A SUMMARY OF RECENT ECONOMETRIC STUDIES IN AGRICULTURAL ECONOMICS USING THE MULTIPLE REGRESSION METHOD

by

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A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF ARTS

Department of Economics and Sociology

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1963

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TABLE OF CONTENTS

LIST OF TABLES

Table | Page

CHAPTER I

INTRODUCTION

Econometrics is a broad field which deals with theory as well as empirical statistical analysis. The methods recently used include four categories: linear programming, non-linear programming, simultaneous equations, and multiple regression. There are books and papers devoted to each one of these categories to deal with economic problems such as prediction, decision making, etc.

Agricultural economics has applied econometric methods in many problems. Only empirical research in agricultural economics has been surveyed. This survey covered the Journal of Farm Economics for the period February 1957 to February 1962 inclusive. Articles dealing with theory or with methodology and not including empirical research were not considered in this survey. The reason for choosing this periodical is that it is a general journal, which contains articles ranging freely and widely in every field of agricultural economics, so that the results obtained from this journal may be regarded as representative in the whole area. It has close contacts with experiment stations of colleges and universities, and in it are republished bulletins and Ph.D theses which are important in the field. Twenty two articles have been found using econometric methods and empirical data in the journal within the period. Four of these articles used linear programming method; five used simultaneous equations; and thirteen used multiple regression method. This indicates that in the agricultural sector multiple regression method has been most widely applied. That is the reason that this report emphasizes the multiple regression analysis.

In order to have a better understanding of why this method (multiple regression) is used so often by agricultural economists, and how effective the results obtained are, a concentrated study of this method was undertaken. And it is the purpose of this paper to present a general idea of the results of ten empirical studies,[1] which have been used as the frame of this paper. Specifically, it is desired to find out what are the major objectives of the researches, what success did these authors have in testing their theories (Did they get good statistical fits in their regressions?), and what types of independent variables are more important, if any. Before discussing the results of this survey a brief description of the nature of econometrics will be given in Chapter II.

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[1]Among thirteen articles which used multiple regression, there are three the writer had difficulty in understanding, therefore only ten articles were used for this paper. See list of ten articles in Chapter III.

CHAPTER II

THE NATURE AND DEVELOPMENT OF ECONOMETRICS

Economics, Statistical Economics, Mathematical Economics and Econometrics

Economics is a science which studies the alternative uses of the scarce resources for satisfying various human wants. It involves the theories of price, of production, of demand and supply, of income, of trades, of economic organizations etc. And the theories have been used as tools to understand the situation of society, to guide the decision making for economic activities, to promote the living standard of the whole world.

Mathematical economics is applied mathematics, a partnership between mathematics and economics. It states the axioms or basic assumptions of economic theory in terms of mathematical symbols. It then uses the methods of mathematics to derive theoretical conclusions from the assumptions. Mathematical economics does express pure theoretical statements, but does not prove any theory about the real world. "The testing of a theory can lead to its rejection as inconsistent with facts, but it can never lead to the proof of the theory, but only to its provisional acceptance as not inconsistent with facts," R. G. D. Allen stated.[1] Therefore, mathematical economics is best regarded as the process of following up

[1] See (1), Ch. I.

the consequences of a particular set of self-consistent axioms with economic content.[1]

Statistical economics is a form of quantitative economics that avoids economic theory and claims to provide a statistical summary of the economic data themselves.[2]

"Econometrics is a name for a field of science in which mathematical-economics and mathematical-statistical research are applied in combination."[2] It differs from mathematical economics by including statistical measurement and testing. Since it combines data with theory to obtain quantitative results, it is not statistical economics only. Econometrics, quantitative economic study, has a threefold basis: It is necessary to formulate economic hypotheses, to collect appropriate data, and to confront hypotheses with data.[3]

<u>Development of Econometrics</u>

Economic theory involves quantitative analysis, and therefore requires the language or method available to deal with quantitative arguments. Some economic authors, like Smith and Say, in writing on Political Economy, have preserved all the beauties of a pure literary style; but there are others like Ricardo, who, when treating the most abstract questions, or when seeking great accuracy, have not been able to avoid algebra, and have only disguised it under arithmetical calculations of tiresome length. Geva has been regarded as the first known writer to apply mathematical methods to economic problems. In 1826, J. H. von Thünen's

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[1] *Ibid*

[2] See (19), p. 1

[3] See (16).

book could have taught us how theory grows out of the observation of business practice. He pointed out the idea of marginal productivity, cost accounting, bookkeeping, and related subjects, all of which cover a mass of material which economists had entirely neglected up to that time, and these are great contributions to economics and statistics as well as to econometrics.

