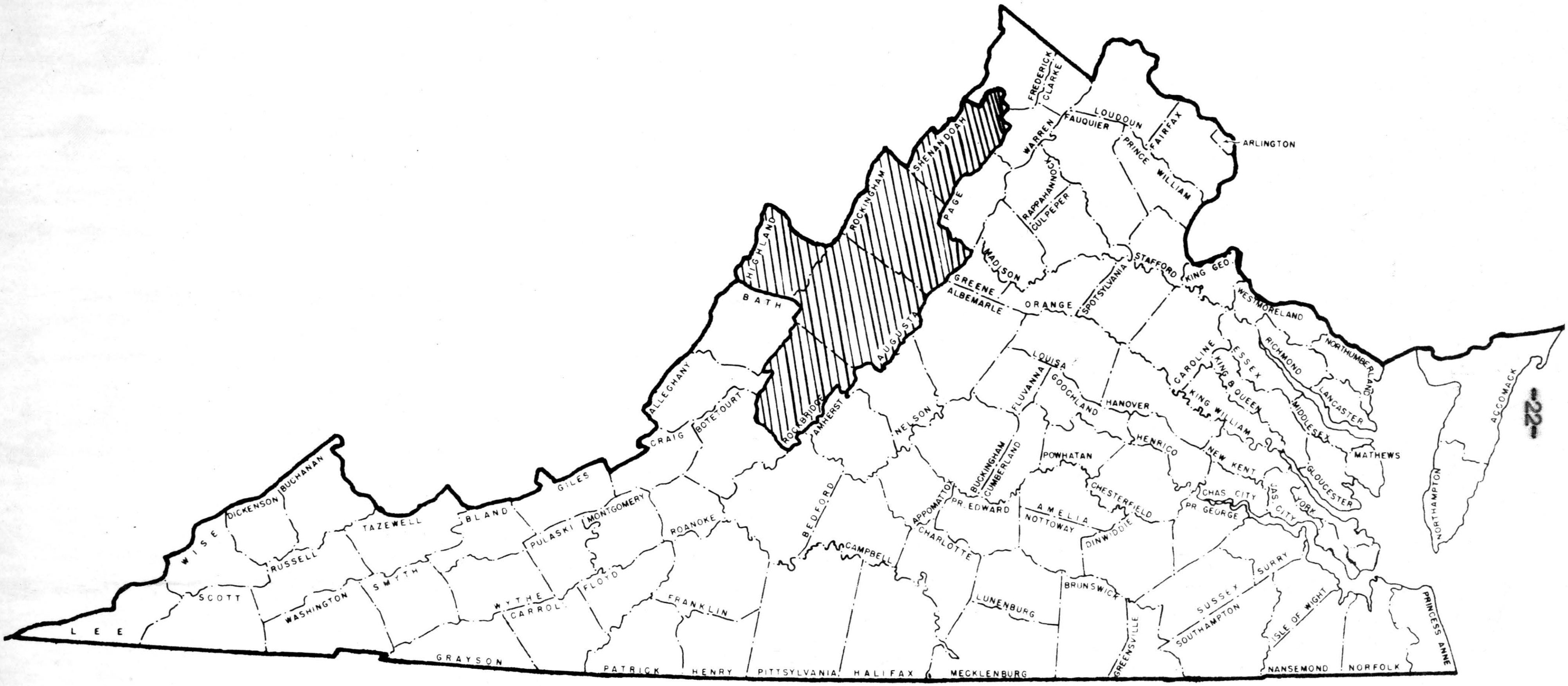

Figure 2. Counties Included in the Sample

METHODS OF PROCEDURE

As previously stated, the major objective of this study is to provide basic cost and investment data relative to the production of commercial broilers in Virginia. These data will be presented in the form of estimated costs of production for stated situations regarding chick prices, feed prices, and feed conversion ratios, and average investment requirements for various types of buildings and equipment. Also, the effect of scale on building and equipment investment will be estimated.

Several sources of data were used for calculating individual costs. Dealer records provided information on the cost of feed, chicks, litter, fuel, grit, and medication. Information on building and equipment costs, labor requirements, and electricity and other miscellaneous costs were taken from producer records. The various items of cost from the dealers' records and producers' schedules were broken down and tabulated with particular attention being given to properly identifying them by means of producer number. This was necessary since any production factors that might have a bearing on total costs were tabulated separately and identified in a similar manner so that, if desired, analysis of these factors might be made.

In tabulating the items of cost and other production data from the dealers' records, no attempt was made to record feed consumed or pounds of meat produced from the individual records. Instead, the feed conversion ratio[1] of each batch of broilers was recorded. This

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[1]Feed conversion ratio is expressed as: $\frac{\text{Pounds of feed consumed}}{\text{Pounds of meat produced}}$

is thought to be a more meaningful figure since feed costs vary according to feed prices and feed conversion ratios.

Costs of litter and grit for each batch of broilers were taken from the dealer records. Fuel costs for each individual batch of broilers were tabulated and identified by the date started so that the effect of date started on total cost could be determined. Costs of medication, vaccination, and hauling were also tabulated and averaged for later use in computing total production cost.

More detailed tabulation, as well as some degree of adjustment, was required for those items of cost taken from producers' schedules. Building costs for each major type of broiler house were tabulated separately, and yearly costs per 1,000 bird capacity were then calculated. This total yearly building cost per 1,000 bird capacity included depreciation, repairs, interest on the investment and taxes.[1]

An annual building depreciation cost was calculated using the producers' estimates of replacement costs and total years of useful life for each building. Annual cost of repairs was taken directly from the producers' schedule. Interest on investment was calculated at an annual rate of 5% on one-half the estimated replacement cost.

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[1]While it is realized that insurance on buildings is naturally a building cost item, difficulty was anticipated in obtaining accurate farmer estimates of insurance cost for individual buildings. Therefore, total insurance costs for each producer were included in the schedule under "other costs" rather than attempting to establish a figure for each building separately.

Taxes were calculated on the basis of information obtained from the Commissioners of Revenue of the various counties included in the study.[1]

Since some of the broiler producers also used their houses for turkey production during part of the year, the total annual building costs chargeable to broilers had to be adjusted to take this into account. Costs for each house were adjusted individually, using information obtained from the producers' schedules as to the length of time the house was used for turkeys during the year. This was computed as follows:

(1) 52 minus number weeks used for turkeys = weeks used for broilers

(2) weeks used for broilers ÷ 52 = percent of costs chargeable to broilers

Generally, the same methods of tabulation were used for equipment costs as were used for building costs. A separate tabulation was made for each major kind of equipment, and in those cases where there were several major types within a given kind, such as heating equipment, a separate tabulation was made for each type.

Some adjustments also were made in equipment costs. In those cases where houses were used for turkey production during part of the

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[1]The average rate of tax on farm buildings in the area was \$2.40 per \$100 of assessed value; assessed value of buildings was approximately 25% of the fair market value. Since the value of farm buildings was reassessed every six years, fair market value was assumed to be equal to one-half the estimated replacement cost.

year, the percent of total building costs chargeable to broilers was used to adjust the total equipment cost chargeable to broilers. The yearly cost of the water system was adjusted on the basis of the percent of the water system chargeable to broilers taken from the producers' schedule. Both of these adjustments were made for each individual producer before calculating total equipment cost.

Both the dealers records and the producers' schedules were used in calculating the total labor requirements per batch of broilers. The producer's schedule showed estimates of daily labor requirements for routine chores during each week of production for the producer's usual size of batch. The dealer records indicated the age at sale of each batch of broilers, which made it possible to determine the total routine chore labor requirements for the producer's usual size of batch. For ease in computation, this was reduced to daily chore labor requirements per 1,000 birds.

In some cases, manure was given away to anyone who would remove it from the broiler house. This was, in effect, giving the manure in payment for the labor required to remove it. In order to put all farms on a comparable basis, it was felt that this labor requirement should be taken into consideration. An average time required for manure removal per 1,000 birds was computed from those producer records where such a figure was given. This was then added to the labor requirements of those producers who had reported giving manure away. Estimates of labor requirements for cleaning (other than removing manure) and disinfecting the broiler house between broods were taken from the producer schedules.

