USE AND INTERRELATION OF MARGINAL ANALYSIS AND OTHER ANALYTICAL PROCESSES BY FARMERS IN DECISION MAKING

by

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INTRODUCTION

Empirical evidence bearing on the use of analytical processes by farmers when making decisions has not been available. The processes they use or are capable of using have direct implications upon the type of research conducted for and the type of information and training made available to them. This study concentrates upon a consideration of some factual material on processes used and interpretation and meaning of the results.

Analytical processes may be of different degrees of refinement. Marginal analysis is the most exact process, and is regarded as an appropriate technique for solving farm problems. Although these principles are probably touched upon in all college level farm management courses, and an increasing number of experiments and surveys are being designed to yield information of a marginal nature, it is not known which farmers or how many use this process.

It can be reasoned that any farmer who uses marginal analysis must be able to figure costs and returns. In fact, figuring costs and returns, either financially or otherwise, is a part of marginal analysis. A farmer cannot use marginal analysis unless the data are made available to him directly from a study conducted by others or unless he can figure costs and returns. It is therefore argued that for a farmer to use marginal analysis he must be able to figure costs and returns. Not all costs and returns that are figured may be of a marginal nature and some of this figuring may be of value even if it does not lead to a marginal analysis. Its relation to marginal analysis is clear and it is because of this tie that the study of methods farmers use to figure costs and returns were also studied intensively.

On the other hand, figuring costs and returns is a deductive process. It is a thought process the decision maker uses to deduce the outcome of a

problem based upon specified assumptions. For this reason type of reasoning forms the first of three major portions of this work.

Type of reasoning forms the first link in the managerial chain. All those farmers who can figure costs and returns and use marginal analysis would be expected to use deductive reasoning.

Likewise, figuring costs and returns is the second link. Some of those farmers who can think deductively can figure costs and returns, and all those farmers using marginal analysis would figure costs and returns.

Moving along the chain this way leads to the farmers using marginal analysis, the ultimate technique with respect to analytical development. Some farmers will use deductive thinking but not figure costs and returns. There will also be some who can reason deductively and figure costs and returns but not use marginal analysis. Some farmers will remain in the chain through the marginal analysis phase.

For each stage in the chain, what will be called "external conditioning factors" will also be related. Examples of these include age, education, net worth, main product, and others.

Three general hypotheses emerge. These are (1) Farmers use or are capable of using deductive reasoning, and this is necessary if they are to also figure costs and returns. (2) Farmers figure costs and returns, and this is necessary if they are to use marginal analysis. (3) The use of each stage of the process is also influenced by external conditioning factors.

THEORETICAL CONCEPTS

Inductive and Deductive Reasoning

Searles (9), p. 4, defines the process of deduction as "methods of correct

reasoning from premises to conclusion, or the methods of supporting conclusions by premises which imply them". He contrasts deduction to induction which he defines as "the method of arriving at general conclusions of varying degrees of probability on the basis of factual evidence". Deduction can be termed the "method of formal proof", while induction is often designated the "method of discovery".

It is generally recognized that both deductive and inductive reasoning are necessary. There is not complete agreement as to the proportions of each that should be used. For example, Haney (4), p. 309, was critical of Ricardo because he felt that the premises upon which he based his work were often merely taken for granted. This suggests that if deductive reasoning is not combined with a certain minimum amount of basic truth obtained by induction, the decision rendered may be a poor one.

According to Searles, "induction provides the groundwork for hypotheses, and deduction explores the logical consequences of the hypotheses, in order to eliminate those that are inconsistent with the facts, while induction again contributes to the verification of the remaining hypothesis."

Knight (8), p. 6, emphasizes the point made by Mill that "we must reason deductively as far as possible, always collating our conclusions with observed facts at every stage."

Information of much value can be obtained by farmers through the process of induction from agricultural colleges, the extension service, and other agencies. Through the use of test plots and experimental farms situated in various type-of-farming areas, factual evidence regarding certain production practices is obtained. To the extent that the experimental farm conditions from which the evidence was obtained are similar to conditions existing on

individual farms direct application of this information can be made by farmers. This serves as an illustration of the usefulness of the inductive method of reasoning.

Weaknesses resulting from the use of induction exclusively by farmers are readily apparent. No two farm units have identical resources, and no privately owned farm is exactly like the experimental farms. It does not appear that it would ever be possible to provide all the data necessary to fit all conditions on all farms. However, if farmers can reason deductively, the problem of providing this mass of data becomes less serious.

Figuring Costs and Returns

For farmers to achieve their goals with the resources they have, cost and return figures must be available to them. These measurements may or may not be in monetary terms, and may be figured in writing or in the head or both. Some farmers will not be able to figure these. For them, the figures will have to be supplied. The problem again is to provide enough costs and returns measures to fit all the conditions and problems needing solution. The likes and dislikes, the goals of farmers differ. Also, as conditions change, especially costs and prices, the cost and return figures will all need to be changed. The problem of providing all the necessary figures for all conditions, for farmers with all types of goals, again appears formidable.

Some farmers can figure the costs and returns for themselves. If so, then only certain necessary basic data will need to be supplied. The problem here is far less serious. They can figure costs and returns in light of their own goals, and as costs and price levels change, they will have the necessary basic data and can make the adjustments in the costs and returns as needed.

Marginal Analysis

The figuring of costs and returns may be at different levels of analytical refinement. They may be rather crude, perhaps not going beyond averages. Such information may have value in their decision making. For some problems it may be considerably inferior to marginal analysis.

Bradford and Johnson (2), p. 365, describe marginal analysis by stating that "this body of deductive thought processes concentrates upon problems of defining and locating the most profitable combinations of inputs and enterprises as well as the most profitable levels of output." These "most profitable" levels of output for an enterprise occur at the point where the additional cost of producing one more unit of output just equals the additional return obtained from the production of this additional unit.

By use of average data it is possible for farmers to determine total profit for an entire enterprise. By dividing this total profit by the number of producing units, the farmer can obtain the average profit per producing unit. Determination of this figure involves figuring costs and returns in one form, and is of some value to the farm operator for planning purposes. A basic weakness of this system is that even though the farmer knows whether or not a profit has been made, it is not possible for him to determine the most profitable level of production. Possibly increasing or decreasing the size of the enterprise would yield a greater total return.

The difference between use of averages and marginals can also be illustrated with Fig. 1. Curve AC is an average cost curve and curve MC is a marginal cost curve. These are presented as in any elementary textbook of static economic principles, where a firm operates under perfect competition, perfect knowledge, etc. Consider a farmer producing an output of A. His

profit equals A ($p - AC_A$). He is considering expanding output. He knows his average costs for an output of B units. He knows that AC is less when output is B than when only A units are produced. He also knows his new profit would be B ($p - AC_B$), which is considerably greater than if only A units are produced.

His profits are not a maximum with B units produced. If marginal data were available to him, he would produce C units, where MC = price, and where profits were a maximum.

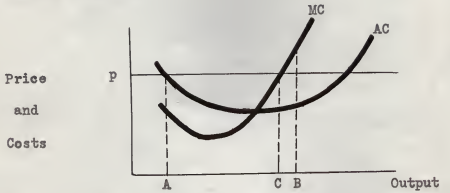

Fig. 1. Average and marginal cost curves.

Farmers probably fall into three groups with respect to use of information in marginal form. A first group cannot use it even if made available. A second could use it if made available and a third could reason and figure out data in a marginal form if only certain basic data were made available.

The problem of supplying the necessary information would be the most manageable if large numbers of farmers fell into the third group. Here the problem would consist of teaching farmers economic principles and possibly supplying a minimum of basic data.

Farmers falling in the second group would also need some training in economic principles. Here, however, the problem of supplying all the necessary

data, all in marginal form, for all possible conditions, becomes nearly formidable. It would be most encouraging if a large number of farmers fell in the third group or could be trained so they would fall in that group.

PROCEDURE

The Empirical Data

All data used in this study were obtained by a personal interview survey of 1075 farm managers. This survey was organized and conducted by agricultural economics personnel from Agricultural Experiment Stations in seven of the fourteen North-Central states. The states, and the number of records from each state, are as follows: Kentucky, 124; Ohio, 137; Indiana, 189; Michigan, 229; North Dakota, 129; Iowa, 120; and Kansas, 147. The project, known as The Interstate Managerial Study, was conceived and developed by the Risk and Uncertainty Subcommittee within the North Central Farm Management Research Committee. The services of the Farm Foundation were used to establish the cooperative relations among the participants from the various states.

Questionnaire

Members from the cooperating states, with the assistance of a Sociologist from Michigan State University, formulated the questionnaire, which included 66 questions. Michigan State University accepted the responsibility for training interviewers and coding of the data preparatory to analysis. Most of the data were gathered during the summer of 1954.

The Interstate Managerial Survey was an empirical one dealing with the decision making process in farming. Recently developed managerial concepts suggest that farm management research needs to place more emphasis on the

decision making or managerial process. With this goal in mind, survey questions were designed that can be classified functionally as follows:

1. Information needs.
2. Analytical problems and processes in the management function.
3. Expectations.
4. Strategies.
5. Knowledge situations.
6. Applications of risk bearing.
7. Controls.

The assignment here has been narrowed to those questions bearing on the hypotheses as specified above. Questions studied intensively on this particular work are given in the appendix in the exact form in which they were asked. The complete list of questions used in the entire study will be published in a forthcoming publication authored by members of the cooperating states.

Because of the length of the questionnaire, some of the questions were rotated so that no respondent would have to answer all of them. Questions were divided among six separate forms which were used in a fixed rotation. Questions were arranged in such a way as to facilitate anticipated cross tabulation.

Some of the questions in the questionnaire consisted of hypothetical problems set up to gain certain insights, while others dealt with real world problems which the respondent had faced. Many questions were open-ended because there was little basis for predicting what the answers might be, and it was hoped that as wide a range of complete responses as possible would be obtained. Since some of the questions involved difficult concepts such as inductive and deductive reasoning and use of marginal analysis, illustrative

cards were prepared for the respondent to use. The cards were designed to clear up certain concepts with which the farmer might be unfamiliar. In some cases farmers were asked to give examples which were designed to ascertain their understanding of certain principles. The examples given were then considered either verified or not verified depending on whether or not they satisfied specified definitions.

Sample

Each participating state indicated the area or areas for sampling and the number of schedules they had the time and money to obtain. Michigan used two survey areas and each of the other states used one area.

The universe was restricted to farms with an average gross income of 2500 dollars or more. Farms with livestock share leases, tobacco share croppers, and two-family partnerships were excluded because of the probability of dual decision making under such arrangements.

The Statistical Laboratory at Iowa State College assisted with the drawing of the sample. A stratified random sample within each selected state area was taken.

ANALYSIS

Inductive and Deductive Reasoning

Type of Reasoning. The importance of deductive reasoning in figuring costs and returns and in the use of marginal analysis has been argued. It is believed necessary to determine if farmers who reason deductively possess characteristics that set them apart from other farmers. A number of characteristics, or variables called "external conditioning factors", were related to

type of reasoning. The type of reasoning in turn has been presented in three ways-- (a) Combinations of induction and deduction used, i.e., whether farmers used mainly deduction, mainly induction or a combination, (b) proportion of thinking deductive and (c) verified examples given by farmers. Information in (a) and (b) was obtained directly by question 13 (appendix) while (c) was coded from examples farmers gave to support the type of reasoning they claimed to use.

Combinations of Induction and Deduction. Farmers were asked to indicate which of the two methods or combination of the two methods they used to arrive at conclusions. The responses are related to other variables in Tables 1 and 2.

Sixty-two and two-tenths per cent of the farmers who answered the question said they used a combination of induction and deduction. Eleven and two-tenths per cent used mainly deduction, while mainly induction was used by 23.5 per cent of all farmers questioned. Other answers, were given by 3.2 per cent of the farmers. Approximately three-fourths of the farmers reported using deductive reasoning either alone or in combination with inductive reasoning.

Table 1 is a two-way table showing the influence of different levels of both age and education. The age groups were under 40 years, 40-54.9 years and 55 and above, and the education groups were no more than 8 grades completed and above 8 grades completed. This type of table, which is also used elsewhere in this study, permits the study of responses of farmers of a given age (range) for the two levels of education, or responses of a given level of education for farmers of different ages. This type of information is more detailed than a table where the effects of either age or education

Table 1. Relation of use of induction and deduction by farmers to different levels of both age and education for farmers sampled.

Age and education	Number of farmers	% combinations of induction and deduction used: Both induction and deduction	Mainly deduction	Mainly induction	Other answers *
Education					
Grades 1-8					
Age:					
Under 40	49	59.2	16.3	22.4	02.0
40-54.9	87	52.9	08.0	33.3	05.7
55 and above	111	56.8	05.4	32.4	05.4
Above 8 grades					
Age:					
Under 40	126	69.0	19.8	10.3	00.8
40-54.9	109	68.8	11.0	17.4	02.8
55 and above	55	61.8	03.6	32.7	01.8
All age groups					
Education					
Grades 1-8	247	55.9	08.5	30.8	04.9
Above 8 grades	290	67.6	13.4	17.2	01.7
All education levels					
Age					
Under 40	175	66.3	18.9	13.7	01.1
40-54.9	196	61.7	09.7	24.5	04.1
55 and above	166	58.4	04.8	32.5	04.2
All farmers **	537	62.2	11.2	23.5	03.2

* Other answers include induction only, deduction only, not ascertainable, neither induction nor deduction, and don't know.

** Age and education ascertained.

Table 2. Relation of use of induction and deduction by farmers to net worth and main product.

Factors	Number of farmers	% of combinations of induction and deduction used: Both induction and deduction	Mainly deduction	Mainly induction	Other answers*
Net worth					
Under $20,000	148	55.4	16.2	26.4	02.0
$20,000-$49,999	234	62.0	11.1	24.4	02.6
$50,000 and over	126	69.8	07.1	19.8	03.2
Main Product					
Hogs	136	61.0	15.2	22.1	03.7
Wheat	113	54.0	18.6	23.9	03.5
Dairy	85	65.9	05.9	27.1	01.2
Corn and other feed	81	69.1	07.4	22.2	01.2
Beef and sheep	50	66.0	10.0	18.0	06.0
Others **	76	61.8	07.9	26.3	03.9
All farmers	541	62.1	11.3	23.5	3.1

* Other answers include induction only, deduction only, not ascertainable, neither induction nor deduction, and don't know.