Augustin Cournot of France was apparently the first to apply mathematics with a great degree of success. His "Researches into the Mathematical Principles of the Theory of Wealth" published in 1838, is one of the most striking achievements in the field of mathematical economics. Cournot stated in the preface of his book that: "The employment of mathematical symbols is perfectly natural when the relations between magnitudes are under discussion."[1] In Cournot's book the first principles of differential and integral calculus are applied in order to obtain the solution of the general questions which arise from the theory of wealth.

Leon Walras, in his theory of equilibrium, gave a powerful base to the work of econometrics. It is true that while he made the decisive step in the quantitative, he failed to move in the numerical line, but when we look on the numerical possibilities of that most general and most abstract part of econometrics we see that it is the equilibrium theory in Walras' sense.

Jevons, the writer of Theory of Political Economy, was concerned with marginal utility and the general mathematical treatment of "value and utility."

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[1] See (6), p. 3.

In 1914, when Henry Ludwell Moore published his "Economic Cycles: Their Law and Cause",[1] the first definitive and systematic attack on the problem of deriving demand curves was completed. This book contains equations expressing the relation between quantity and price for each of several agricultural products and, derived from these equations, elasticities of demand for each crop. The work has served as a point of departure for practically all the demand studies which have subsequently been made. From 1925 until his death in 1938, Henry Schultz was the leader of this field. His book: "Statistical Laws of Demand and Supply with Special Application to Sugar"[2] is devoted to the determination of the demand and supply function, and elasticities for sugar, with special attention to the logical basis for procedure and with an illustrative application to the tariff.

I. Fisher expanded Jevons' determination of exchange of two commodities between two trading bodies to the exchange of any number of commodities between any number of traders and obtained the interpretation of the mechanism, which was expressed by writing many equations in as many unknowns. These equations are essentially those of Walras. The only fundamental differences are that Fisher used marginal utility throughout and treated it as a function of the quantities of commodity, whereas Walras makes the quantity of each commodity a function of the prices.

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[1]See (17).

[2]See (18).

CHAPTER III

RECENT EMPIRICAL STUDIES IN AGRICULTURAL ECONOMICS

Kinds of Subject Matter Discussed

Economists have contributed numerous works both in theoretical analysis and empirical researches on demand and supply, from which all the economic activities hang. When such topics as government policy, international trade, farm income, labor forces, market prices are discussed, demand and supply come into the picture very often. Also it is true with agricultural problems that demand and supply are most important factors to be considered. A review of the ten articles from the Journal of Farm Economics which have been chosen for this report, reveals the same conclusion. The ten articles analyzed are the following:

Barker, "Supply Functions for Milk Under Varying Price Situations". Reference (2).

Brake, "Fertilizer Demand in the South Atlantic and East North Central Regions". Reference (3).

Buse and Brandow, "The Relationship of Volume, Price, and Costs to Marketing Margins for Farm Foods". Reference (5).

Cromarty, "The Farm Demand for Tractors, Machinery and Trucks". Reference (7).

Dawson, "The Productivity of Water in Agriculture". Reference (8).

Dean and Heady, "Changes in Supply Response and Elasticity for Hogs". Reference (9).

Doll, Jebe and Munson, "Computation of Variance Estimates for Marginal Physical Products and Marginal Rates of Substitution". Reference (10).

Franzmann and Judge, "Estimation of Response Relationship for Eggs". Reference (12).

Griliches, "Estimates of the Aggregate U. S. Farm Supply Function". Reference (13).

Hartman and Anderson, "Estimating the Value of Irrigation Water from Farm Sales Data in Northeastern Colorado". Reference (14).

Table I indicates that agricultural economists favor demand and supply analysis when they deal with empirical quantitative studies.

TABLE I

CLASSIFICATION OF TEN EMPIRICAL STUDIES
IN THE JOURNAL OF FARM ECONOMICS, 1957–1962
(MULTIPLE REGRESSION METHOD)

Classifications	Number of Articles	Number of Equations	Average Number of Variables Used for Each Equation[a]
Demand	4	17	3.5
Supply	3	40	3.5
Others	3	30	5.0
Marketing margin	1	28	5
Production function[b]	1	1	3
Evaluation of input	1	1	8
Total	10	87	4.0

[a]Including dependent variables.