A detailed tabulation was made of other costs reported on the producer schedules. Extreme care was exercised, however, in order to avoid double counting and adding items which were not applicable. For example, depreciation was sometimes reported under other costs, but it had already been included in building and equipment costs. Also, hired labor was sometimes recorded, but using this again would have caused double counting since both hired and family labor were included in total labor requirements.

Analysis of the Data

One of the objectives of this study was to estimate the building and equipment requirements for the production of commercial broilers. Since scale is considered an important variable affecting investment requirements per unit of output for any livestock enterprise,[1] a series of scatter diagrams were prepared relating the investment requirements per thousand birds to the size of batch for each major type of buildings and equipment. This preliminary graphical analysis of the data indicated a curvilinear relationship in most cases. Since it was not possible to determine these relationships accurately from the graphs, least squares regression techniques were used to derive estimates of the association between the size of the broiler enterprise and the investment requirements.

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[1]Earl O. Heady and Harold R. Jensen, Farm Management Economics, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1954. See page 469 for a discussion of the general effects of scale on buildings and equipment investment for a livestock enterprise.

The regression model[1]

The general regression model chosen postulates a curvilinear functional relationship of the form:

$$Y = \beta_o + \beta_1 X_1 + \beta_2 X_1{}^2 + \ldots + \beta_{2n} X_n{}^2 + \epsilon$$

where Y is the dependent variable;

X_i is the independent variable;

β_o is the Y intercept representing the value of Y with X_i approaching zero;

$\beta_1, \beta_2 \ldots \beta_{2n}$ are the effects of a unit change in the independent variable;

ϵ is the random error which measures the lack of fit of the curvilinear relationship between X_i and Y. This random variable is normally and independently distributed with zero mean and variable σ^2.

The parameters of the model were estimated by second degree polynomial regression equations fitted by the method of least squares giving the equation:

$$\hat{Y} = b_o + b_1 X_1 + b_2 X_1{}^2 + \ldots + b_{2n} X_n{}^2$$

where $b_o, b_1, \ldots b_{2n}$ are estimates of β_o, $\beta_1, \ldots, \beta_{2n}$.

Estimation equations

Least squares estimation equations were calculated for the purpose

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[1]Bernard Ostle, Statistics in Research, The Iowa State College Press, Ames, Iowa, 1952, and C. Y. Kramer, "A Note on Multiple Regression, "Virginia Polytechnic Institute, Blacksburg, Va. (mimeo). These publications were used as sources of statistical theory and computational procedure.

of estimating the following relationships:

(1) The relation of size of batch to building investment.

$$\hat{Y} = b_o + b_1X + bX^2$$

where $\hat{Y}$ = estimated replacement cost per 1,000 bird capacity;

b_o = the mean replacement cost per 1,000 bird capacity that would be obtained with X approaching zero;

X = producer's usual capacity expressed in thousands of birds for each major type of building;

b_1 and b_2 (standard partial regression coefficients) are to be estimated to indicate the effect of scale on replacement cost.

(2) The relation of size of batch to labor requirements.

$$\hat{Y} = b_o + b_1X + b_2X^2$$

where $\hat{Y}$ = estimated labor required per 1,000 birds;

b_o = the mean labor requirement with X approaching zero;

X = the producer's usual capacity expressed in thousands of birds:

b_1 and b_2 are to be estimated to indicate the effect of size on labor requirements.

(3) The relation of size of batch to heating investment requirements.

$$\hat{Y} = b_o + b_1X + b_2X^2$$

where $\hat{Y}$ = estimated replacement cost per 1,000 birds for heating equipment;

b_o = the mean replacement cost with X approaching zero;

X = the producer's usual capacity expressed in thousands of birds for each major type of heating equipment;

b_1 and b_2 are to be estimated to indicate the effect of scale on heating equipment replacement cost.

(4) The relation of weight and age at sale to the efficiency of feed conversion.

$$\hat{Y} = b_o + b_1X_1 + b_2X_1^2 + b_3X_2 + b_4X_2^2$$ [1]

where $\hat{Y}$ = estimated feed conversion ratio;

b_o = the mean feed conversion ratio with X_1 and X_2 approaching zero;

X_1 = weight at sale;

X_2 = age at sale;

$b_1, \ldots b_4$ are to be estimated to indicate the effect of age and weight at sale on the feed conversion ratio.

The amount of variation explained by these regression equations was measured by the computation of R^2, the correlation index.[2] The statistical significance of the regressions was tested by the analysis of variance using the standard "F" test procedures. In those equations where the portion of variation explained by the quadratic term was found nonsignificant, a simple linear regression was computed and similarly tested. The "Students" t-test was used to determine the

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[1]Due to the extensive nature of the calculations required in estimating the regression coefficients for this equation, the data were transferred to punched cards and computations were performed using the IBM 650 Data Processing Machine.

[2]Ostle, op. cit., pp. 187-189. This is also described as the multiple correlation coefficient by some authorities.

significance of the individual regression coefficients (b_i). The results of these computations and tests of significance are presented in Appendix tables 6-9.

RESULTS OF THE ANALYSIS

Production Relationships

The interrelationship of several production factors which were thought to affect certain items of cost were investigated. While a producer would not consider any one of these various factors alone as a basis for decision making without first considering its relative importance in the entire production framework, it is possible that the relationships discovered may indicate areas of needed adjustment in an individual producer's production practices.

Seasonality of production

The effect of the season of the year in which a batch of broilers was started on (1) efficiency of feed conversion, (2) weight at sale, and (3) percent mortality were investigated (Table 1).[1] The average feed conversion ratio, weight at sale, and mortality rate were lowest for those birds started during the summer. Birds started during the fall showed least efficient feed conversion and higher average weight, while those started during the winter months had the highest average rate of mortality.

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[1]Seasons of the year were defined as follows: Fall - August, September, October; Winter - November, December, January; Spring - February, March, April; Summer - May, June, July.

Table 1. Seasonal Effect on Average Feed Conversion Ratio, Weight at Sale, and Percent Mortality, 641 Batches of Broilers, Virginia, 1954-55

Item	Season started			
	Fall	Winter	Spring	Summer
Feed conversion ratio	3.08	3.01	2.92	2.83
Average weight per bird at sale (pounds)	3.2	3.2	3.1	3.0
Percent mortality	4.7	4.8	4.3	4.1

Age at sale related to feed efficiency, weight, and mortality

The age at which broilers were sold proved to be a factor affecting feed efficiency, weight at sale, and rate of mortality (Table 2). Without exception, the older birds showed a higher average feed conversion ratio, weight at sale, and percent mortality.

Table 2. Effect of Age at Sale on Average Feed Conversion Ratio, Weight at Sale, and Percent Mortality, 641 Batches of Broilers, Virginia, 1954-55

Item	Age at sale		
	Less than 10 weeks	10 weeks to 11 weeks	11 weeks and over
Feed conversion ratio	2.8	2.9	3.2
Average weight per bird at sale (pounds)	3.0	3.1	3.2
Percent mortality	2.8	4.4	6.7

Age and weight at sale related to feed efficiency

The feed conversion ratio was significantly affected by the production factors, age at sale and weight at sale (Table 3). As age at sale increased with weight at sale held constant, the feed conversion ratio increased at an increasing rate. Conversely, with age at sale held constant, the feed conversion ratio decreased at the same rate with which weight at sale increased. Thus, while a nonlinear relationship was exhibited between feed conversion ratio and age at sale, the factor of weight at sale affected the feed conversion ratio in a linear manner.