** "Others" includes tobacco, soybeans and flax, beans, vegetables and truck crops, poultry and eggs, and not ascertainable.

is studied by itself across all levels of education or age, respectively, although information in this form is also presented in Table 1 and other tables.

Younger farmers of both the low and high education groups made a greater use of deduction and a lesser use of induction than did older farmers in their respective education groups.

A comparison of responses for farmers in the low education group with those from farmers with more education, with farmers grouped by age, was also made. The better educated farmers used more deduction and less induction than did the low education group, and this relation holds for all age groups.

In the sample studied, the less educated farmers also were older, and vice versa, and the more educated farmers were younger and vice versa. This being true, and because the less educated, and older farmers use more induction while the more educated, and younger farmers use more deduction, it was expected that for responses grouped by age, the relations would be even more exaggerated when no stratification was made for education. Likewise, the same was expected for responses grouped by education when no stratification was made for age. Data in the lower portion of the table, education levels across all age groups and age groups across the two education levels, confirms this. For this reason the two-way table was used so that the effects of age and education might be studied when education and age respectively were somewhat taken into account by stratification.

Table 2 shows the relationship between two other external variables and the use of induction and deduction by farmers. The two variables considered were net worth and the main product produced on the farm.

Fifty-five and four-tenths per cent of the 148 farmers with a net worth of less than $20,000 said that they used a combination of both induction and

deduction to arrive at conclusions. This compared with 69.8 per cent for the 126 farmers who had a net worth of $50,000 and over. A smaller percentage of farmers with a low net worth used a combination of induction and a higher percentage of them used mainly induction and mainly deduction than did the other farmers.

A comparison was made between answers given by farmers specializing in different products. No clear-cut relations were evident with this grouping. It was noted, however, that only 5.9 per cent of the dairy farmers said that they used mainly deduction compared with 11.3 per cent for all the farmers questioned. Possibly the dairy enterprise is better adapted to the use of induction than are other types of production. Once the initial organization of the dairy enterprise is developed and the physical plant established, it is probable that fewer production adjustments would need to be made than would be true for the production of most other products.

Proportion of Thinking Deductive. Answers to question 13 yielded information on the number of farmers claiming to do various proportions of their thinking inductively and deductively. The results of the study are as follows:

Proportion of time thinking	Percentage of farmers	
	Inductive	Deductive
None	0.4	4.1
Less than 1/4	1.3	8.5
About 1/4	7.4	18.5
Between 1/4 and 1/2	5.7	9.4
About 1/2	31.1	29.8
Between 1/2 and 3/4	11.6	5.9
About 3/4	17.7	8.3
More than 3/4 but not all	7.8	1.3

All	4.1	0.4
Don't know how much but not all	6.3	6.5
No answer	6.7	7.4

Only the proportion of thinking deductive was singled out for further study in this work. For purposes of analysis, the groups were combined into less than 1/2, about 1/2, more than 1/2, and don't know.

Table 3 is a 2-way table showing the influence of age and education upon proportion of thinking deductive. Of the 537 farmers questioned, 40.6 per cent estimated that less than one-half of their thinking was deductive. Thirty per cent felt that about one-half was deductive. Only 15.6 per cent answered that more than one-half of their thinking was deductive, while 13.7 per cent didn't know.

The results shown in Table 3 are very similar to those shown in Table 1. Younger farmers of the low education group indicated a greater proportion of their thinking was deductive than did the older farmers. The same relationship existed in the high education group. Likewise, for given age groups, a smaller percentage of the more highly educated farmers used less than 1/2 deductive thinking and a larger percentage used about 1/2 and a larger percentage used more than 1/2 deductive thinking. When age groups were collapsed, the farmers educated beyond the 8th grade indicated clearly they used more deductive thinking, as did the younger farmers when education levels were not used.

Verification. An effort was made to verify the understandings of induction and deduction. The interviewers asked farmers to give an example of each type of reasoning the farmer claimed to use. The examples given by the farmers were critically analyzed. Verification of understanding of induction

Table 3. Relation of use of deductive thinking by farmers to different levels of both age and education for farmers sampled.

Age and education	Number of farmers	Proportion of thinking deductive			
		Less than 1/2	About 1/2	More than 1/2	Didn't know and no answer
		%	%	%	%
Education					
Grades 1-8					
Age:					
Under 40	49	42.9	22.4	16.3	18.4
40-54.9	87	48.3	24.1	10.3	17.2
55 and above	111	47.7	25.2	09.9	17.1
Above 8 grades					
Age:					
Under 40	126	32.5	35.7	27.8	4.0
40-54.9	109	28.4	40.4	15.6	15.6
55 and above	55	54.5	21.8	07.3	16.4
All age groups					
Education					
Grades 1-8	247	47.0	24.3	11.3	17.4
Above 8 grades	290	35.2	34.8	19.3	10.7
All education levels					
Age:					
Under 40	175	35.4	32.0	24.6	8.0
40-54.9	196	37.2	33.2	13.3	16.3
55 and above	166	50.0	24.1	09.0	16.8
All farmers *	537	40.6	30.0	15.6	13.7

* Age and education ascertained.

and deduction for each farmer depended upon whether or not the example fell within certain definitions of induction and deduction. The following definitions were the ones upon which verifications were based:

Definition of induction.

a. A generalized conclusion drawn on the basis of one or more personal observations of anyone's experience.

(1) Generalized conclusion.

(a) If based on the experience of others the conclusion must refer to more than the respondent's own case.

(b) If based on the respondent's own experience conclusion must refer to more than one further occurrence.

Definition of deduction.

a. Conclusions must be specific.

b. Premises must be stated.

c. There must be some evidence of a reasoned and a reasonable relationship between premises and conclusions.

Not verified.

a. Does not meet the conditions for induction and/or deduction.

b. Both are present even though induction only seems to be used in the derivation of the premises for deduction.

c. Descriptions of behavior without description of thought process.

d. Blank.

e. Confusing answer.

These specifications for verification of induction and deduction were rather stringent. As may have been expected percentages of verifications were relatively low. Table 4 shows the percentages of verifications for all farmers sampled and also the relation of verifications to certain external

Table 4. Relation of verification of induction and deduction to certain external conditioning factors for farmers sampled.

External variables	Number of farmers	% of farmers with different verification: Both induction and deduction verified	Only deduction verified	Only induction verified	Neither verified
Age:					
Under 40	173	02.9	02.9	17.3	76.9
40-54.9	192	02.1	03.1	18.2	76.6
55 and above	165	02.4	04.8	18.8	73.9
Education:					
Grades 1-8	241	02.9	01.7	13.3	82.2
Above 8 grades	289	02.1	05.2	22.1	70.6
Net worth:					
Under $20,000	146	02.7	01.4	11.6	84.2
$20,000-$49,999	229	01.3	03.1	19.2	76.4
$50,000 and over	126	04.8	06.3	23.8	65.1
Main product:					
Hogs	135	02.2	05.2	15.6	77.0
Wheat	107	04.7	06.5	29.0	59.8
Dairy	85	01.2	03.5	15.3	80.0
Corn and other feed	81	01.2	01.2	17.3	80.2
Beef and sheep	49	04.1	0.0	22.4	73.5
Others *	75	01.3	01.3	08.0	89.3
All farmers	532	2.4	3.6	18.0	75.9

* "Others" includes tobacco, soybeans and flax, beans, vegetables and truck crops, poultry and eggs, fruit, and not ascertainable.

variables.

Two and four-tenths per cent of the 532 farmers questioned gave replies which verified their understanding of both induction and deduction. A slightly higher percentage gave examples of only deduction that were verified, and 18.0 per cent gave verified examples of inductive thinking. With the prescribed requirements for verification, more than three-fourths of the answers given could not be verified for any of the three categories of reasoning.

Age had only a very slight effect on the percentage of verifications. A direct relationship did appear between level of education and percentages of verifications both for only deduction and only induction. Those farmers with more education had a higher percentage of verifications for these types of thinking.

No definite trend existed between the size of net worth and per cent of verifications. It was noted, however, that the high net worth group was consistently above those with lower net worths in percentages of verification for induction, deduction, and a combination of both. An extremely high percentage of farmers with a low net worth did not give verified answers for either type of reasoning.

The percentages of verifications were fairly consistent for responses of farmers where farmers were grouped according to major product. Wheat farmers, however, did have somewhat higher percentages of verifications than did the others.

In general, the number of farmers giving answers that could not be verified for either of the types of reasoning was so large and the number of farmers giving verified answers was so small that less could be learned from Table 4 than from Tables 1, 2 and 3.

Summary. Farmers who use or are capable of using deductive reasoning do possess distinguishing characteristics. There is rather clear evidence that young farmers use more of this type of reasoning, as do farmers with more education.

Costs and Returns

The necessity for figuring costs and returns for marginal analysis has been stated. Question 10, (appendix) was used to determine if farmers figured costs and returns and if so, what method was used to figure. The all farmers line of Table 5 summarizes the responses given by the 562 farmers sampled. Only 10.2 per cent of the farmers said that they did not figure costs and returns. That means that 89.8 per cent figured costs by writing out or by figuring in the head or by both methods. Fifty-two and two-tenths per cent of those who said they sometimes figure costs and returns indicated they do this by writing, compared to 84.6 per cent who sometimes figure these out in the head. The percentages of farmers who figure by writing out only, in the head only, and by both writing and in the head are shown. As might be expected very few farmers (only 3.3 per cent) stated that they figure costs and returns only by writing.

Farmers were asked to give examples of each type of reasoning they claimed to use. These answers were classified as verified or unverified. Thirty-four and eight-tenths per cent were able to give verified examples of both types of reasoning.

A study was made to determine if those farmers figuring costs and returns were different from other farmers. Of the many characteristics that might have been examined, type of reasoning, as observed from answers to questions

Table 5. Relation of method used to figure costs and returns, both in writing and in head, verified and unverified, to various proportions of deductive thinking and type of reasoning used by farmers.

Reasoning	Number of farmers	% of farmers who: Do not figure	Write out: Verified	Write out: Unverified	Write out: Total	Figure in head: Verified	Figure in head: Unverified	Figure in head: Total	Figure: Write out only	Figure: In head only	Figure: Do both, verified
Proportion deductive											
Less than 1/2	88	56.8	34.1	11.4	45.5	73.9	17.0	90.9	02.3	46.6	23.9
About 1/2	49	02.0	63.3	06.1	69.4	77.6	18.4	96.0	0.0	28.6	49.0
More than 1/2	21	0.0	71.4	04.8	76.2	76.2	09.5	85.7	14.3	23.8	47.6
Type of reasoning											
Inductive	5	0.0	20.0	0.0	20.0	100.0	0.0	100.0	0.0	80.0	20.0
Deductive	47	06.4	42.6	06.4	49.0	78.7	04.3	83.0	04.3	38.3	42.6
Integrated inductive-deductive process	74	23.0	44.6	0.0	44.6	64.9	08.1	73.0	02.7	32.4	35.1
All farmers	362	10.2	45.6	6.6	52.2	72.7	11.9	84.6	3.3	35.9	34.8

13 and 20, (appendix) and the external conditioning factors age and education were studied.

It has been hypothesized that those farmers figuring costs and returns use deductive reasoning. This hypothesis is tested by the data in Table 5, where the methods used by farmers to figure costs and returns were related to type of reasoning used. These data lend considerable support to the hypothesis as stated.

More than one-half (56.8 per cent) of the 88 farmers who indicated that less than one-half of their thinking was deductive did not figure costs and returns. All of the farmers who said that more than one-half of their thinking was deductive figured costs and returns. The relation between the proportion of deductive reasoning used and the percentages of farmers who figured costs and returns by writing was direct, but approximately equal percentages (all rather high) of farmers in each group figured in the head. A higher percentage of those farmers with about one-half or more deductive thinking gave verified examples of both types of reasoning. A higher percentage of farmers whose thinking was less than one-half deductive figured in the head only, and a higher percentage gave unverified answers for writing out and figuring in the head than did the other groups.

The method of figuring costs and returns was also related to type of reasoning as coded from answers farmers gave on their decision to buy their last major piece of machinery. It was believed that this question, No. 20, appendix, was less hypothetical than question 10. Therefore, the figuring of costs and returns can be related to types of reasoning obtained in a different and an independent manner. A fairly large number of answers were coded as deductive (47) and integrated inductive-deductive (74) but only

five replies were coded as inductive (Table 5). Farmers who used the integrated inductive-deductive process or deduction alone to decide on farm machinery purchases tended to write out costs and returns more than those who reasoned inductively, and a higher percentage gave verified answers for both types of figuring. A higher percentage of farmers who solved the machinery problem with only inductive reasoning figured in the head.

The insights gained by relating the method of figuring costs and returns to type of reasoning were similar in the two tests. Relatively more of the farmers using inductive reasoning figured in the head only. For both analyses, a higher percentage of the farmers using deductive reasoning gave verified examples of both types of figuring and a higher percentage wrote out answers.

The effects of various combinations of age and educational levels upon the method used (if any) to figure costs and returns are shown in Table 6. An inverse relationship existed between the age of the farmer and both the percentage of those who figured costs and returns by writing and the percentage who figured both by writing and in the head. The relationships existed for the different age groups for both educational levels. A smaller percentage of the younger farmers indicated that they did not figure costs and returns. The same relations hold when education is studied and age is considered fixed. For given age ranges, the percentage of farmers with more than 8 grades of education was higher for writing out, for verified answers for writing out, for verified answers for figuring in the head, and for doing both writing out and figuring in the head. Relatively more of the less educated farmers indicated that they did not figure costs and returns.

The pattern of figuring was similar for young farmers and for the more educated farmers, and relatively more of the young farmers were educated. Therefore, when education was studied across all age ranges, or when age was

Table 6. Relation of method used to figure costs and returns, both in writing and in head, verified and unverified, to different levels of both age and education for farmers sampled.