[b]Doll copied the regression equation from the paper "Crop Response Surfaces and Economic Optima in Fertilizer Use" which was presented by Heady, Pesek and Brown, see (15).

The number of equations of demand, supply or "others" merely presents the work which has been done by economists. The average number of variables used for each equation indicates that four is a practical number to be chosen in the empirical studies.

Since all ten articles studied are in the agricultural field, it will be interesting to know what kinds of agricultural commodities have been mostly studied. The following Table 2 summarizes the agricultural commodities into six groups, then according to the classification mentioned above (demand, supply and others). The frequency tells what kinds of commodities were studied under each classification.

TABLE 2

FREQUENCY OF STUDIED AGRICULTURAL COMMODITIES

Commodities	Number of Articles	Demand	Supply	Others		
				Marketing Margin	Production Function	Evaluation[a]
Farm foods	3	1		20[b]	1	
Farm inputs	4	5[c]				1
Livestock and livestock products	3[d]		3			
All crops combined			1			
All agricultural commodities combined			1			
Total	10	6	5	20	1	1

[a]Evaluates economic effects of irrigation water.

[b]Twenty kinds of farm foods have been studied in one article .

[c]Three kinds of farm inputs have been studied in one article.

[d]One article contains livestock and livestock products, all crops combined and all agricultural commodities combined.

Objectives of Studies and Variables Used

A brief summary concerning the objectives of the studies is presented in a table form:

TABLE 3

OBJECTIVES OF STUDIES

Classification	Number of Articles	Average Number of Observations	Objectives
Demand	4	22	
Farm food	1	18	Price-consumption estimation for eggs.
Farm input	3	26	Demand for tractor, machinery, trucks, irrigation water, and fertilizer.
Supply	3	26	
Livestock	1	14	Supply of hogs.
Aggregate supply	1	31	Aggregate supply of all agricultural commodities.
Livestock production	1	33	Illustrate the irreversibility of supply function.
Others	3	28.5	
Market margin	1	33	"Determine the relation of farm-retail price spreads for individual foods to the average spread for all foods collectively and to the volume, retail price and change in price of the individual food."[a]
Production function[b]	1		Demonstrate the procedure of estimating marginal physical products and variances of marginal physical products.
Water	1	24	Evaluate the economic effects or irrigation water.

[a]See (5).

[b]See footnote b under Table 1, p. 8.

In empirical studies of multiple regression, one of the problems that needs to be solved first is what effective factors are to be used in the equations. Of course this should be decided according to the purpose of the study.

Quantity demanded for different products is effected by different factors or different combinations of factors. But the most commonly used factor in demand study is current price of the commodity concerned and the wealth or income of the farm. The others are price of substitute commodities, and lagged price etc. Table 4 will indicate this result. This table includes cases of both factor demand and consumer demand.

TABLE 4

FREQUENCY OF VARIABLES USED FOR DEMAND STUDIES

Products Studied	Number of Equations Containing Specified Variables						
	X_1	X_2	X_3	X_4	X_5	X_6	X_7
Irrigation water	1						2
Machinery	1		1	1	4	1	
Tractor	1				1	2	
Trucks	1				1		2
Fertilizer	2	2			5	2	2
All eggs	3	1					
AA grade eggs	2						
A grade eggs	2						
B and non grade eggs	1						
Total	14	3	2	1	11	5	6

X_1 : price of commodity at time period t
X_2 : price of commodity at time period t-1
X_3 : Price of substitute goods
X_4 : price of complementary or supplementary goods
X_5 : wealth or income of the farm
X_6 : stock of commodity
X_7 : others

One way to estimate supply elasticity is via the production function. Dean and Heady[1] estimated the production functions for hogs then computed the supply elasticity. It may be said that causal factors of production are also indirectly causal factors of supply. The causal factors used for supply or for production are presented in following Table 5.

TABLE 5

FREQUENCY OF VARIABLES USED FOR SUPPLY STUDIES

Products Studied	Number of Equations Containing Specified Variables							
	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
Hogs	4	6	8	4	2			
Aggregate supply[a]	6					6	5	5
Aggregate of all crops	6					6	6	3
Aggregate of livestock & livestock products	20[b]	14[b]					20	6
Total	36	20	8	4	2	12	31	14

[a] For all agricultural commodities.

[b] When the variable used in the equation is price of commodity deflated by price of input, then it has been counted for X_1 & X_2 one each.

[1] See (9).