Table 3. Estimated Effect of Age at Sale and Weight at Sale on Feed Conversion Ratio, 641 Batches of Broilers, Virginia, 1954-55

Age at sale (days)	Weight at sale (pounds)						
	2.4	2.6	2.8	3.0	3.2	3.4	3.6
	Estimated pounds of feed required per pound of meat sold[a]						
60	2.78	2.68	2.58	2.48	2.38	2.29	2.19
62	2.80	2.70	2.60	2.50	2.41	2.31	2.21
64	2.83	2.73	2.63	2.53	2.43	2.34	2.24
66	2.86	2.76	2.67	2.57	2.47	2.37	2.28
68	2.91	2.81	2.71	2.61	2.52	2.42	2.32
70	2.96	2.86	2.87	2.67	2.57	2.47	2.38
72	3.03	2.93	2.83	2.73	2.64	2.54	2.44
74	3.10	3.00	2.90	2.80	2.71	2.61	2.51
76	3.19	3.08	2.98	2.88	2.79	2.69	2.59
78	3.27	3.17	3.07	2.97	2.88	2.78	2.68
80	3.36	3.27	3.17	3.07	2.97	2.88	2.78
82	3.47	3.37	3.28	3.18	3.08	2.98	2.89
84	3.59	3.49	3.39	3.29	3.20	3.10	3.00

[a]Calculation based upon the formula $\hat{Y} = 7.3490 - .4885X_1 - .1213X_2 + .001077X_2^2$ where $\hat{Y}$ = estimated feed conversion ratio; X_1 = weight at sale; X_2 = age at sale.

Labor Requirements

Daily chore labor requirements

Average requirements for daily chore labor per 1,000 birds started followed a definite pattern throughout the weeks of the production period. Each 1,000 broilers started required an average of .724 hours chore labor daily during the first week. This dropped to .664 hours during the fifth week, but then climbed steadily through the eleventh week which averaged a daily requirement of .705 hours (Table 4). A majority of the birds were sold during the tenth week of the production period although some were held for eleven weeks or longer.

Table 4. Average Daily Chore Labor Requirements per 1,000 Birds Started, 641 Batches of Broilers, Virginia, 1954-55

Weeks in production period	Hours labor daily per 1,000 birds	Number of birds (thousands)
1	.724	1158.8
2	.710	1158.8
3	.673	1158.8
4	.671	1158.8
5	.664	1158.8
6	.669	1158.8
7	.669	1158.8
8	.690	1158.8
9	.697	1158.8
10	.701	1103.3
11	.705	124.0

Labor requirements related to type of heating system

The effect of type of heating systems employed in the broiler houses on total labor requirements was investigated (Table 5). This showed dramatic differences in average labor requirements per 1,000 birds started among the four types of heating systems. Those producers who used coal and wood brooders required an average of over 125 hours labor per 1,000 birds started compared with an average of only 44.08 hours labor per 1,000 birds started required by those producers who used central heating systems. Some of this difference, however, may be accounted for by the fact that those producers using central heating arrangements had an average total capacity almost three times that of those producers using coal and wood brooders.[1]

Table 5. Effect of Type of Heating System on Average Total Labor Requirements, 641 Batches of Broilers, Virginia, 1954-55

Type of heating system	Number of producers	Average total capacity	Total hours labor per 1,000 birds
Coal and wood brooders	77	3,400	125.04
Gas brooders	53	5,100	65.96
Central heat[a]	48	9,800	44.08
Miscellaneous and combinations[b]	6	4,200	80.48

[a]Includes hot water or hot air heating systems using stoker-fired furnace or oil furnace.

[b]Includes kerosene, infra-red, and other types of brooders not listed in the study and combinations of two or more types.

[1]Total capacity is the number of broilers a producer can house at any one time.

Size of batch related to total labor requirements

An investigation of the effect of size of batch on total labor requirements showed that a significant relationship did exist (Table 6). Total labor requirements per 1,000 birds declined from 75.60 hours for a batch of 1,000 birds to 60.43 hours when 20,000 birds were raised in one batch. It should be kept in mind, however, that these calculations were based on labor requirements reported by all producers sampled and that the type of heating system employed also has an effect on total labor requirements.

Table 6. Effect of Size of Batch on Estimated Total Labor Requirements, 641 Batches of Broilers, Virginia, 1954-55

Size of batch (number birds started)	Estimated hours of labor required[a]	
	Per 1,000	Total
1,000	75.60	75.60
2,000	74.78	149.56
3,000	73.76	221.28
4,000	73.15	292.60
5,000	72.34	361.70
6,000	71.53	429.18
7,000	70.72	495.04
8,000	69.91	559.28
9,000	69.11	621.99
10,000	68.31	683.10
11,000	67.51	742.61
12,000	66.72	800.64
13,000	65.93	857.09
14,000	65.14	911.96
15,000	64.35	965.25
16,000	63.56	1,016.96
17,000	62.77	1,067.09
18,000	61.99	1,115.82
19,000	61.21	1,162.99
20,000	60.43	1,208.60

[a]Calculations based upon the formula $\hat{Y} = 76.420898 - .821991X + .00113X^2$ where $\hat{Y}$ = estimated labor requirements per 1,000 birds and X = size of batch in thousands of birds.

Investment Requirements for Buildings and Equipment

The inexperienced producer who is planning to increase his commercial broiler enterprise, as well as persons who are contemplating producing broilers for the first time, need basic information on investment required for broiler production. This is especially true in those areas where a large percentage of the commercial broiler production is on a contract basis since initial investment in buildings and equipment is the major item of capital requirement for an individual producer under this system.[1]

Investment in buildings

The largest single item of capital investment required for the production of commercial broilers is the broiler house. The replacement cost and investment per 1,000 bird capacity for the different major types of buildings observed in the study are shown in Table 7.[2] A majority of the houses included in the study were of one-story wood construction, and this type of house had the lowest average replacement cost and investment per 1,000 bird capacity. The more permanently

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[1]For a complete discussion of broiler contracts, see Frank D. Hansing, Financing the Production of Broilers in Lower Delaware, University of Delaware Agricultural Experiment Station, Bulletin 322, October 1957, and John T. Buck, An Evaluation of Broiler Financing Methods in Virginia, Virginia Agricultural Experiment Station, Bulletin 470, October 1954.

[2]Average investment over the lifetime of the house is calculated as being one-half the replacement cost.

constructed block houses required a higher average investment per 1,000 birds and would have cost more to replace.

Table 7. Average Replacement Cost and Investment per 1,000 Bird Capacity for Different Types of Buildings, 184 Broiler Producers, Virginia, 1954-55

Type of building	Number houses	Average replacement cost per 1,000 bird capacity	Average investment per 1,000 bird capacity
One-story wood	157	$ 754.00	$377.00
Two-story wood	28	884.00	442.00
One-story block	64	1,002.00	501.00
Two-story block	9	1,220.00	610.00
Other[a]	23	960.00	480.00

[a]This included one-story, two-story, and three-story buildings constructed of a variety of materials.

Building capacity related to building investment.[1] The size of house had a significant effect on replacement cost and average investment for the one-story wood and one-story block houses (Table 8). For the one-story wood houses, each increase in capacity of 1,000 birds decreased the replacement cost $20 per 1,000 birds. Replacement cost for the one-story block houses decreased from $1,448 per 1,000 for a house with a capacity of only 1,000 birds to $799 per 1,000 for a house with a capacity of 8,000 birds. Size did not have a significant

[1]Building capacity in thousands of birds was taken as the measure of size or scale of operation.

Table 8. Effect of Size of Broiler House on Estimated Replacement Cost and Average Investment, 184 Broiler Producers, Virginia, 1954-55

Capacity (number of birds)	One-story wood[a]				One-story block[b]			
	Replacement cost		Average investment		Replacement cost		Average investment	
	Per 1,000	Total	Per 1,000	Total	Per 1,000	Total	Per 1,000	Total
1,000	$798	$ 798	$399	$ 399	$1,448	$1,448	$724	$ 724
2,000	778	1,556	389	778	1,347	2,694	674	1,347
3,000	758	2,274	379	1,137	1,248	3,744	624	1,872
4,000	738	2,952	369	1,476	1,152	4,608	576	2,304
5,000	717	3,585	358	1,792	1,059	5,295	530	2,648
6,000	697	4,182	348	2,091	969	5,814	484	2,907
7,000	677	4,739	338	2,370	883	6,181	442	3,090
8,000	657	5,256	328	2,628	799	6,392	400	3,196

[a] Calculation based upon the formula $\hat{Y} = .818702 - .020256X$ where $\hat{Y}$ = estimated replacement cost per bird and X = capacity in thousands of birds.