Age and education	Number of farmers	% of farmers who: Do not figure	Write out: Verified	Write out: Unverified	Write out: Total	Figure in head: Verified	Figure in head: Unverified	Figure in head: Total	Figure: Write out only	Figure: In head only	Figure: Do both
Education											
Grades 1-8											
Age											
Under 40	37	13.5	48.6	16.2	64.8	64.9	10.8	75.7	08.1	21.6	54.1
40-54.9	50	16.0	36.0	04.0	40.0	70.0	10.0	80.0	02.0	44.0	36.0
55 and above	67	09.0	28.4	07.5	35.9	74.6	13.4	88.0	01.5	52.2	32.8
Above 8 grades											
Age											
Under 40	94	06.4	58.5	06.4	64.9	75.5	12.8	88.3	04.3	26.6	59.6
40-54.9	77	07.8	57.1	02.6	59.7	77.9	09.1	87.0	01.3	29.9	64.5
55 and above	27	14.8	33.3	03.7	37.0	66.7	14.8	81.5	03.7	48.1	33.3
All age groups											
Education											
Grades 1-8	154	12.3	35.7	08.4	44.1	70.8	11.7	82.5	05.2	42.2	39.0
Above 8 grades	198	08.1	54.5	04.5	59.0	75.3	11.6	86.9	03.0	30.8	54.0
All education levels											
Age											
Under 40	131	08.4	55.7	09.2	64.9	72.5	12.2	84.7	05.3	25.2	58.0
40-54.9	127	11.0	48.8	03.1	51.9	74.8	09.4	84.2	01.6	35.4	47.2
55 and above	94	10.6	29.8	06.4	36.2	72.3	13.8	86.1	02.1	51.1	33.0
All farmers *	352	09.9	46.3	06.2	52.5	73.3	11.6	84.9	03.1	35.8	47.4

* Age and education ascertained.

studied across all education levels, the relations were even more pronounced. Here, the 198 farmers with more than 8 grades of education, and the 131 young farmers, were both characterized by relatively smaller numbers that do not figure at all, and by relatively larger numbers that write out, that both write out and figure in the head, and that gave verified examples of writing out.

The entire picture for the effect of age and education on figuring costs and returns, Table 6, was as expected, given the background of analysis to this point. In Table 5 there were relations that indicated that among farmers who used more deductive reasoning, the percentages were higher for writing out, giving verified answers for both types of figuring and lower for not figuring out. In Tables 1, 2, 3 and 4, there was evidence that relatively more of the educated farmers and relatively more of the younger farmers used deductive reasoning. Because there was a pattern between deductive thinking and for figuring costs and returns, and because there was also a relation between age and education and deductive reasoning, the same pattern might be expected for the study of figuring costs and returns and age and education when they were related directly. This common pattern was determined.

The analysis thus has proceeded to the figuring costs and returns step. A pattern has been developed by studying in order deductive reasoning and then figuring costs and returns, and by studying figuring costs and returns directly without going through the reasoning phase. The work has been built sufficiently that the final step, marginal analysis, may now be examined.

Hog Production Problem: Average and Marginal Data

Farmer Use of Economic Analysis. Information on farmer use of economic analysis in decision making was obtained through the use of two hypothetical

questions (11 and 12, appendix) and three questions on real responses of farmers on quantities of products produced and inputs used (17, 18, 20, appendix). This analysis was restricted to a study of responses to the hypothetical questions, with the responses to the other questions used only as they might be related to responses obtained from the questions studied intensively.

One hypothetical question covered the most profitable number of litters of pigs to produce, and the second dealt with the most profitable level of machinery investment. It was hoped that farmers would see these as general and not specific problems. Farmers were given a card with the questions stated.

Data, both averages and marginals were a part of each question. Farmers were asked to appraise the adequacy of the data in each form toward solving the problem. The purpose of these two questions was to test farmers understanding of average and marginal analysis.

Hog Problem. A problem was set up in which a farmer must decide whether the hog enterprise should be expanded beyond 15 litters. The price of hogs was assumed given, and each litter was assumed to gross $270. If the enterprise were expanded, per litter costs would rise. The question put to 356 farmers, for data in average form, part (a) of question 11, and for data in marginal form, part (b) of question 11, was as follows: Was this enough information to tell how many litters should be raised? If so, then how many litters should be raised?

Responses to the data in average form were studied first, and the responses to the data in marginal form were studied second.

Data in Average Form. It was demonstrated that data in marginal form permits an exact solution and is more valuable than data in average form.

Although a considerable amount of data is presented to farmers in average form, there is at least some theoretical question as to the appropriateness of data in average form in decision making. Do farmers recognize that data in average form is not adequate to determine exact solutions to problems as the most profitable number of litters of hogs to produce? The immediate discussion, covering four tables, was included to yield insights toward answering that question. Farmer response to data in average form for the hog problem, is studied with respect to four other types of factors--(a) the figuring of costs and returns, (b) type of reasoning and approach to farm organization, (c) external conditioning factors and (d) real responses indicated for products and inputs. The responses of farmers to the data were studied against these considerations to yield characteristics that set apart those farmers who think such data are not all that are needed.

The overall responses to the question were as follows: Ninety-one of the 356 farmers said that the average data were sufficient to determine how many litters should be produced, and all of them indicated the number of litters to be produced. Eleven farmers said the information was adequate, but did not give the number of litters to be produced. One hundred eighty-four farmers indicated the average information was inadequate for determining the most profitable number of litters. Sixty-three of the farmers replied that they didn't know, while seven left this part of the question unanswered. The number of farmers giving "don't know" and "no answer" responses was large.

The answers given by the farmers were re-grouped for analysis. Those who said that average data were adequate (whether or not they indicated the number of litters to produce) were placed in one group. Their answers to the question were judged inaccurate. The second group consisted of those who indicated that average data were not adequate, and they were judged to

have answered the question correctly. The third group consisted of those who said that they didn't know or that gave no answer.

Of the 356 farmers in the three groups, 51.7 per cent of them correctly indicated that the data given were not adequate for determining the number of litters to produce. Twenty eight and seven-tenths per cent of them incorrectly determined the average data to be adequate, while 19.7 per cent didn't know.

Methods of Figuring Costs and Returns. The relation between methods used to figure costs and returns and ability to judge that the average data were not adequate is shown in Table 7. Analysis of this table indicated only a slight difference among percentages of correct answers given by farmers who figure by writing out, those who figure in the head, and those who do not figure. The percentages of correct answers were slightly higher for those groups who figure either by writing or by figuring in the head than for those who said that they did not figure costs and returns. Farmers giving verified examples for both types of figuring gave a higher percentage of correct answers and a lesser percentage of don't know answers than did all farmers. Thus there is some, although not a marked relation between figuring costs and returns and answers that were expected to this problem.

Type of Reasoning and Approach to Farm Organization. The relation of deductive reasoning, figuring costs and returns, and marginal analysis has been hypothesized. Extending that reasoning to analysis using averages, an investigation was made to determine if those using deductive reasoning saw the need for more extensive information than data in average form. The farmers using a combination of induction and deduction to arrive at conclusions show a slightly higher percentage of correct answers than the groups

Table 7. Relation of farmers' conceptions of the adequacy of data in average form in determining level of hog production to methods used to figure costs and returns.

Method of figuring	Number of farmers	% of farmers who		
		Indicated average data were adequate	Indicated average data were not adequate	Didn't know
Does not figure	9	22.2	55.6	22.2
Writes out				
Verified	86	30.2	59.3	10.5
Unverified	17	41.2	52.9	5.9
All writing out	103	32.0	58.3	9.7
Figures in head				
Verified	138	24.6	62.3	13.0
Unverified	27	33.3	48.1	18.5
All figuring in head	165	26.1	60.0	13.9
Figures				
By writing only	7	28.6	42.9	28.6
In head only	69	18.8	58.0	23.2
Both by writing and in head, both verified	62	29.0	66.1	4.8
All farmers	356	28.7	51.7	19.7

using only induction or deduction (Table 8). This implies some value may be placed upon the use of a combination of the two types of reasoning to arrive at conclusions.

Farmers verified understandings of induction and/or deduction were also related to responses given to the hog data in average form. Eighty-three and three-tenths per cent of those giving verified examples of both induction and deduction correctly said that the average data were not adequate for determining the number of litters to produce. This compares with 75.0 per cent for those with verification of deduction only, and with only 56.4 per cent for those with verification of induction only. None of the farmers giving verified examples of both inductive and deductive reasoning said the average data were adequate, whereas 1/3 of the farmers giving a verified example of inductive reasoning said the data were adequate.

The relations of type of reasoning to answers to the hog problem data in average form were not clear. The only possible generalization is that more of those farmers using both inductive and deductive reasoning recognized the need for more information than did other groups.

Approach to farm organization was also studied at this point. Many if not all of the approaches involve deductive reasoning. Farmers using different approaches did not, in general, answer the problem differently. However, a slightly higher percentage of farmers using the livestock approach (starts with conception of ideal number of livestock to maintain and adjusts other resources accordingly) correctly judged the fallacy of attempting to use data in average form to determine the exact level of production when applied to a livestock problem.

External Conditioning Factors. Educational level appeared to have some

Table 8. Relation of farmers' conceptions of the adequacy of data in average form in determining level of hog production to type of reasoning and approach to farm organization.

Type of reasoning and approach	Number of farmers	% of farmers who		
		Indicated average data were adequate	Indicated average data were not adequate	Didn't know
Combinations of induction and deduction used				
Both induction and deduction	110	26.4	61.8	11.8
Mainly deduction	16	37.5	43.8	18.8
Mainly induction	51	21.6	58.8	19.6
Other answers *	7	28.6	42.9	28.6
Verification of:				
Both induction and deduction	6	0.0	83.3	16.7
Deduction only	4	25.0	75.0	0.0
Induction only	39	33.3	56.4	10.3
Neither induction nor deduction	131	26.0	58.8	15.3
Approach to farm organization				
Land use	77	27.3	44.2	28.6
Livestock	19	26.3	52.6	21.1
Simultaneous	29	48.3	37.9	13.8
Price expectation	8	37.5	37.5	25.0
Other **	39	28.2	46.2	25.6
All farmers	356	28.7	51.7	19.7

* Other answers include induction only, deduction only, not ascertainable, neither induction nor deduction, and don't know.

** Other approaches include labor use, income or debt payment, and special market.

positive effect on the percentage of correct answers given, Table 9. Fifty-four and six-tenths per cent of the 185 farmers who had completed more than eight grades correctly indicated the limitations of the average figures. This compares with 48.2 per cent of correct answers by those with less education. However, the more educated group also had a higher percentage of incorrect answers, while relatively more of the less educated group didn't know.

The age level of the farmers seemed to have little effect on their ability to judge data in average form as applied to the hog problem. About one-half of the farmers in each age group correctly judged the marginal data as not adequate for determining the most profitable number of litters to produce. It was noted, however, that the older farmers gave relatively fewer incorrect answers and relatively more don't know answers than did the younger farmers.

Grouping the farmers according to equity position failed to reveal any definite relations. Low equity farmers gave a higher percentage of both correct and incorrect answers to the hog problem than did the high equity group. The percentage of farmers in the high equity group that indicated that they didn't know was higher than for the low equity group.

The percentages of correct answers given by farmers classified according to level of net worth suggested no observable influence of this factor. Percentages of correct answers for the low, medium, and high net worth groups were all approximately 50 per cent, or 54.9, 50.3, and 51.1 per cent respectively.

The answers given by farmers specializing in different products revealed that the livestock producers (those whose main product was either hogs, dairy, or beef and sheep) gave a higher percentage of correct answers to this part

Table 9. Relation of farmers' conceptions of the adequacy of data in average form in determining level of hog production to certain external conditioning factors for farmers sampled.

External Variables	Number of farmers	% of farmers who Indicated average data were adequate	Indicated average data were not adequate	Didn't know
Education				
Grades 1-8	168	25.0	48.2	26.8
Above 8 grades	188	32.4	54.6	13.0
Age				
Under 40	120	34.2	52.5	13.3
40-54.9	125	30.4	49.6	20.0
55 and above	109	21.1	52.3	26.6
Equity				
Greater than 95%	188	26.1	48.4	25.5
95% or less	134	35.8	51.5	12.7
Net Worth				
Under $20,000	102	28.4	54.9	16.7
$20,000-$49,999	147	32.0	50.3	17.7
$50,000 and over	92	23.9	51.1	25.0
Main Product				
Hogs	91	23.1	59.3	17.6
Wheat	75	33.3	33.3	33.4
Dairy	55	18.2	65.5	16.4
Corn and other feed	42	35.7	47.6	16.7
Beef and sheep	43	32.6	51.2	16.3
Others *	50	34.0	54.0	12.0
All farmers	356	28.7	51.7	19.7

* "Others" includes tobacco, soybeans and flax, beans, vegetables and truck crops, poultry and eggs, fruit, and not ascertainable.

of the hog problem than did those who specialized in grain production, (wheat, or corn and other feed). Possibly familiarity with livestock production problems aided the livestock farmers in determining the inadequacy of average data for determining the most profitable level of hog production.

Real Responses to Outputs and Inputs. In connection with Fig. 1 it was argued that the optimum output was that output for which the marginal cost and price were equal. Therefore, the marginal cost curve traces out a supply curve of the firm for the product. Some farmers indicated that they responded to price. Then it could be reasoned that they might adjust by moving along a marginal cost curve and hence to use marginal analysis. One step further, it might be reasoned that farmers responding to price might need more information than data in average form to determine what level of production (here, number of litters) was optimum.

The same argument might be used for changes in the quantity of an input used.

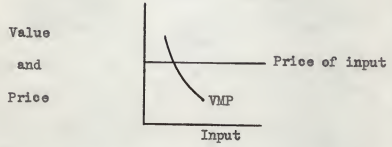

Fig. 2. Value of marginal product curve.

The optimum level of use of the input is at the point where the price of a unit of the input is equal to the value of its marginal product. The value of marginal product curve forms a demand curve of the firm for the product. It might be reasoned that a farmer responding to changes in the input price

might move along a value of marginal produce curve and hence to use marginal analysis. Then, the last step in the argument, farmers responding to prices of an input might be expected to need marginal data and to not appraise data in average form as adequate.