X_1 : Price of commodity
X_2 : Price of input
X_3 : Price of competitive commodity
X_4 : Stock of commodity
X_5 : Quantity of input commodity produced
X_6 : Weather index
X_7 : Trend (time)
X_8 : Lagged output

From the table, it is obvious that price of commodity and trend (time) are used most often. As for X_2 (price of input), the third highest frequency in this table, this variable was used because two out of the three articles were discussing a product which required feed. So whether X_2 is an effective variable for supply studies or not depends on the product studied.

So far the variables used for seven empirical studies have been summarized in two previous tables under the categories of demand and supply. The last three articles, which were classified into the category of "others" are difficult to summarize as to what kind of variables were commonly used, for the dependent variables of each article varied one from another. However, the average number of variables per equation used for each study is presented in the last column of Table I.

Goodness of Fit

The value of the multiple correlation coefficient squared, R^2, expresses the reliability of the relationship of the independent variables to the dependent variable. And the term $1-R^2$ indicates the ratio of the variance of the unexplained residuals in the regressions to the original variance of the dependent variable. Therefore, the greater the R^2 is, the better fitted the equation is. Of course the variances or standard errors of the regression coefficients will affect the value of the R^2 too.

When authors publish the results of their empirical studies, it usually means that the results have approached some standard of satisfaction. There are only two equations with really low values of the multiple correlation coefficient squared.

Table 6 gives a general idea about the range of the multiple correlation coefficient squared.

TABLE 6

RANGE OF MULTIPLE CORRELATION COEFFICIENT SQUARED FOR TEN EMPIRICAL STUDIES. (NUMBER OF EQUATIONS)

Classification	Below 0.60	0.60-0.69	0.70-0.79	0.80-0.89	0.90-0.99	Total
Demand		3	2	1	11	17
Supply	1	2	2	4	31	40
Others	1	2	1	4	22	30
Total	2	7	5	9	64	87

One of the major reasons for the residual error of the prediction is that there are some other causal independent variables which were not included in the study. Take the egg study of Mr. J. R. Franzmann and G. G. Judge[1] as an example. One of the equations of this study is:

$$Y_1 = 33.91 - 0.2757Z_1 , \qquad R^2 = 0.70 \qquad (1)$$

where Y_1 = total purchases of eggs in dozens per 100 customers, and Z_1 = average price of eggs per dozen. (Assume a uniform increase in

[1] See (12)

price level of all grades of eggs). The price of eggs alone has been used as a causal variable in this equation. There are many other variables which might affect the demand for eggs, such as price of previous years, income of the consumer, etc. The authors have given another equation in their study and included the difference between the average price per dozen in time period t and the average price per dozen in time period t-1 as an additional causal factor, and obtained the equation and multiple correlation coefficient squared as follows:

$$Y_1 = 45.77 - 0.4829Z_1 - 0.0873Z_2 , \qquad R^2 = 0.93 \qquad (2)$$

The result of adding one more variable reveals that: (1) there are effective variables which were neglected in equation 1; (2) the former price of the eggs does affect the purchase of eggs in time period t. Roughly speaking, when R^2 is more than 0.9 the prediction is considered rather good or significant, because there are always some unpredictable facts which will influence the actual demand, but the influence will not be significant; therefore they are not included in the study.

A change in the causal variables in the equations will affect the accuracy of the prediction or will affect the value of R^2. Therefore a variety of formulations will present different goodness of fit. Take the demand for eggs as a function of the average price of eggs as an example, six equations published contain a range of R^2 from 0.60 to 0.98, which indicated that some of the equations are better than others.

The Relative Importance of the Independent Variables

One of the objectives of this study is to find out if there is a tendency for certain classes of independent variables used in econometric research to be more important than other kinds. A measurement of relative importance or contribution of individual independent variables in explaining the variation in the dependent variable can be obtained by the t-ratio or by the partial correlation coefficient.

The t-ratio is computed anyway in tests of hypotheses, or in forming confidence intervals for regression coefficients. The t-ratio for coefficient b_i is defined as:

$$t_i = b_i / S_{b_i}$$

S_{b_i} denotes the estimated standard error of the regression coefficient. The larger the t-ratio, the more important is the variable i in the regression equation.