[b] Calculation based upon the formula $\hat{Y} = 1.55300 - .1061512X + .001482X^2$ where $\hat{Y}$ = estimated replacement cost per bird and X = capacity in thousands of birds.

effect upon replacement cost or average investment for the two-story wood and the two-story block houses.

Investment in equipment

Average investment requirements for equipment. Average equipment replacement cost and investment per 1,000 birds are shown in Table 9. The heating system and water system were the two major capital investment items included in equipment. However, it should be noted that in most cases a water system will already be available on the farm of anyone who is contemplating producing commercial broilers and, for the purpose of this study, water system costs were pro-rated on the basis of information obtained from the producers' schedules.[1]

Table 9. Average Equipment Replacement Costs and Investment per 1,000 Bird Capacity, 184 Broiler Producers, Virginia, 1954-55

Equipment	Average replacement cost	Average investment
Heating system	$155.92	$77.96
Water system	132.82	66.41
Feeders	54.14	27.07
Waterers	20.44	10.22

[1]Estimates were obtained from the producers of the replacement cost of their present water system and of the percent of their water system costs chargeable to broilers.

Effect of type of heat on equipment investment. The type of heating equipment had a definite effect on the average replacement cost and average investment per 1,000 birds (Table 10). The average replacement cost for coal, wood or gas brooders averaged only a little more than $100 per 1,000 birds. Those producers who were using central heating systems estimated their average replacement cost to be almost $300 per 1,000 bird capacity.

Table 10. Average Replacement Costs and Investment per 1,000 Bird Capacity for Various Types of Heating Equipment, 184 Broiler Producers, Virginia, 1954-55

Type of heating equipment	Number in sample	Average capacity (number birds)	Average replacement cost per 1,000	Average investment per 1,000
Coal and wood brooders	87	3400	$107.65	$ 53.82
Gas brooders	60	5100	100.33	50.16
Central heating	56	9800	294.57	147.23
Miscellaneous and combinations	8	4200	127.18	63.59

Equipment capacity related to equipment investment. The effect of size of house on estimated replacement cost and average investment for various types of heating systems was estimated through the use of least squares regression techniques (Table 11). It was felt that replacement cost and average investment per 1,000 birds would decrease as size of house increased. This was not the case, however, with coal and wood brooders, since this type of heating equipment increased in replacement

Table 11. Effect of Size of House on Estimated Replacement Cost and Average Investment for Various Types of Heating Systems, 184 Broiler Producers, Virginia, 1954-55

Capacity (number birds)	Coal and wood brooders[a]				Gas brooders[b]				Central heating[c]			
	Replacement cost		Average investment		Replacement cost		Average investment		Replacement cost		Average investment	
	per 1,000	Total	per 1,000	Total	per 1,000	Total	per 1,000	Total	per 1,000	Total	per 1,000	Total
1,000	$ 97	$ 97	$48	$ 48	$106	$106	$53	$ 53				
2,000	103	206	52	103	104	208	52	104				
3,000	108	324	54	162	102	306	51	153				
4,000	113	452	56	226	100	400	50	200				
5,000	119	595	60	298	98	490	49	245	$331	$1655	$166	$ 828
6,000	124	744	62	372	96	476	48	288	318	1908	159	954
7,000	130	910	65	455	94	658	47	329	306	2142	153	1071
8,000	135	1080	68	540	92	736	46	368	294	2352	147	1176
9,000					90	810	45	405	283	2547	142	1274
10,000									272	2720	136	1360
11,000									262	2882	131	1441
12,000									252	3024	126	1512

[a] Calculation based upon the formula $\hat{Y} = .091812 + .005395X$ where $\hat{Y}$ = estimated replacement cost per bird and X = capacity in thousands of birds.

[b] Calculation based upon the formula $\hat{Y} = .1078515 - .002012X$ where $\hat{Y}$ = estimated replacement cost per bird and X = capacity in thousands of birds.

[c] Calculation based upon the formula $\hat{Y} = .398672 - .014589X + .000196X^2$ where $\hat{Y}$ = estimated replacement cost per bird and X = capacity in thousands of birds.

cost and investment as size increased.[1] The replacement cost and average investment for both gas brooders and central heating systems decreased with increases in size.

Costs of Production

Production cost may be divided into cash and non-cash costs.[2] Cash expenditures in commercial broiler production generally include feed cost, chick cost and other items such as medication, fuel, litter and repairs. Non-cash cost items include depreciation, interest on investment and labor. Although some producers reported hired labor, in order to put all producers on a comparable basis, all labor is considered a non-cash cost item.

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[1]It is believed that this apparent disagreement with the concept that there should be economies to scale can be explained by the fact that those producers who reported using coal and wood brooders had an average capacity of only 3,400 birds (Table 11), with many having a capacity of less than 1,000, and thus were not to be considered as highly commercialized as those other producers with a greater capacity. The estimates of replacement costs given by these small-scale growers are not believed to be as reliable as those given by producers who operate on a larger scale.

[2]The individual producer will make this distinction between cash and non-cash or fixed and variable costs as an aid in deciding whether he should start a batch of broilers, especially under conditions of low prices. Under such conditions, even though the selling price of broilers is not expected to be high enough at the end of the production period to cover average or total costs, production will be economic in the short-run so long as the selling price will more than cover the cash costs of production.

For a more complete discussion of decision-making involving minimum loss principles, see Earl O. Heady, Economics of Agricultural Production and Resource Use, Prentice-Hall, Inc., New York, 1952, p. 330.

Annual building and equipment costs

The average annual building costs and equipment costs per 1,000 bird capacity were calculated for the different major types of buildings and equipment observed in this study. These included charges for depreciation, repairs, and interest on investment. Taxes were included as a part of building cost.

Type of building related to annual building costs. Type of building construction had some effect on total annual building cost (Table 12). Two-story wood and one-story block buildings had the lowest average annual cost of less than $77 per 1,000 bird capacity. This was very little lower than the highest average annual cost reported which was over $90 per 1,000 bird capacity for the two-story block building.

Table 12. Average Annual Building Costs per 1,000 Bird Capacity for Different Types of Buildings, 184 Broiler Producers, Virginia, 1954-55

	Average annual costs per 1,000 bird capacity				
Type of building	Depreciation	Repairs	Interest on investment	Taxes	Total building cost
One-story wood	$38.71	$15.30	$20.68	$4.97	$79.66
Two-story wood	34.79	10.74	25.20	6.06	76.79
One-story block	35.88	10.64	24.57	5.78	76.87
Two-story block	42.07	13.40	28.35	6.79	90.61
Other[a]	40.53	12.56	26.81	6.44	86.34

[a]This includes one-story, two-story, and three-story buildings constructed of a variety of materials.

Average annual equipment costs. Average annual costs per 1,000 bird capacity for various types of equipment are shown in Table 13. Heating system costs which include depreciation, interest on investment, and repairs make up almost one-half the total annual equipment cost.

Table 13. Average Annual Equipment Costs per 1,000 Bird Capacity, 184 Broiler Producers, Virginia, 1954-55

Equipment	Average annual cost[a]	Percent of total
Heating system	$17.19	48.1
Water system	5.36	15.0
Feeders	8.84	24.7
Waterers	4.35	12.2
Total	$35.74	100.00

[a]Includes depreciation, interest on investment, and repairs.

Type of heat related to annual heating equipment costs. The effect of type of heating equipment on average annual heating equipment cost per 1,000 bird capacity was investigated (Table 14). Of the three major types, gas brooders show the lowest average annual cost per 1,000 birds capacity while central heating systems show the highest average annual cost. When interpreting these results, however, the difference in total labor requirements for each type of heating system should also be considered (Table 4).