For the types of problems where Figs. 1 and 2 represent theoretical solutions, there are some factors that are fixed, or what Bradford and Johnson (2), p. 133, call "fixed assets". Some farmers indicated that these factors determined their output. Although it can be demonstrated that responding to these considerations is also marginal analysis, it is reasonable to believe that these farmers may not be as conscious of the need for data in marginal form as those farmers responding to price, and fewer of them may indicate the inadequacy of data in average form.

Information on how farmers decided about the quantity of product to produce was obtained by using question 17, (appendix). A number of factors to which farmers responded were coded, but only two were related to answers to the hog problem. These were (1) adjustments to price, price changes or price expectations, and (2) adjustments to limitations placed on production by feed supply and/or livestock.

The 26 farmers who adjusted to price were better able to indicate the inadequacy of average figures than were the 98 farmers who adjusted to feed supply and/or livestock. A relatively smaller number of them also indicated that average data were adequate.

Adjustments farmers made in the use of certain inputs used in production when prices of these inputs changed was revealed by answers to question 18, (appendix). Replies were coded as, "made no change", "changed" and "not ascertainable", and farmers were grouped according to these answers. A larger percentage of the farmers who made adjustments to input price changes

correctly indicated that the average figures were inadequate for determining the most profitable number of litters of pigs to produce. Also, a smaller percentage of them indicated that the average data were adequate.

In general, then, data in Table 10 provide evidence that a farmer's responsiveness to price and input cost changes has a direct relationship to his ability to understand the fallacy of attempting to figure levels of production by the use of data in average form. Relatively more of them indicated that average data were not adequate and relatively fewer indicated that average data were adequate.

Summary. Groups that most nearly handled this question correctly (i.e., indicated average data were not adequate or did not indicate average data were accurate), were farmers with the following characteristics: gave verified examples of both types of figuring, used both inductive and deductive thinking, used the livestock approach to farm organization, produced livestock, and made real responses to price changes.

Marginal Data. The 356 farmers who answered part (a) of the hog production problem regarding the adequacy of average data for figuring the most profitable level of hog production were then asked to appraise the adequacy of data in marginal form (part b). Again, they were asked to judge the data in terms of adequacy in determining the number of litters to produce, and if they thought the data were adequate, they were asked to indicate the optimum number of litters. The previous analysis was concerned with the farmers' abilities to recognize that average data were not adequate. The farmers were first given insufficient data to solve the problem, and were asked, in essence, if more data were needed. In part (b) they were asked to indicate their understanding of a superior method of figuring costs and returns (marginal

Table 10. Relation of farmers' conceptions of the adequacy of data in average form in determining level of hog production to real responses in quantities of inputs used and products produced.

Adjustment	Number of farmers	% of farmers who		
		Indicated average data were adequate	Indicated average data were not adequate	Didn't know
Decision about quantity of product to produce				
Adjusted to price	26	26.9	53.8	19.2
Adjusted to feed supply and/or livestock	98	34.7	46.9	18.4
Decision about input quantity changes to input price changes				
Made no change	76	30.3	60.5	09.2
Changed	60	16.7	65.0	18.3
Not ascertainable	48	31.2	47.9	20.8
All farmers	356	28.7	51.7	19.7

analysis) to the same hog problem, but with the data in a different form. A theoretical argument for marginal analysis was presented. The purpose of this section is to test empirically the use of marginal analysis as hypothesized above.

In the problem asked, a farmer was supposed already producing 15 litters of pigs, as in part (a), analyzed above. A schedule was presented to the respondent telling him how much each additional litter would add to or subtract from total returns. These figures were assumed single valued, but some farmers answered the problem under other assumptions. The situation was the same as in part (a), data in average form. The price of hogs was given, and each litter was assumed to gross the same amount. However, costs were increasing and the profit or loss for each litter was found by subtracting these increasing marginal costs per litter from the gross of $270 per litter. Not all of these data were explicit in the statement given the farmer. It is believed that the question as stated contained the optimum information for the purpose at hand, and that more facts would have confused most of the farmers more than helping them.

Responses were originally classified as indicated in the following outline:

Group Number	Response	Number of farmers
	A. Data were adequate to determine number of litters and	
1	20 litters were given for most profitable level.	48
2	21 litters were given for most profitable level.	1
3	22 litters were given for most profitable level.	47

4	Some other number was given for most profitable level.	129
5	No answer was given for number of litters	10
6	B. Data were not adequate to determine number of litters	62
	C. Response did not indicate either that data were adequate or not adequate.	
7	Farmer didn't know as to adequacy	50
8	Part (b) of hog question not answered.	9
	Total	356

The "correct" answer to the problem with the data as given and the assumptions, both explicit and implicit, was, of course, 22 litters. Total profits for any other number of litters would be less than for this level of output.

For purposes of analysis the answers were regrouped, and some alternate groupings seemed logical. One group consisted of those answers from farmers indicating the exact number of litters (22), and these responses were called "the most profitable point". A second group comprised the answers 20, 21, and 22 litters, and these responses were called "acceptably correct answer". Here, the definition of "exact" was made slightly less stringent. The main reason for this grouping was that many of the assumptions implicit in the problem may not have been understood by the farmer. He may still have been making an allowance for such things as uncertainty of the data, for some costs such as less leisure that he didn't think were included in the costs, and for limitations in his own situation as feed, buildings and labor. Lastly, because of the hypothetical nature of the problem, the "arithmetics" of it, and the short period of time the farmer had to think about the problem, it was believed important to study these answers as a group.

A third group consisted of all those farmers who recognized the marginal data as adequate for solving the problem. The interpretation of these answers differs from that for the groups of answers 22 exactly or 20, 21, and 22. Although some of these farmers gave an answer other than 20, 21, or 22 litters, or no answer at all as to number of litters, it was believed that some insights could be gained by observing characteristics of farmers who recognized that data in marginal form were adequate, even though some of them did not give the "right" answer to the number of litters.

A fourth group of answers were those "not adequate" and a fifth group were from farmers who said they didn't know as to the adequacy or that didn't answer the question.

While only 15.2 per cent of the farmers gave 22 litters as the most profitable size of enterprise, 27.0 per cent gave as an answer 20, 21 or 22 litters and nearly 2/3 of the farmers indicated that the marginal data were adequate. Only 17.4 per cent indicated the data were not adequate but a rather large number (16.6 per cent) didn't know.

Responses as grouped were related to various characteristics of farmers as hypothesized. The relations successively studied, as for part (a) are (a) the figuring of costs and returns, (b) type of reasoning, (c) external conditioning factors, and (d) real responses to quantities of products produced and inputs used.

Figuring Costs and Returns. Farmers showing a high degree of understanding of marginal analysis would determine the most profitable point (22 litters) or give an acceptably correct answer (20, 21 or 22 litters) or at least recognize the adequacy of data in marginal form. Few such farmers should indicate that data in marginal form are not adequate, and, of course,

few should give "didn't know" answers. These were the criteria used in evaluating the understanding of marginal analysis.

Farmers figuring costs and returns were expected to show more of an understanding of marginal analysis than other farmers. There are a large number of relations, Table 11, that confirm that this was the case for the farmers sampled.

Those farmers giving verified answers for both types of figuring demonstrated a superior understanding of marginal analysis to those farmers who do not figure, for all the criterion listed above. Only 1/3 of the farmers who did not figure could as much as recognize that the data were adequate, while 74.2 per cent of the farmers giving verified examples of both types of figuring recognized the data as adequate, 22.6 per cent were even able to choose the most profitable point and 40.3 per cent gave 20, 21 or 22 litters as the answer. They also demonstrated somewhat more knowledge than those who figure by writing and considerably more than those who figure in the head only.

No generalizations can be drawn for differences in understanding for those giving verified and unverified answers, for either writing out or figuring in the head. All farmers writing out, however, demonstrated superior understanding to all farmers figuring in the head. About three-fourths of those who figured costs and returns by writing and more than two-thirds of those who figured costs and returns in the head correctly recognized the data in marginal form as adequate. Only one-third of the nine farmers who did not figure costs and returns recognized the data as adequate.

Type of Reasoning and Approach to Farm Organization. It was demonstrated

Table 11. Relation of farmers' conceptions of the adequacy of data in marginal form in determining level of hog production to methods used to figure costs and returns.

Method of figuring	Number of farmers	% of farmers who				
		Determined most profitable point	Gave Acceptably Correct Answer	Recognized marginal data as adequate	Indicated marginal data were not adequate	Didn't know
Does not figure	9	0.0	11.1	33.3	33.3	33.3
Writes out						
Verified	86	18.6	36.0	74.4	14.0	11.6
Unverified	17	5.9	23.5	76.5	17.6	5.9
All writing out	103	16.5	34.0	74.8	14.6	10.7
Figures in head						
Verified	138	13.0	26.8	66.7	19.6	13.8
Unverified	27	14.8	29.6	85.2	3.7	11.1
All figuring in head	165	13.3	27.3	69.7	17.0	13.3
Figures						
By writing only	7	0.0	42.9	57.1	14.3	28.6
In head only	69	7.2	17.4	59.4	20.3	20.3
Both by writing and in head, both verified	82	22.6	40.3	74.2	16.1	9.7
All farmers	356	13.2	27.0	66.0	17.4	16.6

that those farmers who figure costs and returns show more knowledge of marginal analysis. It was also demonstrated that a higher percentage of those farmers who use deductive reasoning also figure costs and returns. Therefore, it might be expected that there is a relation between type of reasoning and understanding of marginal analysis. Data in Tables 12 and 13, although with some irregularities, show that this was true for the farmers studied.

The highest degree of understanding of marginal analysis was shown by those farmers using mainly deduction, followed in order of understanding by farmers using both induction and deduction and by farmers using mainly induction, Table 12. These relations were very clear for all criteria of understanding. For the group of farmers using mainly deduction, 31.3 per cent determined the most profitable point, 1/2 gave an acceptably correct answer and 3/4 recognized the data as adequate. The corresponding percentages for the group using mainly induction were 3.9, 21.6 and 58.8 per cent, and the respective figures for the group using both induction and deduction fell between the percentages given by the group using mainly deduction and those given by the group using mainly induction.

The pattern of understanding was roughly similar where farmers were grouped on the basis of proportion of thinking deductive. A smaller percentage of the farmers whose thinking was less than 1/2 deductive demonstrated an understanding of marginal analysis than did the other farmers. This was especially true for the criterion "most profitable point", selected by only 4.5 per cent of these farmers. The group whose thinking was about 1/2 deductive ranked ahead of the group whose thinking was more than 1/2 deductive. These results, although not greatly different between the two groups, do not

Table 12. Relation of farmers' conceptions of the adequacy of data in marginal form in determining level of hog production to type of reasoning.

Type of reasoning	Number of farmers	% of farmers who				
		Determined most profitable point	Gave acceptably correct answer	Recognized marginal data as adequate	Said marginal data were inadequate	Didn't know
Combinations of induction and deduction used						
Both induction and deduction	110	13.6	29.1	70.0	18.2	11.8
Mainly deduction	16	31.3	50.0	75.0	12.5	12.5
Mainly induction	51	03.9	21.6	58.8	21.6	19.6
Other answers *	7	0.0	0.0	57.1	0.0	42.9
Proportion of thinking deductive						
Less than 1/2	88	04.5	17.0	61.4	22.7	15.9
About 1/2	49	22.4	44.9	83.7	8.2	8.2
More than 1/2	21	23.8	33.3	76.2	14.3	9.5
Don't know	26	07.7	19.2	46.2	23.1	30.8
All farmers	356	13.2	27.0	66.0	17.4	16.6

* Other answers include induction only, deduction only, not ascertainable, neither induction nor deduction, and don't know.

Table 13. Relation of farmers' conceptions of the adequacy of data in marginal form in determining level of hog production to type of reasoning and approach to farm organization.

Type of reasoning and approach	Number of farmers	% of farmers who				
		Determined most profitable point	Gave acceptably correct answer	Recognized marginal data as adequate	Said marginal data were inadequate	Didn't know
Verification of:						
Both induction and deduction	6	16.7	33.3	50.0	33.3	16.7
Deduction only	4	25.0	25.0	75.0	25.0	0.0
Induction only	39	10.3	25.6	69.2	15.4	15.4
Neither induction nor deduction	131	11.5	26.0	66.4	18.3	15.3
Approach to farm organization						
Land use	77	19.5	32.5	66.2	13.0	20.8
Livestock	19	15.8	21.1	52.6	26.3	21.1
Simultaneous	29	10.3	31.0	75.9	17.2	6.9
Price expectation	8	25.0	50.0	100.0	0.0	0.0
Other *	39	0.0	12.8	53.8	23.1	23.1
All farmers	356	13.2	27.0	66.0	17.4	16.6

* Other approaches include labor use, income or debt repayment, and special market.

entirely match the results discussed above, where relatively more farmers in the group using mainly deduction showed an understanding of marginal analysis. Both comparisons indicated that fewer (relatively) of those farmers using inductive reasoning understood marginal analysis.

The relation of understanding of marginal analysis to groupings of farmers based upon verified examples of various types of reasoning is less clear. This may be explained by the small number of farmers in some of the groups. Those with verified examples of deduction were able to determine the most profitable point and to recognize the adequacy of data in marginal form better than the other groups. One-third of those giving verified answers for both induction and deduction gave an acceptably correct answer, and this was a slightly higher percentage than for those with verification of only deduction or only induction. In any case, the numbers in the groups "both induction and deduction" and "deduction only" were so small that little could be learned. The outstanding relation in the table (and for this generalization numbers in the groups are more suitable) is that the understanding of those giving verified examples of only induction and of those farmers giving no verified examples was not at all unlike the understanding indicated by all 356 farmers.

Very few insights were gained by relating farmers' conceptions to approach to farm organization. The eight farmers who based their planning on expected prices appeared to show a higher degree of understanding of marginal analysis. All of the eight said that the marginal data were adequate. Again, the number in the group is probably too small to make generalizations possible.

The analysis has progressed to the following state. Farmers' under-

standing of marginal analysis is related to the methods of figuring of costs and returns. Figuring of costs and returns, however, is on the one hand related to type of reasoning and on the other hand to understanding of marginal analysis. It was related to external conditioning factors, especially age and education. With the theoretical arguments and empirical relations established thus far, it appears logical to suppose that the external factors age and education might be related directly to the farmers' understanding of the data in marginal form. The empirical relations as shown in Table 14 bear out this reasoning.