Using the demand for machinery as an example,[1] the demand function is:

$$Y_1 = \underset{}{2,397,952} - \underset{(450)}{720.5Y_6} + \underset{(255.4)}{235.8Z_2} - \underset{(257.0)}{1,206.3Z_3} + \underset{(46.3)}{28.8Z_4} + \underset{(4.1)}{15.6Z_5}$$

$$+\underset{(22.4)}{38.6Z_6} + \underset{(2,549.6)}{1,232.9Z_7} - \underset{(126.5)}{433.0Z_9} \quad , \qquad R^2 = 0.95$$

Y_1 : the value of manufacturers' sales of farm machinery and equipment for use on farms deflated by the wholesale price index for farm machinery, or quantity of machinery purchases by farmers.

Y_6 : the wholesale price index for farm machinery deflated by the general price level.

Z_2 : the index of prices received by farmers for crops and livestock, deflated by the general price level.

Z_3 : the index of prices paid by farmers for items used in production excluding wages and the components of farm machinery and motor vehicles indexes, deflated by the general price level.

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[1] See (7)

Z_4 : the value of farm machinery on farms at the beginning of each year deflated by the wholesale price index for all machinery.

Z_5 : the asset position of farmers at the beginning of the year deflated by the general price level.

Z_6 : realized net income for the previous years, deflated by the general price level.

Z_7 : the average acreage of cropland per farm.

Z_9 : an index of farm labor costs, deflated by the general price level.

The t-ratios are:

$$t_{Z_3} = \frac{1,206.3}{257.0} = 4.69 \qquad t_{Y_6} = \frac{720.5}{450} = 1.56$$

$$t_{Z_5} = \frac{15.6}{4.1} = 3.80 \qquad t_{Z_2} = \frac{235.8}{255.4} = 0.92$$

$$t_{Z_9} = \frac{433.0}{126.5} = 3.42 \qquad t_{Z_4} = \frac{28.8}{46.3} = 0.62$$

$$t_{Z_6} = \frac{38.6}{22.4} = 1.72 \qquad t_{Z_7} = \frac{1,232.9}{2,549.6} = 0.48$$

From the t values the Z_3 is the most important factor. The other variables Z_5, Z_9, Z_6, Y_6, Z_2, Z_4, Z_7, have importance respectively going down.

The partial correlation coefficient will now be discussed. It represents the relationship of two variables, holding other variables in the equation non-effective. Here we emphasize the partial relationship between dependent variables with each independent variable only. Therefore, the greater the partial correlation coefficient squared (coefficient of partial determination) of the dependent variable to the independent variable is, the more important the contribution the independent variable provides in explaining the dependent variable. The calculation of the coefficient of partial determination may be defined as:

$$r^2_{1i(p)} = 1 - \frac{S^2_{1.2,3,\ldots\ldots\ldots k}}{S^2_{1.2,3,\ldots)i(\ldots\ldots k}}$$

where $S^2_{1.2,3,\ldots)i(\ldots k}$ denotes the S^2 in a set of variables in which variable i is omitted, but all other independent variables are included; $S^2_{1.2,3,\ldots k}$ denotes the variance of residuals. Another easier way to calculate the coefficient of partial determination after t value is obtained is:

$$r^2_{1i(p)} = \frac{1}{1 + (n-k)/t_i^2}$$

where n-k is the number of degrees of freedom.[1]

Using the latter formula, and t values of the last example, the partial correlation coefficient squared can be obtained (n-k = 23).

$r^2_{1Z_3(p)}$	= 0.49	$r^2_{1Y_6(p)}$	= 0.10
$r^2_{1Z_5(p)}$	= 0.39	$r^2_{1Z_2(p)}$	= 0.04
$r^2_{1Z_9(p)}$	= 0.34	$r^2_{1Z_4(p)}$	= 0.02
$r^2_{1Z_6(p)}$	= 0.11	$r^2_{1Z_7(p)}$	= 0.01

The results reveal the same conclusion as using t-ratios.

Since the t test of the significance of the coefficient b_i is equivalent to an F test of the significance of $r^2_{1i(p)}$, where $F = t_i^2$ with 1 and (n-k) degrees of freedom. The t-ratios have been computed to indicate the importance of variables used for these articles. Table 7

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[1]See (11), p. 6

shows the variables used for demand studies and Table 8 shows the variables used for supply studies.