These average building and equipment costs were calculated and presented on an annual basis rather than on the basis of building and equipment costs per batch. Therefore, an individual producer may determine his building and equipment costs per bird produced on the basis of the number of batches he has produced or will produce during the year. As an example, consider the case of a producer using gas brooders in a one-story block house and producing three batches of broilers per year:

Building cost per 1,000 birds (Table 12) = \$76.87 ÷ 3 = \$25.62

Equipment cost per 1,000 birds(Table 14) = \$33.77 ÷ 3 = \$11.26

Total building and equipment cost per 1,000 birds produced = \$36.88

Table 14. Average Annual Costs per 1,000 Bird Capacity Using Various Types of Heating Equipment, 184 Broiler Producers, Virginia, 1954-55

Type of heating equipment	Number in sample	Average capacity (no. birds)	Average annual heating equipment cost[a]	Average annual equipment cost[a]
Coal and wood brooders	87	3,400	\$16.62	\$35.17
Gas brooders	60	5,100	15.22	33.77
Central heating[b]	56	9,800	21.04	39.59
Combinations and miscellaneous	8	4,200	11.17	29.72

[a]Includes depreciation, interest on investment, and repairs.

[b]Includes hot water or hot air heating systems using stoker-fired coal furnace or oil furnace.

Estimating cash costs

As a means of estimating cash costs of production under various combinations of feed and chick prices and feed conversion ratios, the following formula was developed:

(1) Feed conversion ratio x cost of feed per pound = feed cost per pound of meat.

(2) .34 x cost per chick = chick cost per pound of meat.[1]

(3) Feed cost per pound of meat + chick cost per pound of meat ÷ .939 = total cash cost per pound of meat.[2]

This formula was used to calculate the costs in Table 15, assuming a feed conversion ratio of 2.4.[3]

Use of cash cost estimates. By using these tables or the formula above, an individual producer can estimate his cash costs under almost any set of conditions if he knows his usual feed conversion ratio, the cost of feed, and the cost of chicks. As an example, consider the hypothetical case of a producer who expects to maintain an average feed conversion ratio of 2.6 on feed which costs 5 cents per pound with chicks at 15 cents each. When the formula above is used to calculate the cash cost per pound of meat produced, the computations are as follows:

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[1]An average of 2.96 pounds of meat were sold for each bird started in this study. $\frac{1}{2.96}$ = .34 of a chick required to produce a pound of meat.

[2]Feed and chick costs accounted for 93.9% of the total cash costs. Use of this formula assumes that cash costs other than those for feed and chicks will vary at the same rate as do feed and chick costs.

[3]See Appendix Tables 2-5 for estimations of cash costs calculated by the same formula assuming other conversion ratios.

(1) 2.6 x \$0.05 = \$0.13

(2) .34 x \$0.15 = \$0.051

(3) $\frac{\$0.13 + \$0.051}{.939} = \$0.193$

This gives an estimated cash cost of 19.3 cents per pound of meat produced.

Table 15. Estimated Cash Cost of Production per Pound of Meat Sold,[a] at Various Feed and Chick Prices, When Feed Conversion Ratio is 2.4

Feed cost (dollars per 100)	Cost of chicks (dollars per 100)						
	12	13	14	15	16	17	18
	Cash cost per pound of meat sold (cents)						
4.00	14.6	14.9	15.3	15.7	16.0	16.4	16.7
4.25	15.2	15.6	15.9	16.3	16.7	17.0	17.4
4.50	15.8	16.2	16.6	16.9	17.3	17.7	18.0
4.75	16.5	16.8	17.2	17.6	17.9	18.3	18.7
5.00	17.1	17.5	17.8	18.2	18.6	18.9	19.3
5.25	17.8	18.1	18.5	18.8	19.2	19.6	19.9
5.50	18.4	18.8	19.1	19.5	19.8	20.2	20.6
5.75	19.0	19.4	19.8	20.1	20.5	20.9	21.2
6.00	19.7	20.0	20.4	20.8	21.1	21.5	21.9
6.25	20.3	20.7	21.0	21.4	21.8	22.1	22.5
6.50	21.0	21.3	21.7	22.0	22.4	22.8	23.1

[a]Estimated using the formula:
(1) Feed conversion ratio x cost of feed per pound = feed cost per pound of meat.
(2) .34 x cost per chick = chick cost per pound of meat
(3) Feed cost per pound of meat + chick cost per pound of meat ÷.939 = cash cost of production per pound of meat sold.

This formula is based on the assumption that cash costs other than feed and chick costs will vary at the same rate as feed and chick costs.

Under the conditions specified in this example, the producer would consider starting a batch of broilers if the price at the end of the production period was expected to exceed 19.3 cents per pound. This would allow any returns above the cash cost of production to be applied toward payment of the non-cash costs. Operation under these conditions will only be economic over the short run since, although losses will be reduced, total returns will not equal or exceed total production costs.[1]

Use of non-cash cost estimates. If the producer in the above example is to continue commercial broiler production in the long run, his returns must be greater than his total cash and non-cash costs of production.[2] Assuming that his physical production facilities include a one-story block broiler house with a capacity of 8,000 birds and a central heating system, his average total production costs when producing three batches of broilers each year would be as follows:

(1) $\dfrac{\text{Annual building costs per 1,000 birds (Table 12)}}{\text{3(number batches per year)}} = \dfrac{\$76.87}{3} =$ \$25.62 building cost per 1,000 birds

(2) $\dfrac{\text{Annual equipment costs per 1,000 birds (Table 14)}}{\text{3(number batches per year)}} = \dfrac{\$39.59}{3} =$ \$13.20 equipment cost per 1,000 birds

(3) Hours labor per 1,000 birds (Table 4) x Average wage rate[3]

44.08 x \$.478[3] = \$21.07 labor cost per 1,000 birds

Total non-cash costs per 1,000 birds \$59.89

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[1]See the discussion and reference concerning the principles of loss-minimization on the first page of this section.

[2]Heady and Jensen, op. cit., p. 68.

[3]Virginia Farm Statistics, op. cit., p. 105.

(4) Total non-cash costs per bird $= \frac{\$59.89}{1,000} = \$0.0599$

(5) $\frac{\text{Total non-cash costs per bird}}{\text{Average pounds meat sold per bird started}} = \frac{\$0.0599}{2.96} = \$0.020$ non-cash costs per pound

(6) Total cash cost per pound = \$0.193
Total non-cash cost per pound = \$0.020

Total production cost per pound = \$0.213

Under the assumptions stated in this example, the producer could profitably continue commercial broiler production in the long run if he could sell his output at a price of 21.3 cents per pound or more. However, some precautions should be observed when interpreting the results of calculations such as those above. The non-cash costs derived by such calculations are based on average costs at a specified level of operation with certain types of buildings and equipment. The cash costs are estimated using averages of weight at sale, mortality, and miscellaneous cash costs. While these would apply to the "average" producer in each case, if such an individual exists, they can only be regarded as indications of the actual cost structure of commercial broiler production when applied to the many producers who make up the industry.

CONCLUSIONS

1. On the average, broilers started during the summer months exhibited a lower feed conversion ratio than those started at any other time. They also weighed less at sale and had a lower rate of mortality. Those started during the winter had highest average mortality.

2. Average feed conversion ratio, weight at sale, and rate of mortality increased as age at sale increased.

3. Broilers required more hours of chore labor during the first week of the production period than at any other time. The least amount of chore labor was required during the fifth week.

4. Producers who used coal and wood brooders in their broiler house required an average of almost three times the amount of labor required by producers using central heating systems.

5. As size of batch increased, labor requirements per 1,000 birds decreased at a decreasing rate.

6. Average investment in buildings was affected by type of building construction. Wood houses required less investment than those constructed of cinderblocks.

7. The size or capacity of one-story wood and one-story block houses had an effect on the investment requirements per 1,000 birds. As capacity increased, investment requirements per 1,000 birds decreased, but at a different rate for each type of house.

8. The major item of equipment investment was the heating system which accounted for almost one-half the total equipment investment.

Investment per 1,000 birds in gas, coal, or wood brooding systems was only about one-third of that required for central heating.

9. The total annual charge per 1,000 bird capacity for depreciation, taxes, and interest on investment averaged lowest for the two-story wood and one-story block houses; highest for two-story block houses.

10. The type of heating system used in the broiler houses had only a slight effect on total annual heating equipment costs per 1,000 birds.

SUMMARY

This study is a summary of production costs of commercial broilers as reported by a sample of producers and contract feed dealers in the Shenandoah Valley area of Virginia. However, the findings should be applicable to all broiler producing areas of the state. The results are presented in the form of estimated costs under stated situations of production facilities, performance, and input costs. The presentation of average investment requirements for buildings and equipment needed for the production of commercial broilers should be of particular interest to prospective producers and contract dealers.