External Conditioning Factors. Younger farmers show a higher degree of understanding than do older farmers. This relation holds, except for determining the most profitable point, between age group comparisons for education, grades 1-8, above 8 grades, or across both education levels. Comparisons for education levels, for respective age groups, show that marginal analysis is better understood by the more educated farmers. This relation holds very regularly and between education levels for all ages. Because of these relations, farmers with more than 8 grades of education ranked highest in understanding while farmers 55 years old and above with 8 grades or less of education ranked lowest among all the groups. The farmers with the highest degree of understanding are, for age groups, the younger, and for education groups, the more educated. Also, younger farmers are more educated. Therefore, when understanding is related to either age or education without the use of a multiple classification table, the relations are even more pronounced than when understanding is related to age or education with education or age, respectively, somewhat taken into account by the two-way grouping.

The effects of several external conditioning factors on percentages of

Table 14. Relation of farmers' conceptions of the adequacy of data in marginal form in determining level of hog production to different levels of both age and education for farmers sampled.

Age and education	Number of farmers	% of farmers who				
		Determined most profitable point	Gave acceptably correct answer	Recognized marginal data as adequate	Indicated marginal data were not adequate	Didn't know
Education						
Grades 1-8						
Age						
Under 40	37	08.1	21.6	73.0	10.8	16.2
40-54.9	58	12.1	24.1	62.1	15.5	22.4
55 and above	73	11.0	17.8	43.8	24.7	31.5
Above 8 grades						
Age						
Under 40	83	13.3	36.1	83.1	12.0	4.8
40-54.9	66	18.2	31.8	71.2	21.2	7.6
55 and above	34	17.6	26.5	64.7	14.7	20.6
All age groups						
Education						
Grades 1-8	168	10.7	20.8	56.5	18.5	25.0
Above 8 grades	183	15.8	32.8	75.4	15.8	8.7
All education levels						
Age						
Under 40	120	11.7	31.7	80.0	11.7	8.3
40-54.9	124	15.3	28.2	66.9	18.5	14.5
55 and above	107	13.1	20.6	50.5	21.5	28.0
All farmers *	351	13.4	27.1	66.4	17.1	16.5

* Education and age ascertained.

correct and incorrect answers given to the hog problem were considered in Table 15. The farmers surveyed were grouped by length of farming experience. Those who started farming before 1933 comprised one group, while those who started in 1933 or later were included in the second group. The results of this comparison were not entirely consistent with the results discussed above. A higher percentage (72.0) of those farmers with more experience recognized the marginal data as adequate for determining the number of litters of pigs to produce, and a slightly higher percentage (28.0) of them gave an acceptably correct answer regarding the number to produce than did those with less experience. However, 14.5 per cent of the farmers with less experience correctly determined the exact number of litters for greatest profit compared to 12.0 per cent of the more experienced who determined the most profitable number of litters. The farmers who started farming before 1933 were, of course, older farmers. They indicated a slight superiority in understanding of marginal analysis. To the extent that their understanding was superior, the results differ from those where age itself was related to understanding.

Very little additional information was obtained by relating understanding to equity ratios. A higher percentage of those farmers whose equity was more than 95 per cent of their total assets determined the exact number of litters to produce than did the low equity group. The low equity group, however, recognized the adequacy of the marginal data better than did the high equity group.

The net worth levels appeared to have some influence on the percentages of farmers who determined the exact number of litters for greatest profit. Percentages of correct answers were 8.8, 14.3 and 16.3 per cent for the low, medium, and high net worth levels respectively. Other criteria do not

Table 15. Relation of farmers' conceptions of the adequacy of data in marginal form in determining level of hog production to certain external conditioning factors for farmers sampled.

External variables	Number of farmers	% of farmers who				
		Determined most profitable point	Gave acceptably correct answer	Recognized marginal data as adequate	Indicated marginal data were not adequate	Didn't know
Experience						
Started farming						
Before 1933	200	12.0	28.0	72.0	16.5	11.5
In 1933 or later	152	14.5	25.7	58.6	17.8	23.7
Equity						
Greater than 95%	188	14.4	26.1	60.6	18.6	20.7
95% or less	134	09.7	28.4	75.4	14.2	10.4
Net worth						
Under $20,000	102	08.8	30.4	71.6	14.7	13.7
$20,000-$49,999	147	14.3	25.9	60.5	22.4	17.0
$50,000 and over	92	16.3	27.2	70.7	13.0	16.3
Main product						
Hogs	91	15.4	28.6	51.6	26.4	22.0
Wheat	75	10.7	30.7	74.7	6.7	18.7
Dairy	55	12.7	20.0	58.2	29.1	12.7
Corn and other feed	42	16.7	31.0	66.7	14.3	19.0
Beef and sheep	43	11.6	30.2	79.1	9.3	11.6
Others*	50	12.0	20.0	78.0	14.0	10.0
Acres managed						
Under 130 acres	109	15.6	23.9	57.8	25.7	16.5
130-270 acres	126	10.3	25.4	65.9	15.9	18.3
Over 270 acres	121	14.0	31.4	73.6	11.6	14.9
All farmers	356	13.2	27.0	66.0	17.4	16.6

* "Others" includes tobacco, soybeans and flax, beans, vegetables and truck crops, poultry and eggs, fruit, and not ascertainable.

suggest the above or any other generalized relation between understanding and net worth.

The understanding was also related to the main product, Table 15. Results followed no particular pattern. However, it was noted that a smaller percentage of the farmers who produced hogs as a main product correctly recognized marginal data as adequate when applied to a hypothetical hog problem than did those farmers who specialized in other products. Other criteria do not lend additional support to indicate that they understand marginal analysis less well than farmers producing other products.

A direct relationship existed between the percentages of farmers who recognized marginal data as adequate for determining the level of hog production and the number of acres managed. The percentages of those who recognized marginal data as adequate were 57.8, 65.9 and 73.6 for the small, medium, and large farmers respectively. An inverse relationship existed between the percentages of those who indicated that the marginal data were inadequate and the number of acres managed. Therefore, there is some evidence that the larger farmers have a higher degree of understanding of marginal analysis.

Real Response to Products and Inputs. Farmers' understanding of marginal analysis was related to real responses in quantities of products produced and inputs used in the same way that farmers' conceptions of the adequacy of data in average form were related. The logic for making the relation is the same, i.e., those farmers who respond to price might be expected to show more of an understanding of marginal analysis. The data in Table 16 lend some evidence in that direction, but the relations are not conclusive.

Those farmers who decide about quantity of product to produce show a

Table 16. Relation of farmers' conceptions of the adequacy of data in marginal form in determining level of hog production to real responses in quantities of inputs used and products produced.

Adjustment	Number of farmers	% of farmers who: Determined most profitable point	Gave acceptably correct answer	Recognized marginal data as adequate	Indicated marginal data were not adequate	Didn't know
Decision about quantity of product to produce						
Adjusted to price	26	15.4	34.6	73.1	19.2	7.7
Adjusted to feed supply and/or livestock	98	15.3	29.6	66.3	18.4	15.3
Decision about input quantity changes to input price changes						
Made no change	76	09.2	21.1	63.2	21.1	15.8
Changed	60	16.7	25.0	63.3	21.7	15.0
Not ascertainable	48	10.4	37.5	77.1	8.3	14.6
All farmers	356	13.2	27.0	66.0	17.4	16.6

slight superiority in understanding. The relation was demonstrated by differences in percentages who gave an acceptably correct answer, recognized marginal data were adequate, and didn't know.

Those farmers who changed the quantity of some input in response to a change in its price showed a slight superiority in understanding over the group that made no change, as testified by the difference in percentage of farmers in the two groups that gave the exact answer and that gave an acceptably correct answer. The relations are clouded by the group of farmers whose responses to a change in quantity of an input was not ascertainable. This group, using all criteria except the percentage of farmers giving the most profitable point, demonstrated superior understanding to both of the other groups, namely those changing and those making no change in the quantity of an input used.

Although some relation was expected, as argued on theoretical grounds, very little evidence was detected empirically.

The 356 farmers who were asked parts (a) and (b) of question 11 (appendix) regarding the adequacy of average and marginal data for determining the most profitable level of hog production for the hypothetical problem were then asked, "Which way do you figure costs and returns in similar situations?" (question 11c, appendix). The answers given by the farmers were coded into the following groups:

Method of figuring used	No. of farmers
Average analysis	46
Marginal analysis	62
Both average and marginal analysis	16
Another method indicating an understanding of marginal analysis	2

Another method not indicating an understanding of marginal analysis	181
Doesn't use any method	13
No answer given to this part	36
Total	356

It was hoped that respondents would see the question as concerning general ways of figuring. Of the 320 farmers answering part (c), 151 understood the question as concerning general ways of figuring, 50 saw the question as only concerning hogs and the understanding of 119 farmers was not ascertainable.

Two of these groups were selected for analysis. One group consisted of the 62 farmers who indicated a use of marginal analysis to figure problems similar to the hog problem. The second group consisted of the 181 farmers who said that they used some other method of figuring costs and returns (a method not indicating an understanding of marginal analysis). Only 17.4 per cent of all the farmers indicated use of a method that could be called "marginal analysis", while slightly more than 1/2 of them reported use of a method that did not indicate understanding of marginal analysis. It was also true that the percentage of farmers that used a method not indicating an understanding of marginal analysis was greater than the percentage that used marginal analysis for all groups. However, the percentage of farmers using marginal analysis and the percentage using some other method varied widely among groups.

Some relationship existed between the method of figuring costs and returns used by farmers, question 10 (appendix), and their use of marginal analysis to figure problems similar to the hog problem, Table 17. None of the farmers who said that they did not figure costs and returns indicated a

Table 17. Relation of methods used to figure costs and returns and size of enterprise as given in response to questions in hog problems to methods used to figure costs and returns.

Method of figuring	Number of farmers	% of farmers figuring			
		Costs and Returns in Similar Situations by		Size of enterprise by adjusting to	
		Use of marginal analysis	Some other method	Price	Feed Supply
Does not figure	9	0.0	11.1	0.0	11.1
Writes out					
Verified	86	25.6	37.2	3.5	19.8
Unverified	17	5.9	58.8	5.9	47.1
All writing out	103	22.3	40.8	3.9	24.3
Figures in head					
Verified	138	23.9	48.6	3.6	29.0
Unverified	27	7.4	40.7	3.7	22.2
All figuring in head	165	21.2	47.3	3.6	27.9
Figures					
By writing only	7	14.3	42.9	14.3	28.6
In head only	69	17.4	59.4	4.3	34.8
Both by writing and in head both verified	62	30.6	37.1	3.2	19.4
All farmers	356	17.4	50.8	5.6	27.0

use of marginal analysis. The percentage of farmers using marginal analysis was only slightly higher for those who figure by writing compared to those who figure in the head. Those groups with method of figuring verified indicated a much greater use of marginal analysis than did the unverified groups. A higher percentage of those farmers who gave verified examples of figuring by both writing and figuring in the head used marginal analysis and a smaller percentage used a method other than marginal analysis than did the other groups. Those giving verified examples differed especially from those that do not figure and those that figure only in the head. Of those farmers who figure only in the head, 17.4 per cent used marginal analysis while 59.4 per cent used another method not indicating an understanding of marginal analysis. For those who figure (and gave verified examples) both by writing and in the head, 30.6 per cent used marginal analysis, while 37.1 per cent used another method.

Farmers were asked to give other ways which they frequently used to adjust size of enterprise. The responses, as coded, with number of farmers, were as follows:

Adjustment	No. of responses
To price, price changes, and price expectations	20
To income and/or debt repayment needs	4
To any one of the following limitations:	
Land and cropping pattern	10
Feed supply	96
Labor	33
Equipment and operating capital	12
Buildings, fences, tiling and other real estate improvements	37
Livestock	2
Experience, knowledge and management	14

The 20 farmers who said that they adjusted to price, price changes, and price expectations and the 96 farmers who adjusted to feed supply were selected for further analysis. Table 17 shows the relation between these two ways of determining size of enterprise and methods used to figure costs and returns, question 10 (appendix).

The percentage of the farmers who indicated that enterprise size adjustments were made according to price, price changes, and price expectations, were small for all groups. The method of figuring costs and returns had only a slight influence on these percentages. A much larger percentage of the farmers adjusted size of enterprise in response to limitations placed by available feed supply, and this was true for all groups. Little was learned from this comparison. For those farmers who do not figure, for those giving verified answers to writing out, and for those giving verified answers for both types of figuring, the percentages of farmers adjusting to either price or feed supply were below average. In general, the percentages of farmers adjusting to price or feed supply varied but little from group to group or from the average.

Table 18 shows the relation of the same methods used to figure costs and returns and size of enterprise (defined and explained in the discussion of Table 17) to other responses made by the same farmers regarding decisions made on their own farms. Two categories of answers given by farmers in response to question 17, (appendix), are related to responses to similar questions on the hog problem. A higher percentage of farmers who said that they made production adjustments according to price in question 17 indicated a use of marginal analysis to figure problems similar to the hog problem than did those who adjusted to feed supply and/or livestock. A slightly smaller percentage of those who adjusted to price used some other method of figuring

Table 18. Relation of methods used to figure costs and returns and size of enterprise to real responses in quantities of inputs used and products produced and to approach to farm organization.

Answer	Number of farmers	% of farmers figuring: Costs and returns in similar situations by: Use of marginal analysis	Some other method	Size of enterprise by adjusting to: Price	Feed Supply
Decision about quantity of product to produce					
Adjusted to price	26	19.2	61.5	15.4	23.1
Adjusted to feed supply and/or livestock	98	14.3	70.4	5.1	37.8
Decision about input quantity changes to input price changes					
Made no change	76	14.5	56.6	2.6	34.2
Changed	60	31.7	33.3	6.7	20.0
Not ascertainable	48	12.5	43.8	2.1	25.0
Approach to farm organization					
Land use	77	13.0	62.3	10.4	29.9
Livestock	19	5.3	78.9	5.3	36.8
Simultaneous	29	10.3	51.7	13.8	34.5
Price expectation	8	25.0	37.5	0.0	12.5
Other *	39	25.6	41.0	0.0	12.8
All farmers	356	17.4	50.8	5.6	27.0

* Other approaches include labor use, income or debt repayment, and special market.

not indicating an understanding of marginal analysis than did those who adjusted to feed supply and/or livestock. These empirical relations were expected on a priori grounds.