TABLE 7

AVERAGE VALUE OF THE t-RATIOS FOR VARIABLES USED IN DEMAND STUDIES

Product Studied	X_1	X_2	X_3	X_4	X_5	X_6	X_7
Irrigation water	2.38						3.15
Machinery	1.56		0.92	4.69	2.36	0.62	
Tractor	1.99				1.59	4.38	
Trucks	2.31				5.00		2.29
Fertilizer	4.10	2.54			3.88	15.47	2.71
All eggs	13.99	3.22					
AA grade eggs	5.96						
A grade eggs	3.56						
B and non grade eggs	2.68		2.52				
Average	4.28	2.88	1.72	4.69	3.21	6.82	2.72

X_1 : price of commodity at time period t
X_2 : price of commodity at time period t-1
X_3 : price of substitute goods
X_4 : price of complementary or supplementary goods
X_5 : wealth or income of the farm
X_6 : stock of commodity
X_7 : others

In comparing the average value of the t-ratios of variables used in demand studies, Table 7 reveals a rather unusual results. Stock of commodities and price of complementary or supplementary goods are the most effective variables instead of the price of the commodities and the wealth or income of the farm, which are usually considered as the most effective variables in demand study.[1]

TABLE 8

AVERAGE VALUES OF THE t-RATIOS OF VARIABLES USED IN SUPPLY STUDIES

Products Studied	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
Hogs	10.81	4.04	3.14	3.77	2.86			
Aggregate supply[a]	2.08					4.61	9.16	4.61
Aggregate of all crops	2.45					5.07	6.03	1.50
Aggregate of livestock and livestock products	2.95	3.00					3.36	8.87
Average	4.57	3.52	3.14	3.77	2.86	4.84	6.27	4.99

[a]For all agricultural commodities.

X_1 : price of commodity
X_2 : price of input
X_3 : price of competitive commodity
X_4 : stock of commodity
X_5 : quantity of input commodity produced
X_6 : weather index
X_7 : trend (time)
X_8 : lagged output

This table reveals that trend (time) is the most effective factor in supply studies; lagged output is the next important one; weather index is counted as the third effective factor. In general, price of commodity and price of competitive commodity are the most significant effective varia-

[1]But see limitations to this conclusion stated on page 21 and 22 below.

bles. Since both Table 7 and Table 8 present such unusual results, there must be some reasons.

One reason for these results is that these two tables are computed by using simple averages, and do not count the frequency of use of variables in all studies. Therefore, a weighted average value of the t-ratios of variables used in both demand and supply studies has been computed. The weights used in these computations are the numbers of times the variables appeared in the published equations, as shown in Tables 4 and 5. The result has improved the previous results just a little.

For all demand studies, the weighted average value of t-ratios still indicates that stock of commodity has the highest value, 8.06. The cause of this high value was one extremely high ratio of this variable in one equation, (fertilizer study[1]). This ratio pulls up both simple average and weighted average. Should this extremely large t-ratio be eliminated, then price of commodity would have the highest t-ratio (5.42).

As for the supply studies, the weighted average value did not improve the result at all. Trend, lagged output, and weather index are the three most important variables.

Another possible explanation of the results of Table 7 and Table 8 is that the authors of these ten articles may have omitted some non-significant variables when they presented their predicted equations. If those omitted variables were included in the equations with a very small coefficient, these would affect the average t value of individual factors. In Table 7 and Table 8, there are blank spaces, which might be interpreted as some

[1]See (3).

close to zero t-ratios. Should we fill all the blank spaces with zero, then the results would differ only slightly from the general conclusion.

Irreversibility of Supply Function

In surveying the studies cited, a particular subject of great interest was discussed. The classical supply function is assumed to be reversible over time. Expansion in production with a price rise and contraction in production with a price fall occur along the same path. In fact the adjustments or responses to short-run price changes occur at unequal rates. It is generally accepted that the supply elasticity of expansion under rising prices exceeds the elasticity of contraction under falling prices. The irreversible function is referred to in the static context as being "kinked". Given the level of price and output (point A in Figure 1), change can occur in either direction. In Figure 1 the elasticity of expansion exceeds the elasticily of contraction. In the dynamic frame of reference, contraction may follow expansion or vice-versa. The supply function in Figure 2 is irreversible because the initial point (A) and the final point (C) do not coincide. (dynamic case).

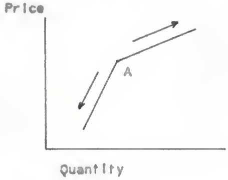

Figure 1

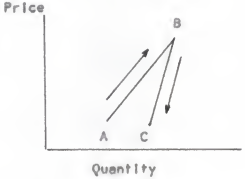

Figure 2

Based on this theoretical background, Barker[1] made an empirical study of milk supply, and presented the results as a table which has been recopied in Table 9.