Various factor-product and factor-factor relationships were studied along with their effects on both cash and non-cash costs of production. A particular attempt was made to estimate the effects of scale on various production factors and cost items.

The multiple regression approach was used to estimate the effect of scale on building and equipment costs and the effect of weight and age at sale on feed efficiency. With very few exceptions, an increase in scale of operation was associated with a decrease in building and equipment costs and investment requirements per unit of productive capacity.

The total cost of production was divided into cash and non-cash costs, and an economic appraisal was made, using examples, of operations under varying conditions of factor costs and product prices. Computational methods are presented that will enable an individual producer

to adjust these findings to his present or prospective production methods and facilities.

Some of the precautions which should be observed when applying the results of this study in actual practices are mentioned. Errors in application will result unless the individual producer realizes the nature and extent of the deviations of his operation from the average presented in the study.

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My particular appreciation is extended to the present and former members of the Department of Agricultural Economics who have been a source of counsel and understanding throughout my course of study; especially to Dr. Harry M. Love, Chairman of the Department, for his encouragement and assistance in making possible the study; Dr. Carl W. Allen for his aid and advice during the preparation of the manuscript; Dr. Jack D. Johnson for his constructive criticisms and suggestions; Dr. T. E. Tramel for his aid during the early stages of the study; and a special note of thanks to Mrs. Mary Jane Rush, Mrs. Margaret Viles, and Mrs. Betty Morie for their help in making the calculations and typing the manuscript.

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APPENDIX

Appendix Table 1. Average Cash and Non-Cash Costs of Producing Broilers, 184 Producers, Virginia, 1954-55

Item	Cost per 1,000 birds started	Cost per pound of meat sold
	(Dollars)	(Cents)
Feed[a]	449.90	15.30
Chicks[b]	150.00	5.10
Fuel	12.32	.42
Litter	7.74	.26
Medication	6.83	.23
Building repairs	3.58	.12
Electricity	2.56	.09
Equipment repairs	1.90	.06
Taxes	1.62	.06
Insurance	.68	.02
Other	.50	.02
Total Cash Cost	637.63	21.68
Building costs[c]	117.59	.60
Equipment costs[c]	8.31	.28
Labor[d]	41.63	1.42
Total Non-Cash Cost	67.53	2.30
Total Costs	705.16	23.98

[a]Feed costs calculated at average feed conversion ratio of 2.95 and average weight at sale 3.05 pounds assuming a cost of 5 cents per pound of feed.

[b]Chick costs calculated on the basis of $15.00 per hundred.

[c]These include depreciation and interest on investment.

[d]Computed on the basis of an average labor requirement of 72.02 hours per 1,000 birds started. Labor at $0.478 per hour. Source: Virginia Farm Statistics, op. cit., p. 105.

Appendix Table 2. Estimated Cash Cost of Production per Pound of Meat Sold[a] at Various Feed and Chick Prices, When Feed Conversion Ratio is 2.6

Feed cost (dollars per 100)	Cost of chicks (dollars per 100)						
	12	13	14	15	16	17	18
	Cash cost per pound of meat sold (cents)						
4.00	15.4	15.8	16.1	16.5	16.9	17.2	17.6
4.25	16.1	16.5	16.8	17.2	17.6	17.9	18.3
4.50	16.8	17.2	17.5	17.9	18.3	18.6	19.0
4.75	17.5	17.9	18.2	18.6	18.9	19.3	19.7
5.00	18.2	18.6	18.9	19.3	19.6	20.0	20.4
5.25	18.9	19.2	19.6	20.0	20.3	20.7	21.1
5.50	19.6	19.9	20.3	20.7	21.0	21.4	21.7
5.75	20.3	20.6	21.0	21.4	21.7	22.1	22.4
6.00	21.0	21.3	21.8	22.0	22.4	22.8	23.1
6.25	21.7	22.0	22.4	22.7	23.1	23.5	23.8
6.50	22.3	22.7	23.1	23.4	23.8	24.2	24.5

[a]Estimated using the formula:

(1) Feed conversion ratio x cost of feed per pound = feed cost per pound of meat.

(2) .34 x cost per chick = chick cost per pound of meat.

(3) Feed cost per pound of meat + chick cost per pound of meat ÷ .939 = cash cost of production per pound of meat sold.

This formula is based on the assumption that cash costs other than feed and chick costs will vary at the same rate as feed and chick costs.

Appendix Table 3. Estimated Cash Cost of Production per Pound of Meat Sold[a] at Various Feed and Chick Prices, When Feed Conversion Ratio is 2.8

Feed Cost (Dollars per 100)	Cost of Chicks (Dollars per 100)						
	12	13	14	15	16	17	18
	Cash Cost per Pound of Meat Sold (Cents)						
4.00	16.3	16.6	17.0	17.4	17.7	18.1	18.4
4.25	17.0	17.4	17.7	18.1	18.5	18.8	19.2
4.50	17.8	18.1	18.5	18.8	19.2	19.6	19.9
4.75	18.5	18.9	19.2	19.6	20.0	20.3	20.7
5.00	19.3	19.6	20.0	20.3	20.7	21.1	21.4
5.25	20.0	20.4	20.7	21.1	21.4	21.8	22.1
5.50	20.7	21.1	21.5	21.8	22.2	22.6	22.9
6.00	22.2	22.6	23.0	23.3	23.7	24.0	24.4
6.25	23.0	23.3	23.7	24.1	24.4	24.8	25.2
6.50	23.7	24.1	24.5	24.8	25.2	25.5	25.9

[a]Estimated using the formula:

(1) Feed conversion ratio X cost of feed per pound = Feed cost per pound of meat

(2) .34 X Cost per chick - Chick cost per pound of meat

(3) Feed cost per pound of meat + chick cost per pound of meat ÷.939 = cash cost of production per pound of meat sold.

This formula is based on the assumption that cash costs other than feed and chick costs will vary at the same rate as feed and chick costs.

Appendix Table 4. Estimated Cash Cost of Production per Pound of Meat Sold[a] at Various Feed and Chick Prices, When Feed Conversion Ratio is 3.0.

Feed Cost (Dollars per 100)	Cost of Chicks (Dollars per 100)						
	12	13	14	15	16	17	18
	Cash Cost per Pound of Meat Sold (Cents)						
4.00	17.1	17.5	17.8	18.2	18.6	18.9	19.3
4.25	17.9	18.3	18.6	19.0	19.4	19.7	20.1
4.50	18.7	19.1	19.4	19.8	20.2	20.5	20.9
4.75	19.5	19.9	20.2	20.6	21.0	21.3	21.7
5.00	20.3	20.7	21.0	21.4	21.8	22.1	22.5
5.25	21.1	21.5	21.8	22.2	22.6	22.9	23.9
5.50	21.9	22.3	22.6	23.0	23.4	23.7	24.1
5.75	22.7	23.1	23.4	23.8	24.2	24.5	24.9
6.00	23.5	23.9	24.2	24.6	25.0	25.3	25.7
6.25	24.3	24.7	25.0	25.4	25.8	26.1	26.5
6.50	25.1	25.5	25.8	26.2	26.6	26.9	27.3

[a]Estimated using the formula:

(1) Feed conversion ratio X cost of feed per pound = Feed cost per pound of meat

(2) .34 X Cost per chick = Chick cost per pound of meat

(3) Feed cost per pound of meat + chick cost per pound of meat ÷.939 = cash cost of production per pound of meat sold.

This formula is based on the assumption that cash costs other than feed and chick costs will vary at the same rate as feed and chick costs.

Appendix Table 5. Estimated Cash Cost of Production per Pound of Meat Sold[a] at Various Feed and Chick Prices, When Feed Conversion Ratio is 3.2.