Price and feed supply responses given to question 11, (appendix) were compared to price and feed supply and/or livestock responses for question 17, (appendix). Question 11 was basically a hypothetical question, and the responses "price" and "feed supply" were coded from responses farmers gave to a sub question on how they figure size of enterprise in a similar situation. Question 17 was more concerned with real responses. Some consistency of responses was shown by the two groups.

For the hog problem, where farmers were asked to indicate how they would determine the size of enterprise in a similar situation, considerably more indicated that they would respond to feed supply than to price. However, in figuring size of enterprise in a similar situation to the hog problem, for those farmers who adjusted production to price in a real problem, relatively more farmers would have adjusted to price and relatively fewer would have adjusted to feed supply than was indicated by those farmers who adjusted to feed supply and/or livestock in the real problem.

A second relation shown in Table 18 was the effect of the degree of the farmer's flexibility in use of inputs when input prices changed to figuring of costs and returns and of size of enterprise. A higher percentage of the farmers who changed input quantities as input prices changed said they used marginal analysis to figure problems similar to the hog problem than did the other groups. On the other hand, a higher percentage of those farmers who made no change as input prices changed and of those who gave answers that were not ascertainable indicated the use of some non-marginal method of figuring costs and returns.

Six and seven-tenths per cent of the farmers making changes determined size of enterprise by adjusting to price or price expectations. This compares with only 2.6 per cent for those who made no change and 2.1 per cent for those who gave answers that were not ascertainable. A lower percentage of those farmers who changed the quantity of an input would have adjusted size of enterprise on the basis of feed supply. A higher percentage of those farmers who adjusted the use of an input to a price change indicated they would figure, in similar situations, costs and returns by marginal analysis and size of enterprise by adjusting to price than was true for the other groups. These findings are consistent with the relationships expected from the use of theoretical arguments.

Percentages of answers given in Table 18 by farmers approaching farm organization in different ways vary greatly and few clear-cut implications emerge. The eight farmers who based their farm organization on expected prices tended to use marginal analysis to a greater extent than the other farmers, while depending to a less extent on other methods not involving an understanding of marginal analysis.

Summary. A superior understanding of marginal analysis was demonstrated by farmers in the following groups:

1. Farmers who figure costs and returns, especially those giving verified answers for both types of figuring and those who write out.
2. Farmers who use deductive reasoning alone or in combination with inductive reasoning.
3. Farmers who were younger.
4. Farmers with more than 8 grades of education.
5. Farmers with larger farms.

6. Farmers who adjust quantities of products produced and inputs used to price.

Summary, Average and Marginal Analysis, Hog Problem. The original responses to the adequacy of the data in average form and in marginal form were generally as expected. For the data in average form, more of the farmers

	Percentage of farmers responding		
	Data adequate	Data not adequate	Don't know
Data in average form	28.7	51.7	19.7
Data in marginal form	66.0	17.4	16.6

indicated that it was not adequate, and for the data in marginal form, considerably more of the farmers indicated that it was adequate. This means that, for the definitions of "correct" and "incorrect" answers specified, considerably more farmers answered correctly than incorrectly for each type of data. As was expected, farmers were more accurate in answering as to the adequacy of data in marginal form than in average form. It seemed that it would be easier for farmers to recognize the presence of adequate information when presented than to recognize its absence when not presented.

The hypotheses as set forth were in general substantiated when responses to the data in the two forms were studied. However, it is apparent that the results were considerably more clear cut and conclusive for the study of the responses to the data in marginal form. This too was expected.

Machinery Investment Problem: Average and Marginal Data

A second problem, similar to the hypothetical hog problem, was formulated to consider further abilities of farmers to recognize and judge data in

average and marginal form, question 12, (appendix). This problem dealt with the most profitable level of machinery investment, and was presented to 354 farmers, none of which were asked the hypothetical hog problem. Each farmer was shown data arranged first in average form and then in marginal form. The question then asked the farmers (for each type of data) was: Is this enough information to decide whether or not a farmer should invest another 250 dollars in machinery? If so, for what reasons? If not, why not? If don't know, what difficulties are you having figuring this out?

Average Data. The superiority of data in marginal form over data in average form has been discussed. The latter lacks the exactness required for determining the most profitable levels of production and investment. Farmers' understanding of this inadequacy of average data is studied as related to: (a) methods used to figure costs and returns, (b) type of reasoning, (c) certain external conditioning factors, and (d) real analysis used by farmers when buying machinery. In part (a), data in average form, average costs and average returns are assumed. It was assumed, perhaps implicitly, that all costs were included and that returns were accurately measured, and reflected such relations as whether the farmer needed the machinery.

The responses given by the farmers to the question (12a, appendix) regarding the adequacy of average data were as follows:

Group	Response	No. of farmers
1	Yes, with no reason given.	1
2	Yes, indicating that example contained enough information and nothing additional was requested.	82
3	Yes, wanted more information that won't convert example to marginal type.	23
4	No, wanted more information that won't convert example to marginal type.	137
5	Yes, wanted more information that would convert example to marginal type.	15
6	No, wanted more information that would convert example to marginal type.	39
7	Yes, wanted additional average and marginal information.	6
8	No, wanted additional average and marginal information.	22
9	No, with no reason classifiable.	3
10	Don't know.	21
11	Question not answered.	5
	Total	354

The answers given were re-grouped for analysis. All farmers who indicated that the average computations were adequate for determining additional machinery investment were placed in one group. Their answers to the question were judged inaccurate. The second group consisted of those who indicated that average data were inadequate. Their answers were considered as correct. Those 26 farmers who said that they didn't know or left the question unanswered were combined. Two other groups were set up based on the type of additional information requested. All farmers who asked for additional information of a marginal nature were included in one group, and those who asked for additional information of other than a marginal nature in another group. Of the 354

farmers interviewed 56.8 per cent correctly judged the average data as inadequate, while 35.9 per cent thought the data were adequate. Seven and three-tenths per cent didn't know. Twenty three and two-tenths per cent of the farmers wanted more data of a marginal nature, compared to 45.2 per cent who requested data of other than a marginal nature.

All of these groupings provide criteria helpful in understanding the farmers' conception of economic analysis. Those farmers who understand marginal analysis would be expected to indicate average data were not adequate (and not to say that average data were adequate), to indicate more data needed of a marginal nature, and no more than a minimum number should indicate that they didn't know as to the adequacy of the data.

Methods of Figuring Costs and Returns. It was believed that those farmers who figure costs and returns would more likely appraise the average data as inadequate and ask for data in marginal form, Table 19. The percentage of farmers who judged the data as not adequate varied but little among groups (based on method of figuring costs and returns). The percentage of correct answers for all farmers was 56.8, and, with the exception of the five farmers who figure by writing only, there was little deviation from this average. Farmers who do not figure, with 60 per cent correct answers, ranked somewhat below the other groups. Only ten per cent of those farmers who do not figure requested more information of a marginal nature compared with 27.9 per cent for those who figure by writing and 28.4 per cent for those who figure in the head. A high percentage of those farmers who figured costs and returns indicated that more data in marginal form were needed, but the relations were not sharp.

Table 19. Relation of farmers' conceptions of the adequacy of data in average form in determining profitability of additional machinery investment to methods used to figure costs and returns.

Method of Figuring	Number of farmers	% of farmers who indicated: Average data were adequate	Average data were not adequate	More data needed of marginal nature	More data needed of other than marginal nature	They didn't know
Does not figure	28	35.7	50.0	10.7	50.0	14.3
Writes out						
Verified	79	36.7	59.5	26.6	48.1	3.8
Unverified	7	14.3	57.1	42.9	14.3	28.6
All writing out	86	34.9	59.3	27.9	45.3	5.8
Figures in head						
Verified	125	40.8	55.2	27.2	40.8	4.0
Unverified	16	18.8	62.5	37.5	37.5	18.3
All figuring in head	141	38.3	56.0	28.4	40.4	5.7
Figures						
By writing only	5	80.0	20.0	0.0	40.0	0.0
In head only	61	44.3	50.8	27.9	37.7	4.9
Both by writing and in head, both verified	64	37.5	54.9	26.6	46.9	3.1
All farmers	354	35.9	56.8	23.2	45.2	7.3

Type of Reasoning. Because of arguments presented above, type of reasoning and understanding of the data, were related directly. The relation of farmers' judgments of the adequacy of data in average form in determining the profitability of additional machinery investment to type of reasoning was shown in Table 20. This was used to further test the hypothesis that some direct relationship exists in use of deductive reasoning and grasp of marginal analysis by farmers. It was reasoned that recognition of the inadequacy of data in average form was related to a grasp of marginal analysis. Therefore, some relation was expected between use of deduction by farmers and a grasp of the inadequacy of reasoning from averages.

Although mixed tendencies predominated in Table 20, two consistencies were observed. First, a higher percentage of farmers who indicated a use of both induction and deduction when reasoning, as well as those who gave verified examples of both induction and deduction, judged the average data as inadequate for determining the profitability of additional machinery investment. Also, a direct relationship existed between the proportion of thinking which farmers said was deductive and the per cent of correct answers given by them to this problem. The relations between type of reasoning and additional data needed were not as expected. In general, a higher percentage of those farmers whose reasoning was inductive indicated a need for data of a marginal nature. For almost every group, however, more farmers wanted data of a non-marginal nature than of a marginal nature.

External Conditioning Factors. The relation of judgments of farmers regarding the adequacy of average data as applied to the machinery investment problem to certain external conditioning factors was considered, Table 21. Again, arguments outlined above explain why this was done.

Table 20. Relation of farmers' conceptions of the adequacy of data in average form in determining profitability of additional machinery investment to type of reasoning.

Type of reasoning	Number of farmers	% of farmers who indicated: Average data were adequate	Average data were not adequate	More data needed: of marginal nature	More data needed: of other than marginal nature	They didn't know
Combinations of induction and deduction used						
Both induction and deduction	107	29.0	63.5	19.6	50.5	07.5
Mainly deduction	21	47.6	47.6	14.3	47.6	04.8
Mainly induction	43	37.2	53.5	30.2	39.5	09.3
Other answers *	5	20.0	60.0	20.0	60.0	20.0
Proportion of thinking deductive						
Less than 1/2	68	44.1	47.1	22.1	39.7	08.8
About 1/2	41	34.1	63.4	19.5	48.8	02.4
More than 1/2	36	19.4	66.7	8.3	63.9	13.9
Didn't know	31	22.6	71.0	38.7	45.2	06.5
Verification of						
Both induction and deduction	3	0.0	100.0	33.3	66.7	0.0
Deduction only	6	66.7	33.3	50.0	16.7	0.0
Induction only	27	25.9	70.4	40.7	37.0	03.7
Neither induction nor deduction	140	33.6	57.1	16.4	50.7	09.3
All farmers	354	35.9	56.8	23.2	45.2	07.3

* Other answers include induction only, deduction only, not ascertainable, neither induction nor deduction, and didn't know.

Table 21. Relation of farmers' conceptions of the adequacy of data in average form in determining profitability of additional machinery investment to certain external conditioning factors for farmers sampled.

External variables	Number of farmers	% of farmers who indicated				
		Average data were adequate	Average data were not adequate	More data needed of marginal nature	More data needed of other than marginal nature	They didn't know
Education						
Grades 1-8	150	35.3	53.4	22.0	40.7	11.3
Above 8 grades	202	36.1	59.9	23.8	49.0	04.0
Age						
Under 40	107	42.1	56.1	23.4	42.1	1.9
40-54.9	139	33.1	60.4	26.6	46.6	6.5
55 and above	102	31.4	53.9	18.6	48.0	14.7
Experience						
Started farming						
Before 1933	206	37.9	58.3	20.9	48.5	03.9
In 1933 or later	143	33.6	54.5	25.9	41.3	11.9
Equity						
Greater than 95%	175	34.3	58.3	24.0	49.1	07.4
95% or less	137	38.7	54.7	21.9	40.9	06.6
Main product						
Hogs	93	25.8	66.7	22.6	54.8	07.5
Wheat	79	39.2	54.4	34.2	39.2	06.3
Dairy	55	34.5	60.0	25.5	41.8	05.5
Corn and other feed	48	47.9	45.8	16.7	47.9	06.3
Beef and sheep	27	14.8	70.4	18.5	51.9	14.8
Others *	52	50.0	42.3	13.5	34.6	07.7
All farmers	354	35.9	56.8	23.2	45.2	07.3

* "Others" includes tobacco, soybeans and flax, beans, vegetables and truck crops, poultry and eggs, fruit, and not ascertainable.

The more educated farmers demonstrated superior understanding for most of the criteria of comparison. A direct relationship existed between level of education and the percentage of farmers who judged the average data as inadequate. A slightly higher percentage of the better educated farmers recognized a need for more data of a marginal nature than did the less educated group. Also, relatively fewer of the more educated group replied that they didn't know. All of the differences were slight, but the numbers in each group (education) were large.

Little was learned by relating understanding to age. No group deviated far from the average for any response. A slightly higher percentage of the farmers in the age group 40-54.9 years appraised the data as not adequate and indicated a need for more data of a marginal nature.

The influence of experience on ability to handle this problem was not entirely consistent. A higher percentage of both correct and incorrect answers in judging the adequacy of the average data were given by farmers with more experience in farming. It was noted that for the farmers with less experience, a greater percentage mentioned the need for more data of a marginal nature and a lesser percentage requested additional data of a non-marginal nature.

A slightly higher percentage of farmers in the high equity group indicated a grasp of the principles involved in judging the adequacy of data in average form for this particular problem than did the low equity farmers.

When farmers were grouped according to main products produced, the livestock farmers all gave higher percentages of correct answers than did the farmers whose main products were wheat, and corn and other feeds. A similar relationship existed for the hog problem where these groupings were

related to the understanding of data in average form.