Two conclusions have been drawn:

(1) With a rising price trend, the year-to-year elasticity of expansion exceeds the elasticity of contraction.

In equation 1 and equation 2, the elasticity of milk-feed price ratio supported this conclusion (.349, .239). Also in equations 5 and 6 both feed price and milk price gave the same result (.306, -1.95; .369, .227).

(2) The elasticity of expansion is higher under a rising than under a falling price trend. In equations 1 and 3, .349 is greater than .134, while in equations 5 and 7, .306 is greater than -.127, and .369 is greater than .116.

In equations 3, 7, and 8, the elasticities of expansion are less than the elasticities of contraction under falling price trend, which is an inconsistent conclusion. But the small number of observations and the non-significance of elasticities are the causal factors of this inconsistency.

The concept of the irreversibility of the supply function is important in the explanation and prediction of supply response. Although there is evidence in this paper to suggest that the supply function for milk is not reversible, the results of this study are not conclusive. Further research is needed to establish more clearly the shapes of the supply functions under different price movements.

TABLE 9

MILK SUPPLY ELASTICITIES UNDER RISING AND FALLING PRICES; LAKE STATES, 1926–1958[a]

Price Situation	Number of Observations	R^2	Time	Milk–Feed Price Ratio	Feed Price Deflated[b]	Milk Price Deflated[b]
1. Rising trend rising annual	12	.967	.00568 (.00039)	.349 (.136)		
2. Rising trend falling annual	9	.936	.00531 (.000757)	.239 (.108)		
3. Falling trend Rising annual	7	.992	.00447 (.000346)	.134 (.114)		
4. Falling trend falling annual	5	.990	.00541 (.000222)	.254 (.0415)		
5. Rising trend rising annual	12	.977	.00558 (.000347)		.306 (.114)	.369 (.118)
6. Rising trend falling annual	9	.977	.00580 (.000431)		–.195 (.0456)	.227 (.0953)
7. Falling trend rising annual	7	.992	.00470 (.000511)		–.127 (.169)	.116 (.184)
8. Falling trend falling annual	5	.990	.00510 (.000661)		–.293 (.097)	.165 (.183)

[a] This table is copied from Barker's article, see (2).

[b] Feed price and milk price were deflated by the index of prices received for all farm products.

(Numbers in parenthesis are standard error)

CHAPTER IV

CONCLUSION

Recent empirical studies have used the multiple regression method very often as stated on page 1. As indicated in Table 1, seven out of ten articles dealt with demand and supply analysis; also sixty five per cent of the number of equations were devoted to the same categories. All these results reveal the importance of demand and supply studies in the agricultural economics field.

Farm foods, farm inputs, and livestock and livestock products, were subjects of approximately equal interest in studies of the agricultural sector.[1]

Price of commodity is a major factor for both demand and supply studies. Among the fifty-seven demand and supply equations which have been published in these ten articles there are fifty equations which contain this variable (price of commodity).[2] Four equations[3] were found in which price of commodity was a non-significant factor; therefore it was eliminated from the equations by the original author. Two of three other equations[4] contained the lagged price instead of the price of

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[1] First column of Table 2, p. 9.

[2] Tables 4 and 5, pp. 11 and 12.

[3] See (9)

[4] See (3)

commodity. So there is only one equation which did not originally contain the factor of price. With this evidence, we can conclude that price of commodity is the most often used factor in studying demand and supply. Wealth or income of the farm and stock of commodity are the next two often used factors in demand studies. Among seventeen demand equations, lagged price has been used three times, price of substitute goods twice, and price of complementary or supplementary goods only once. For supply functions trend, price of input, lagged output and weather index are ranked as most often used factors[1] without counting price of commodity.

About seventy-four per cent of the published equations (87) which have been fitted with the multiple regression method hold a value of R^2 in the range of .90 - .99; ten per cent in .80 - .89; five per cent in .70 - .79; eight per cent in .60 - .69; two per cent below .60. This result matches the theory very nicely, for we expect to have high value of R^2 for our empirical prediction function.