Food Cost (Dollars per 100)	Cost of Chicks (Dollars per 100)						
	12	13	14	15	16	17	18
	Cash Cost per Pound of Meat Sold (Cents)						
4.00	18.0	28.3	18.7	19.1	19.4	19.8	20.1
4.25	18.8	19.2	19.6	19.9	20.3	20.6	21.0
4.50	19.7	20.0	20.4	20.8	21.1	21.5	21.9
4.75	20.5	20.9	21.3	21.6	22.0	22.3	22.7
5.00	21.4	21.7	22.1	22.5	22.8	23.2	23.6
5.25	22.2	22.6	23.0	23.3	23.7	24.0	24.4
5.50	23.1	23.4	23.8	24.2	24.5	24.9	25.3
5.75	23.9	24.3	24.7	25.0	25.4	25.8	26.1
6.00	24.8	25.2	25.5	25.9	26.2	26.6	27.0
6.25	25.6	26.0	26.4	26.7	27.1	27.5	27.8
6.50	26.5	26.9	27.2	27.6	27.9	28.3	28.7

[a]Estimated using the formula:

(1) Feed conversion ratio X cost of feed per pound = Feed Cost per pound of meat

(2) .34 X Cost per chick = Chicks cost per pound of meat

(3) Feed cost per pound of mest + chick cost per pound of meat ✦.939 = cash cost of production per pound of meat sold.

This formula is based on the assumption that cash costs other than feed and chick costs will vary at the same rate as feed and chick costs.

Appendix Table 6. Regression Coefficients and the R^2's of the Estimation Equations for Determining the Relation of Size of Batch to Building Replacement Cost

Type of building	b_o	Producers usual capacity b_1	Producers usual capacity squared b_2	R^2
One-story wood	818.702	-.020256	a	.0634
One-story block	1553.00	-.1061512	.001482	.2264
Two-story wood	b	b	b	.1806
Two-story block	b	b	b	.3471

[a] The second term did not explain a significant portion of the variance in the Y variable; therefore it was deleted and a linear relationship computed.

[b] A "Student's" t-test of the hypothesis H_o: $\beta_i = 0$ showed these values to be non-significant at the 5% level of probability.

Appendix Table 7. Regression Coefficients and the R^2's of the Estimation Equations for Determining the Relation of Size of Batch to Labor Requirements

b_o	b_1	b_2	R^2
76.4209	-.82199	.00113	.2716

Appendix Table 8. Regression Coefficients and the R^2's of the Estimation Equations for Determining the Relation of Size of Batch on Heating Equipment Replacement Cost

Type of heating equipment	b_o	Producers usual capacity b_1	Producers usual capacity squared b_2	R^2
Coal and wood	.091812	.00539	a	.1112
Gas	.107852	-.002012	a	.0758
Central heating	.398672	-.014589	.000196	.1973

[a]The second degree term did not explain a significant portion of the variance in the Y variable; therefore it was deleted and a linear relationship computed.

Appendix Table 9. Regression Coefficients and the R^2's of the Estimation Equations for Determining the Relationship of Age and Weight at Sale on Feed Efficiency

b_o	Weight at sale b_1	Age at sale b_2	Weight at sale squared b_3	Age at sale squared b_4	R^2
7.3490	-4.885	-.1213	a	.001077	.1109

[a]The second degree term of the first X variable did not explain a significant portion of the variance in the Y variable; therefore, it was deleted and the regression coefficients and R^2's recomputed. See Ostle, <u>op. cit.</u>, p. 224.

Name________________ Address________________ Dealer________________

Table 1. Buildings

House No. / Type construction	Size L.	Size W.	Size area not used by chick Length	Size area not used by chick Width	Usual capacity	When built	Cash cost when built Mater-ials	Cash cost when built Hired labor	Cash cost when built Total	Non-cash cost when built Value of farm mater-ials used	Non-cash cost when built Value of non-hired labor used	Replace-ment cost	Yrs. life remaining	Cost of repairs 7/1/54-6/30/55	No. broods broilers started 7/1/54-6/30/55	No. weeks used for turkeys
1.																
2.																
3.																
4.																
5.																

For houses originally constructed for other uses, total years of useful life of house of similar material if constructed for broilers________.

Table 2. Equipment

Type equipment	Year purchased	Cost when purchased	Replacement cost	Years life remaining	Cost of repairs, 7/1/54 - 6/30/55
Water system					
Waterers (automatic) (non-automatic)					
Feeders (automatic) (non-automatic)					
Heating system (type)					

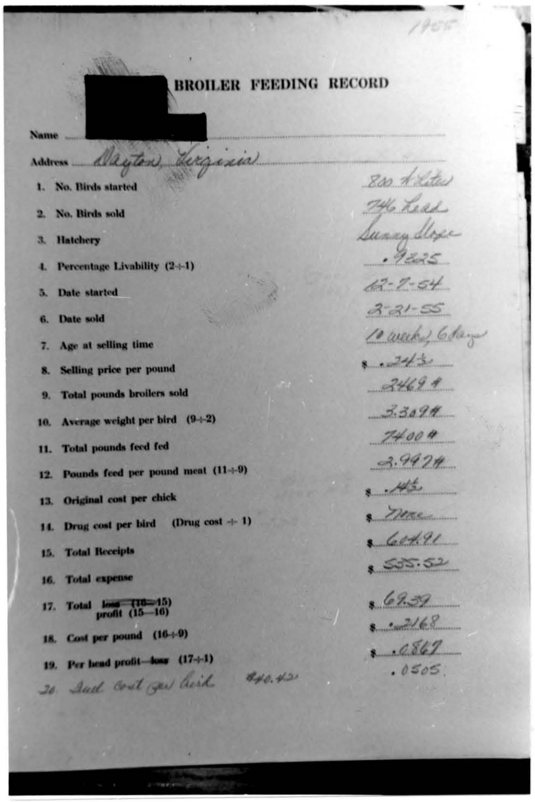
Exhibit 1. Sample Producer Schedules

Table 3. Labor utilization for period broilers are in house

House No.	Total hours of labor per day for daily chores, vacinating, debeaking, etc. during										
	1st week	2nd week	3rd week	4th week	5th week	6th week	7th week	8th week	9th week	10th week	11th week
1.											
2.											
3.											
4.											
5.											
Total											

1. Is heat controlled by thermostat? Yes_____ No______.
2. Is any type of forced ventilation used? Yes_____ No_____.
3. Percentage of water system chargeable to broilers___________.
4. Annual cost of electricity chargeable to broilers___________.
5. Dealer furnishes fuel _________, pays you a flat rate for fuel based on number of chicks ______, pays you cost of fuel furnished by you_________.
6. Dealer furnishes litter_________, pays you a flat rate for litter based on number of chicks_________, pays you cost of litter furnished by you____.
7. Do feed sacks become your property? Yes_____ No_____. If yes, for what price can you sell them? ___________________________.
8. How often do you remove litter and manure from broiler houses?____.
9. When manure is removed from houses, is it used by you____________, sold_______________, given away________________?
   a. If manure is sold, price which can be gotten for manure from_______________brood(s) of _______________birds each.
   b. How many hours of labor on your part are required in removing manure from______________brood(s) of _____________birds each?
10. How many total hours of labor are required, in addition to labor required in removing litter and manure, for cleaning, disinfecting, etc., between broods for house No. 1______, No. 2______, No. 3______, No. 4_______, No. 5_______?
11. Other costs in broiler production not included when contract is settled (telephone, automobile, etc., specify)__________________$ ________per year, _______________$ ____________per year, _______________$ _________________per year.