Analysis and Type of Reasoning for Real Problem. Farmers comprehension of the hypothetical machinery investment problem is related to analysis and reasoning used by these farmers when handling actual machinery investment problems on their farms. The groupings used in Table 22--use of analysis and type of reasoning, were coded from responses given by farmers to an open-ended question (question 20, appendix) regarding how they made up their minds to purchase the last major piece of machinery on their farm. Answers given by the farmers were first coded into two categories depending upon whether or not analysis was used. Answers given by 160 of the farmers indicated analysis was used, while 18 responses indicated no use of analysis.

A higher percentage of the farmers using analysis for machinery decisions on their own farms indicated that the average data given were not adequate for determining the profitability of additional machinery investment than did those who didn't use analysis. Relatively fewer of those who used analysis indicated that average data were adequate than did those who didn't use analysis. Also, a slightly higher percentage of them requested additional data of a marginal nature.

The farmers who used analysis in making a machinery investment decision on their own farms were regrouped according to the type of reasoning indicated by their responses. Three of these groups selected for study consisted of farmers who reasoned inductively, deductively, or by use of an integrated inductive-deductive process.

Because of the small number of farmers using inductive reasoning, little can be inferred from a comparison of reasoning with deduction and reasoning without deduction. No appreciable difference existed between the proportion

Table 22. Relation of farmers' conceptions of the adequacy of data in average form in determining profitability of additional machinery investment to use of analysis by farmers when buying machinery.

Analysis and reasoning	Number of farmers	% of farmers who indicated: Average data were adequate	Average data were not adequate	More data needed: of marginal nature	More data needed: of other than marginal nature	They didn't know
Use of analysis						
Was used	160	37.5	55.6	25.0	43.1	6.9
Was not used	18	50.0	44.4	22.2	38.9	5.6
Type of reasoning						
Inductive	5	0.0	100.0	40.0	60.0	0.0
Deductive	47	36.2	53.2	27.7	38.3	10.6
Integrated inductive - deductive process	74	40.5	54.1	23.0	45.9	5.4
All farmers	354	35.9	56.8	23.2	45.2	7.3

of correct answers given by farmers using deduction only and those using an integrated inductive-deductive reasoning process. A slightly higher percentage of the farmers using deductive reasoning requested additional data of a marginal nature.

In general, farmers who used some type of analysis in a real problem better understood this part of the machinery investment problem then did those who used no analysis. Less was learned from a regrouping of the farmers using analysis on the basis of type of reasoning used.

Summary. Farmers with the following characteristics more adequately judged average data as applied to the machinery investment problem: figured out costs and returns, used analysis to decide on machinery investment on own farm, were better educated, and produced livestock.

Marginal Data. To complete the study of farmer understanding of economic analysis in connection with the hypothetical machinery investment problem, data in marginal form (question 12b, appendix) were shown each farmer after he had studied the data in average form. The data in marginal form contained the necessary information for determining the profitability of additional machinery investment. These data included marginal return and marginal cost values. These were assumed to be correct and to cover all returns and all costs. It was also implicitly assumed that the $250 was available for the purchase.

The farmer was asked to judge the adequacy of the marginal data in the same manner as for the average data. He was asked not only to appraise the adequacy of the data but to give reasons. The reasons given were then studied in the coding process to determine the farmer's understanding of the problem.

The responses given by the farmers were originally coded as follows:

Indicated by response	No. of farmers
Yes - with understanding verified	
Does not request any additional information	134
Requested specific information that did not expand the problem	25
Requested information that expanded the problem	27
Requested both types of information	6
Yes - with understanding not verified	
Does not request any additional information	8
Requests additional information	31
No	
Requests information that expanded the problem	48
Requests specific information that does not expand the problem	26
Requests both types of information	15
Says nothing that fits in the above three categories of "No" answers	4
Don't know, not ascertainable, no answer	30
Total	354

For verification of "yes" answers the farmer must have indicated that: (1) the model showed marginal profit precisely, (2) information was complete or more complete than average data, or (3) profit (e.g. returns enough to buy). "Yes" answers which didn't fit into one of these categories were considered unverified. The number of farmers citing reasons that could be considered as the same as the above were 8, 29 and 162 for each of the definitions, respectively.

The answers given were re-grouped for this study. Farmers who indicated

that the marginal data were adequate (with understanding verified) were placed in one group. These answers were considered "correct" in this study. A second group consisted of those who said that marginal data were adequate (but with understanding unverified). These first two groups were then totaled to form a group which included all farmers (regardless of verification of understanding) who indicated that the marginal data were adequate for deciding on additional machinery investment. A fourth group consisted of those farmers who answered, "No", indicating that they thought the marginal data were not adequate. These answers were considered "incorrect" in this study. A final group studied consisted of those farmers who replied that they didn't know, gave no answer, or gave an answer that was not ascertainable.

Of the 354 farmers who were asked this question 54.2 per cent indicated that the marginal data were adequate with understanding verified, while 11.0 per cent of them indicated the marginal data were adequate but gave reasons which failed to verify their understanding of the problem. Sixty five and two-tenths per cent of all farmers then indicated that the marginal data were adequate. This compares with 26.3 per cent who said the data were not adequate. Eight and five-tenths per cent gave answers classified as don't know. All of these groups of responses were useful in appraising farmers' knowledge of marginal analysis. Those groups of farmers demonstrating a high degree of understanding should show a high percentage of farmers who indicated the marginal data were adequate. Of these responses, the understanding should be verified from a large number of farmers. Those groups demonstrating a higher degree of knowledge should not indicate that marginal data were not adequate and, of course, should give a minimum of don't know answers.

Farmers response to data in marginal form for the machinery problem was studied with respect to the same four other types of factors.

Figuring Costs and Returns. The hypothesis that figuring costs and returns is a link in the chain leading to marginal analysis was substantiated by the relations shown in Table 23. Only 35.7 per cent of the farmers who said that they do not figure costs and returns recognized the marginal data as adequate for determining the profitability of additional machinery investment (with verified understanding). This compares with 57.0 per cent for those who write out, verified, and with 61.6 per cent for those who figure in the head, verified. Relatively fewer of those farmers who figured costs and returns indicated that marginal data were not adequate, and relatively fewer of them answered that they didn't know.

Considering all criteria, those farmers who write out, those who figure in the head, and those who gave verified answers for either method of figuring or both methods indicated an understanding of marginal analysis that was somewhat superior to the percentages for all farmers and markedly superior to those for farmers who do not figure.

Type of Reasoning. As was done above, and with the same arguments, farmers' conceptions of the adequacy of data in marginal form was related directly to the type of reasoning, Table 24. A higher percentage of the farmers who said they used mainly deduction when reasoning judged the data in marginal form were adequate than did the other groups. None of the farmers who used mainly deduction replied that they didn't know as to the adequacy. This compares with about 10 per cent for those farmers who used mainly induction or for those who used a combination of induction and deduction.

The study of knowledge of marginal analysis against both the proportion of thinking deductive and verified examples of types of reasoning did not reveal any precisely defined relations. Those farmers who gave no verified

Table 23. Relation of farmers' conception of adequacy of data in marginal form in determining profitability of additional machinery investment to methods used to figure costs and returns.

Method of figuring	Number of farmers	% of farmers who: Indicated marginal data were adequate: Understanding verified	Understanding unverified	Total	Indicated marginal data were not adequate	Didn't know
Does not figure	28	35.7	14.3	50.0	32.1	17.9
Writes out						
Verified	79	57.0	12.7	69.7	24.1	6.3
Unverified	7	71.4	0.0	71.4	0.0	28.6
All writing out	86	58.1	11.6	69.7	22.1	8.1
Figures in head						
Verified	125	61.6	12.0	73.6	21.6	4.8
Unverified	16	37.5	12.5	50.0	31.2	18.8
All figuring in head	141	58.9	12.1	71.0	22.7	6.4
Figures						
By writing only	5	100.0	0.0	100.0	0.0	0.0
In head only	61	63.9	11.5	75.4	21.3	3.3
Both by writing and in head, both verified	64	59.4	12.2	71.6	21.9	6.2
All farmers	354	54.2	11.0	65.2	26.3	8.5

Table 24. Relation of farmers' conceptions of adequacy of data in marginal form in determining profitability of additional machinery investment to type of reasoning.

Type of reasoning	Number of farmers	% of farmers who: Indicated marginal data were adequate: Understanding verified	Understanding unverified	Total	Indicated marginal data were not adequate	Didn't know
Combinations of induction and deduction used						
Both induction & deduction	107	45.8	13.1	58.9	30.8	10.3
Mainly deduction	21	71.4	04.8	76.2	23.8	0.0
Mainly induction	43	65.1	02.3	67.4	20.9	11.6
Other answers *	5	20.0	20.0	40.0	60.0	0.0
Proportion of thinking deductive						
Less than 1/2	68	57.4	07.4	64.8	23.5	11.8
About 1/2	41	51.2	07.3	58.5	36.6	04.9
More than 1/2	36	52.8	11.1	63.9	27.8	08.3
Don't know	31	45.2	16.1	61.3	29.0	09.7
Verification of						
Both induction & deduction	3	66.7	0.0	66.7	33.3	0.0
Deduction only	6	66.7	0.0	66.7	33.3	0.0
Induction only	27	51.9	22.2	74.1	22.2	03.7
Neither induction nor deduction	140	52.1	07.9	60.0	29.3	10.7
All farmers	354	54.2	11.0	65.2	26.3	8.5

*Other answers include induction only, deduction only, not ascertainable, neither induction nor deduction, and don't know.

examples of reasoning showed slightly less understanding than did all farmers. Those farmers giving verified examples of induction showed a slight superiority in understanding when all criteria were examined. The numbers of farmers in the other two groups were too small to permit inferences.

External Conditioning Factors. Table 25 is a two-way table showing the influence of different levels of both age and education. The results are very similar to those elsewhere in the analysis where age and education influences were studied.

Younger farmers showed more understanding than older farmers. This was especially true for the less educated farmers and the age comparison where education categories were dissolved. A parallel situation held for the more educated farmers but the pattern was not as regular.

Understanding was also related to education. This pattern held for farmers in the 40-54.9 and 55 and above age groups, and for the study of education across all age groups. The less educated demonstrated superior understanding only for the age group "under 40". Although the understanding of the sub group above 8 grades and under 40 years of age was superior to all farmers, the understanding of those in the sub group grades 1-8 and under 40 years of age was very high. That explains the one irregularity in the study of understanding against education level.

With the irregularities specified, the younger farmers and the more educated farmers showed a higher percentage of "adequate" answers, both verified and total, and smaller percentages of "not adequate" and "didn't know" answers than the other groups. As these were the criteria used to measure knowledge of marginal analysis, it may be concluded that these groups demonstrated a superior degree of knowledge compared to that for the other

Table 25. Relation of farmers' conceptions of adequacy of data in marginal forms in determining profitability of additional machinery investment to different levels of both age and education for farmers sampled.

Age and education	Number of farmers	% of farmers who				
		Indicated marginal data were adequate: Understanding verified	Indicated marginal data were adequate: Understanding unverified	Indicated marginal data were adequate: Total	Indicated marginal data were not adequate	Didn't know
Education						
Grade 1-8						
Age						
Under 40	21	66.7	14.3	81.0	14.3	4.8
40-54.9	59	52.5	13.6	66.1	20.3	13.6
55 and above	67	41.8	10.4	52.2	31.3	16.4
Above 8 grades						
Age						
Under 40	86	62.8	07.0	69.8	26.7	3.5
40-54.9	79	58.2	08.9	67.1	29.1	3.8
55 and above	34	50.0	20.6	70.6	23.5	5.9
All age groups						
Education						
Grades 1-8	147	49.7	12.2	61.9	24.5	13.6
Above 8 grades	199	58.8	10.1	68.9	27.1	4.0
All education levels						
Age						
Under 40	107	63.6	08.4	72.0	24.3	3.7
40-54.9	138	55.8	10.9	66.7	25.4	8.0
55 and above	101	44.6	13.9	58.5	28.7	12.9
All farmers *	346	54.9	11.0	65.9	26.0	8.1

* Age and education ascertained.

groups.

The relation of answers given for the hypothetical machinery problem to other external conditioning factors was shown in Table 26. Relatively more of the farmers with more experience indicated that the marginal data were adequate than did the less experienced group. Likewise, relatively fewer of the more experienced farmers indicated that the marginal data were not adequate, or indicated "don't know" as to the adequacy of the data. Thus, for these farmers, there was a direct relationship between experience and grasp of marginal analysis.

Answers given by farmers with high and low average gross incomes (based on the past three-year period) were not entirely consistent. That is, high income farmers had a greater percentage of both correct and incorrect answers, but the difference in percentage of incorrect answers between the two income groups was not large. Relatively fewer of the high income group replied that they didn't know. It may possibly be implied then that, right or wrong, high income farmers tend to have greater confidence in their own judgment. Thus they may be more willing to attempt to answer problems even though they might be wrong.

Grouping the farmers on the basis of equity level failed to reveal any consistent relations. High equity farmers showed a slight tendency to be more conservative in their answers, giving a higher percentage of don't know answers but relatively fewer incorrect answers than did the low equity group.

The percentages of correct answers given by farmers producing different products were relatively stable. The type of product grouping implied very little as related to understanding of marginal analysis in the machinery investment problem. The homogeneity of understanding among these groups is not

Table 26. Relation of farmers' conceptions of adequacy of data in marginal form in determining profitability of additional machinery investment to certain external conditioning factors for farmers sampled.

External variables	Number of farmers	% of farmers who Indicated marginal data were adequate: Understanding verified	Understanding unverified	Total	Indicated marginal data were not adequate	Didn't know
Experience						
Started farming						
Before 1933	206	59.7	12.1	71.8	22.8	05.3
In 1933 or later	143	47.6	09.8	57.4	30.1	12.6
Average gross income						
Under $6500	151	48.4	13.9	62.3	23.8	13.9
$6500 and above	176	61.9	09.1	71.0	25.0	04.0
Equity						
Greater than 95%	175	52.0	14.9	66.9	24.0	09.1
95% or less	137	57.7	06.6	64.3	29.2	06.6
Main product						
Hogs	93	53.8	07.5	61.3	30.1	08.6
Wheat	79	55.7	15.2	70.9	26.6	02.5
Dairy	55	56.4	14.5	70.9	21.8	07.3
Corn and other feed	48	52.1	06.3	58.4	25.0	16.7
Beef and sheep	27	40.7	11.1	51.8	40.7	07.4
Others *	52	61.5	11.5	73.0	15.4	11.5
All farmers	354	54.2	11.0	65.2	26.3	8.5

* "Others" includes tobacco, soybeans and flax, beans, vegetables and truck crops, poultry and eggs, fruit, and not ascertainable.

surprising. Nearly every, if not all of the farmers, regardless of product, utilized some machinery. For that reason, the example was one equally familiar to all groups and it could be reasoned that they would respond to it similarly.