After the average t-ratios were computed for each individual variable[2] we obtained a conclusion that stock of commodity is the most important factor for demand studies; price of commodity at time period t is the next. For supply studies, trend is the most important one, and lagged output is the next. From the same tables, we find that price of substitute goods is the least important factor; and price of commodity at time period t-1 is the next to the least important factor in demand studies. In supply studies quantity of input commodity produced and price of competitive

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[1]Refer to Table 5, p. 12

[2]Refer to Tables 7 and 8, pp. 19 and 20.

commodity are the two least important factors.[1]

The multiple regression equations can be calculated by a desk calculator, if the variables used for the equation are not many. Among the ten articles, there is only one equation containing nine variables (including the dependent variable)[2] and the average number of variables used for each equation is five. When an equation contains more than five variables and the observation number (the average number of observations for all ten articles is 25.5) is great also, then an automatic computer should be used in order to save all the time and computing services involved. But to get the automatic computer is very expensive. No individual could do it, though perhaps an institution could.

The above conclusions are limited because this report is based on a rather small sample size. For example, the small sample size might cause unusual conclusions such as we have drawn from Table 7 and Table 8.

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[1] Limitations to this conclusion stated on page 21 and 22.

[2] See (7)

ACKNOWLEDGMENT

The author wishes to express appreciation to her major instructor, Dr. Walter D. Fisher, Professor, Department of Economics and Sociology, for his guidance and assistance in the preparation of this report.

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A SUMMARY OF RECENT ECONOMETRIC STUDIES IN AGRICULTURAL ECONOMICS USING THE MULTIPLE REGRESSION METHOD

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B. S., Taiwan Provincial College of Agriculture, 1957

AN ABSTRACT OF A REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF ARTS

Department of Economics and Sociology

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1963

Econometrics is a broad field in which mathematics and statistics are applied to deal with economic theory. In many agricultural economic problems, econometric methods have been applied. Linear programming, non-linear programming, simultaneous equations, and multiple regressions are four major methods used in econometrics.

Econometrics, quantitative economic study, has a threefold basis: to formulate economic hypotheses, to collect appropriate data, and to confront hypotheses with data. It differs from mathematical economics by including statistical measurement and testing, and differs from statistical economics by combining data with theory to obtain quantitative results.

In the seventeenth century, econometrics was invented. Augustin Cournot of France was the first to apply mathematics to economic problems with a great degree of success. Leon Walras and Jevons are the pioneers in this field. Henry L. Moore, Henry Schultz, and Irving Fisher have contributed a lot to this field too.

In this report are surveyed ten empirical researches in agricultural economics, contained in the Journal of Farm Economics for the period February 1957 to February 1962. It is the purpose of this report to find out what the major objectives of the researches are, what success these authors had in testing their theories (Did they get good statistical fits in their regressions?), and what types of independent variables are more important, if any.

An analysis of the ten empirical researches has led to the following conclusions:

1. Demand and supply are two most common fields for research in agricultural economics studies.

2. Price of the commodity or factor of production studied is the most commonly used variable for both demand and supply studies.
3. Other factors used for demand studies are: wealth or income of the farm, stock of commodity, price of substitute goods, and price of complementary or supplementary goods.
4. Other factors used for supply studies are: trend (time), price of input, lagged output, weather index, price of competitive commodity, stock of commodity, quantity of input commodity produced.
5. Seventy-four per cent of the published equations (87) have a value of R^2 in the range of .90-.99; ten per cent in .80-.89; five per cent in .70-.79; eight per cent in .60-.69; two per cent below .60.
6. The variables in demand studies are listed in descending order of their importance as follows:
    a. Stock of commodity.
    b. Price of complementary or supplementary goods.
    c. Price of commodity at time period t.
    d. Wealth or income of the farm.
    e. Price of commodity at time period t-1.
    f. Price of substitute goods.
7. The variables in supply studies are listed in descending order of their importance as follows:
    a. Trend (time).
    b. Lagged output.
    c. Weather index.
    d. Price of commodity.
    e. Stock of commodity.

f. Price of input.

g. Price of competitive commodity.

h. Quantity of input commodity produced.

8. Average number of variables used for each equation is five.

Conclusions six and seven need some explanation. Generally speaking, price of commodity is the most important factor for both demand and supply studies. Prices of competitive and substitute commodities, wealth or income of the farm are also very important categories of variables. Conclusions six and seven reached unusual conclusions, which differ from the general theory. The reasons for these conclusions are:

1. The t-ratios, which have been used as the measurement of the importance, are computed by using simple averages.
2. The authors of these ten articles may have omitted some non-significant variables when they presented their predicted equations. And this fact would affect the average t value of individual factors.
3. The sample size (ten articles) is a rather small number.

One of the ten articles presented an interesting subject - irreversibility of supply function. This paper suggested that the supply function for milk is not reversible, but the results of this study are not conclusive. Further researches in this subject are needed.