Exhibit 1. (Continued)



1955

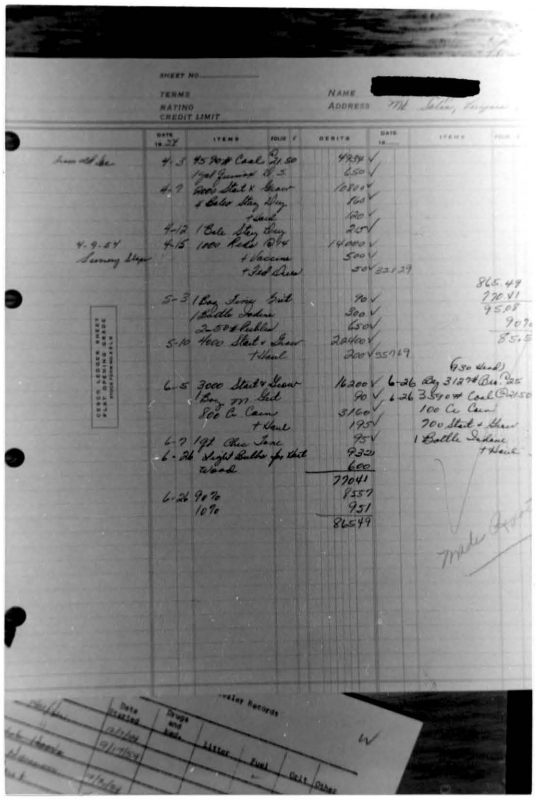
[redacted] BROILER FEEDING RECORD

Name [redacted]

Address Dayton, Virginia

1. No. Birds started	800 Whites
2. No. Birds sold	746 head
3. Hatchery	Sunny Slope
4. Percentage Livability (2÷1)	.9325
5. Date started	12-7-54
6. Date sold	2-21-55
7. Age at selling time	10 weeks, 6 days
8. Selling price per pound	$ .24½
9. Total pounds broilers sold	2469#
10. Average weight per bird (9÷2)	3.309#
11. Total pounds feed fed	7400#
12. Pounds feed per pound meat (11÷9)	2.997#
13. Original cost per chick	$ .14½
14. Drug cost per bird (Drug cost ÷ 1)	$ None
15. Total Receipts	$ 604.91
16. Total expense	$ 535.52
17. Total ~~loss (16—15)~~ profit (15—16)	$ 69.39
18. Cost per pound (16÷9)	$ .2168
19. Per head profit—~~loss~~ (17÷1)	$ .0867
	.0505

20. Feed cost per bird #40.42



SHEET NO.

TERMS

RATING

CREDIT LIMIT

NAME [redacted]

ADDRESS Mt. Solon, Virginia

CESCO LEDGER SHEET FLAT OPENING GRADE

DATE 1954	ITEMS	FOLIO	DEBITS	
4-3	45 90# Coal @21.50		4934	
	1 gal ...		650	
4-7	2000 Start & Grow		10800	
	4 Bales Stay Dry		160	
	+ Haul		120	
4-12	1 Bale Stay Dry		25	
4-15	1000 Reds @14		14000	
	+ Vaccine		500	
	+ Feed ...		50	321.29
5-3	1 Bag Fine Grit		90	
	1 Bottle Iodine		300	
	2-50# Pebbles		650	
5-10	4000 Start & Grow		22400	
	+ Haul		200	557.49
6-5	3000 Start & Grow		16200	
	1 Bag M. Grit		90	
	800 ...		3160	
	+ Haul		195	
6-7	1 qt Chic Tone		95	
6-26	Light Bulbs for that		932	
	Wood		600	
			77041	
6-26	90%		8557	
	10%		951	
			86549	

4-9-54 Sunny Slope

(630 head)

6-26 By 3127# Br. @25

6-26 3540# Coal @21.50

100 ...

700 Start & Grow

1 Bottle Iodine

+ Haul

865.49

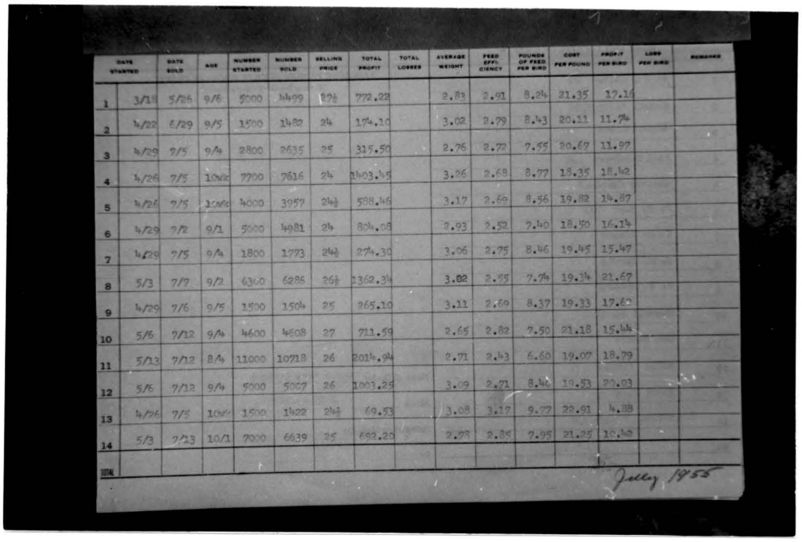
770.41

95.08

90%

85.5

...aler Records — Date Started, Drugs and ..., Litter, Fuel, Grit, Other



	DATE STARTED	DATE SOLD	AGE	NUMBER STARTED	NUMBER SOLD	SELLING PRICE	TOTAL PROFIT	TOTAL LOSSES	AVERAGE WEIGHT	FEED EFFICIENCY	POUNDS OF FEED PER BIRD	COST PER POUND	PROFIT PER BIRD	LOSS PER BIRD	REMARKS
1	3/18	5/26	9/6	5000	4499	27½	772.22		2.83	2.91	8.24	21.35	17.16		
2	4/22	6/29	9/5	1500	1482	24	174.10		3.02	2.79	8.43	20.11	11.74		
3	4/29	7/5	9/4	2800	2635	25	315.50		2.76	2.72	7.55	20.67	11.97		
4	4/26	7/5	10wk	7700	7616	24	1403.45		3.26	2.68	8.77	18.35	18.42		
5	4/26	7/5	10wk	4000	3957	24½	588.46		3.17	2.69	8.56	19.82	14.87		
6	4/29	7/2	9/1	5000	4981	24	804.08		2.93	2.52	7.40	18.50	16.14		
7	4/29	7/5	9/4	1800	1773	24½	274.30		3.06	2.75	8.46	19.45	15.47		
8	5/3	7/7	9/2	6300	6286	26½	1362.34		3.82	2.55	7.74	19.34	21.67		
9	4/29	7/6	9/5	1500	1504	25	265.10		3.11	2.69	8.37	19.33	17.62		
10	5/6	7/12	9/4	4600	4508	27	711.59		2.65	2.82	7.50	21.18	15.44		
11	5/13	7/12	8/4	11000	10718	26	2014.94		2.71	2.43	6.60	19.07	18.79		
12	5/6	7/12	9/4	5000	5007	26	1003.25		3.09	2.71	8.46	19.53	20.03		
13	4/26	7/5	10wk	1500	1422	24½	69.53		3.08	3.17	9.77	22.91	4.88		
14	5/3	7/13	10/1	7000	6639	25	692.20		2.78	2.85	7.95	21.25	10.40		
TOTAL															

July 1955

Exhibit 2. Samples of Photographic Reproductions of Dealer Broiler Contract Summaries - Names of Producers and Dealers Obliterated

AN ESTIMATION OF THE COSTS ASSOCIATED WITH
COMMERCIAL BROILER PRODUCTION IN VIRGINIA

by

James Harkins Simpson, Jr.

Abstract of Thesis submitted to the Graduate Faculty of the
Virginia Polytechnic Institute
in candidacy for the degree of
MASTER OF SCIENCE
in
Agricultural Economics

June 1958

Blacksburg, Virginia

ABSTRACT

This study is a summary of production costs of commercial broilers as reported by a sample of producers and contract feed dealers in the Shenandoah Valley area of Virginia. The results are presented in the form of estimated costs under stated situations of production facilities, performance, and input costs. The presentation of average investment requirements for buildings and equipment needed for the production of commercial broilers should be of particular interest to prospective producers and contract dealers.

Various factor-product and factor-factor relationships are studied along with their effects on both cash and non-cash costs of production. A particular attempt is made to estimate the effects of scale on various production factors and cost items.

The multiple regression approach is used to estimate the effect of scale on building and equipment costs and the effect of weight and age at sale on feed efficiency. The total cost of production is divided into cash and non-cash costs, and an economic appraisal is made, using examples, of operations under varying conditions of factor costs and product prices. Computational methods are presented that will enable an individual producer to adjust these findings to his present or prospective production methods and facilities.