Real Responses to Use of Analysis and Type of Reasoning. Table 27 shows the relation of answers given by farmers regarding the adequacy of data in marginal form for determining the profitability of additional machinery investment to use of analysis and type of reasoning used by these farmers when making machinery investment decisions on their own farms. (These categories were coded from responses given by farmers to question 20, appendix. A more complete explanation of the groupings was made in the discussion of Table 22.)

Fifty six and nine-tenths per cent of the farmers who used analysis indicated that the marginal data were adequate to determine the profitability of additional machinery investment (understanding verified), while only 44.4 per cent of those farmers who did not use analysis correctly answered the question. Study of Table 22 indicated that farmers who used analysis more adequately determined that the average data were not adequate. It has been shown here that farmers who used analysis were also better able to judge data in marginal form. It may be implied then that a relationship exists between the use of analysis by farmers and their grasp of average and marginal reasoning.

A comparison of the types of reasoning used by the farmers who analyzed machinery problems on their own farms gave no clear-cut implications. With only five farmers included in the group that used inductive reasoning, very little could be determined. It was noted, however, that 58.1 per cent of the 74 farmers who used an integrated inductive-deductive type of reasoning

Table 27. Relation of farmers' conception of adequacy of data in marginal form in determining profitability of additional machinery investment to use of analysis by farmers when buying machinery.

Analysis and reasoning	Number of farmers	% of farmers who Indicated marginal data were adequate: Understanding verified	Understanding unverified	Total	Indicated marginal data were not adequate	Didn't know
Use of analysis						
Was used	160	56.9	10.6	67.5	24.4	8.1
Was not used	18	44.4	27.8	72.2	22.2	5.6
Type of reasoning						
Inductive	5	60.0	0.0	60.0	40.0	0.0
Deductive	47	53.2	10.6	63.8	23.4	12.8
Integrated inductive deductive process	74	58.1	09.5	67.6	25.7	6.8
All farmers	354	54.2	11.0	65.2	26.3	8.5

indicated the marginal data were adequate with understanding verified, compared to 53.2 per cent for the 47 farmers who used deductive reasoning. As a whole, the understanding of farmers in these groups was not different from that for all farmers.

Summary. The entire chain leading to a marginal analysis, machinery investment problem, has been examined, and the empirical results were largely as hypothesized.

The following groups demonstrated a superior understanding of marginal analysis for the machinery problem:

1. Figured costs and returns
2. Younger farmers
3. More educated farmers
4. Experienced farmers
5. Used analysis to decide on machinery investment on own farm

Summary, Average and Marginal Analysis, Machinery Problem. As for the hog problem, the original responses to the adequacy of the data in average form and in marginal form for the machinery problem were as expected.

	Percentage of farmers responding		
	Data adequate	Data not adequate	Don't know
Data in average form	35.9	56.8	7.3
Data in marginal form	65.2	26.3	8.5

Farmers predominantly indicated that the data in average form were not adequate and that the data in marginal form were adequate. Also, as for the other problem, farmers were more accurate on their answers to the marginal data. Again, the results were more conclusive when various other factors in the chain

were related to responses to the marginal data than to responses to the data in average form. The percentage of don't know answers was considerably smaller for the machinery problem than for the hog problem.

SUMMARY

Integration of Results

This study has been concerned with possible determinants of and the relationship between hypothesized links in the chain of processes leading to marginal analysis. It was believed that the chain was interrelated so that the whole framework would necessarily form a structure. The interdependence of the system was suggested by the following hypotheses.

1. That farmers use or are capable of using deductive reasoning, and this is necessary if they are also to figure costs and returns.
2. That farmers figure costs and returns, and this is necessary if they are to use marginal analysis.
3. That the use of each stage of the process is also influenced by external conditioning factors.

These steps were all tested empirically with data obtained from farmers.

The study proceeded by first building up to a marginal analysis. Verifications regarding the character and strength of the structure supporting marginal analysis were accomplished by substantiation of hypotheses one, two, and three.

The use of marginal analysis was studied in the next phase. This was done by the use of two hypothetical problems: a hog production problem and a machinery investment problem. In each problem the approach was the same, with data being presented in both marginal and average form. Responses given

by farmers to the data in marginal form were of primary interest. Data in average form were also used because it was believed that something could also be learned from the characteristics of farmers who were able to recognize the limitations of this method of figuring.

The study was especially successful in the results obtained from the analysis of the marginal data proper. This was true for both of the hypothetical problems.

The direct relationship of marginal analysis to each developing step was studied. If the hypotheses mentioned were valid, the same pattern of answers, it was argued, would result by relating use of marginal analysis to primary steps directly or to primary steps indirectly through intermediate steps. Empirical results consistently verified these similarities for all of the hypothesized steps.

Of all the external conditioning factors studied, only age and education showed consistent relations to the use of analytical processes by farmers. It would be fair to generalize that a higher percentage of farmers who are young and a higher percentage who are better educated used analysis at each level.

Further study was made of the responses given to the two hypothetical problems as related to analysis and reasoning used by these farmers when handling actual problems on their farms. In general, methods and analyses used by farmers on their farms were consistent with responses given to the hypothetical problems. Consistency of real world responses with answers given to hypothetical problems served to verify the value of responses to the problems.

Implications

Findings have indicated that farmers vary considerably in their application of marginal analysis and/or steps leading to marginal analysis.

If agencies are to provide a maximum of useful information they must take into account the fact that some farmers are capable of and do perform these different steps leading to and including marginal analysis, and that other farmers stop at different points along the way.

It is apparent that all information beamed towards farmers at a given level in the chain will not be most effective in total. Different farmers need different degrees of refinement in the data that are made available to them. Some farmers will be capable of using information of an even more refined nature, while there will be other farmers whose analytical processes have not been developed to the point that they can use such information.

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APPENDIX

Survey Questions Used in the Analysis

10. In figuring out what action to take on the basis of the information you have about a problem, do you sometimes look at what it will cost you and compare this, both financially and otherwise, with the results you can expect?

___No: Why is it that you don't do this?_____

___Yes: Do you ever try to work out the answers in writing?

___No

___Yes: Can you tell me some of the things you've done this for?_____

Do you sometimes do this figuring in your head?

___No

___Yes: Can you tell me some of the things you've done this for?_____

11. Here is a way for a farmer to figure out the costs and returns of expanding a 15 litter hog enterprise to 25 litters.

a. The farmer figures that his costs per litter will increase from $210 to $222. With the price of hogs remaining as at present, he will gross $270 per litter. On this basis, if he expands his hog enterprise to 25 litters, his net profit per litter will be $48, or the difference between the $270 and $222.

Would these figures tell you how many litters this farmer should raise?

___Yes: How many litters should he raise?_____

___No

___Don't know

b. Here is another way to figure out the same problem.

He figures his costs and returns on each additional litter and finds that each one will add or lose the following amounts after costs are subtracted.

	Profit	Loss		Profit	Loss
16th litter	$80	-	21st litter	$14	-
17th litter	72	-	22nd litter	7	-
18th litter	59	-	23rd litter	-	$11
19th litter	45	-	24th litter	-	15
20th litter	30	-	25th litter	-	20

Would these figures tell you how many litters this farmer should raise?

___Yes: How many litters should he raise?_____

___No

___Don't know

c. Which way do you figure out costs and returns in similar situations?

___Uses a.
___Uses b.
___Uses both
___Uses another method: How would you figure it out?_____

12. a. Here is the information that a farmer has for deciding whether or not to put another $250 into machinery. (INTERVIEWER PRESENT CARD)* His records indicate that his average gross income per $250 invested in machinery is $450. The average returns above fuel and labor costs per $250 invested in machinery are $275. Is this enough information to decide whether or not a farmer should invest another $250 in machinery?

___Yes: For what reasons?_____.

___No: Why not?_____.

___Don't know: What difficulties are you having in figuring this out?_____.

*A card stating this problem was given the respondent for reference while answering the question.

b. Here is another way for him to figure it out. (INTERVIEWER PRESENT CARD)* An analysis of records from his farm and other similar farms indicates that additional investments in machinery can be expected to return 25% on the dollar after the earnings of all other expenditures and investments are accounted for. This 25% includes profits, interest on the machinery investment figured at 5%, and depreciation figured at 10%. Is this enough information to decide whether or not a farmer should invest another $250 in machinery?

___Yes: For what reasons?_____.

___No: Why not?_____.

___Don't know: What difficulties are you having in figuring this out?_____.

*A card stating this problem was given the respondent for reference while answering the question.

13. Two methods of arriving at conclusions are illustrated by the examples on this card (INTERVIEWER PRESENT CARD)*.

1. In some cases we draw conclusions from experience. Thus, we may notice that in certain situations certain results always seem to follow. On the basis of this, we conclude that these results always occur in this situation. An example might occur in fertilizing a field. Thus, if a farmer sees that the poor thin spots in a field respond to fertilizers more than the rich spots, he may conclude that poor thin spots always respond more than rich spots.

2. In other cases, we "reason out" conclusions about new situations facing us from facts and principles we know or assume to be true. For instance, a farmer may know or assume that a certain barn arrangement will save labor and then "figure out" how the use of this arrangement would affect the amount of labor which would be left over for use elsewhere in his business.

a. Do you use both, mainly one, only one, or neither of these methods in arriving at conclusions?

___Both
___Mainly one: Which?_____
___Only one: Which?_____
___Neither
___Don't know

b. Which of these thinking methods is most natural for you to use?

___Both
___One: Which?_____
___Neither
___Don't know

c. Can you use one of these methods without using the other?

___Yes
___No
___Don't know

d. What proportion of your thinking is like the first method? (PRESENT CHECKLIST)**

___None	___About 1/2	___All
___Less than 1/4	___Between 1/2 and 3/4	___Don't know how much, but not all
___About 1/4	___About 3/4	
___Between 1/4 and 1/2	___More than 3/4	___No answer

*A card illustrating methods 1 and 2 of arriving at conclusions was given the respondent for reference while answering the question.

**The respondent indicated the proportions by means of a checklist.

e. What proportion of your thinking is like the second method? (PRESENT CHECKLIST)*

___None	___About 1/2	___All
___Less than 1/4	___Between 1/2 and 3/4	___Don't know how much, but not all
___About 1/4	___About 3/4	
___Between 1/4 and 1/2	___More than 3/4	___No answer

f. Could you give me another example of the first method of arriving at conclusions?

_____

g. Could you give me another example of the second method?

_____

17. Could you please tell me how you made up your mind about what or how much of each product to produce this year?

_____

18. a. What important thing that you buy and use in production has had a fairly big change in price recently?_____(X)

b. What do you use it for?_____(Y)

c. How did you make up your mind about how much of _____X_____ to use in producing _____Y_____, when the price of _____X_____ changed?

_____

20. What was the last major piece of machinery that you bought?

_____

How did you go about making up your mind to buy it?_____

_____

*The respondent indicated the proportions by means of a checklist.

USE AND INTERRELATION OF MARGINAL ANALYSIS AND OTHER ANALYTICAL PROCESSES BY FARMERS IN DECISION MAKING

by

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This study has been concerned with possible determinants of and the relationship between hypothesized links in the chain of processes leading to marginal analysis. It was believed that the chain was interrelated so that the whole framework would necessarily form a structure. The interdependence of the system was suggested by the following hypotheses.

1. That farmers use or are capable of using deductive reasoning, and this is necessary if they are also to figure costs and returns.
2. That farmers figure costs and returns, and this is necessary if they are to use marginal analysis.
3. That the use of each stage of the process is also influenced by external conditioning factors.

The use of these steps was tested with data obtained by interview from 1075 farmers. These farmers were from selected areas of the following seven states: Kentucky, Ohio, Indiana, Michigan, North Dakota, Iowa, and Kansas. Random sampling was conducted within areas, and the universe consisted of farmers with gross incomes of 2500 dollars or more. This particular study was part of a much larger study from which only certain questions were singled out for intensive analysis.

The study proceeded by first building up to a marginal analysis. Verifications regarding the character and strength of the structure supporting marginal analysis were accomplished by substantiation of hypotheses one, two, and three.

The use of marginal analysis was studied in the next phase. This was done by the use of two hypothetical problems. One problem covered the most profitable number of litters of pigs to produce, and the second dealt with the most profitable level of machinery investment.

Data, both averages and marginals, were a part of each problem. Farmers

were asked to appraise the adequacy of the data in each form toward solving the problem. The purpose of these two problems was to test farmers' understanding of average and marginal analysis.

Responses given by farmers to the data in marginal form were of primary interest. Data in average form were also used because it was believed that something could also be learned from the characteristics of farmers who were able to recognize the limitations of this method of figuring. The results obtained from the analysis of the marginal data proper were especially successful. This was true for both of the hypothetical problems.

The direct relationship of marginal analysis to each developing step was studied. If the hypotheses mentioned were valid, the same pattern of answers, it was argued, would result by relating use of marginal analysis to primary steps directly or to primary steps indirectly through intermediate steps. Empirical results consistently verified these similarities for all of the hypothesized steps.

Only age and education, of all the external conditioning factors studied, showed consistent relations to the use of analytical processes by farmers. It would be fair to generalize that a higher percentage of farmers who are young and a higher percentage who are better educated used analysis at each level.

Further study was made of the responses given to the two hypothetical problems as related to analysis and reasoning used by these farmers when handling actual problems on their farms. In general, methods and analyses used by farmers on their farms were consistent with responses given to the hypothetical problems. Consistency of real world responses with answers given to hypothetical problems served to strengthen the value of responses to the problems.