AN ABSTRACT OF THE THESIS OF

Ram Prakash Yadav for the Master of Science
(name of student) (Degree)

in Agricultural Economics presented on July 27, 1971
(Major) (Date)

Title: An Econometric Analysis of the Demand for Selected Agricultural Inputs in Oregon.

Abstract approved: Grant E. Blanch

The objective of this study is to analyze empirically the demand structure for the following important farm production inputs in Oregon: hired labor, chemical fertilizer, farm machinery, repairs and operating costs of motor vehicles and other machinery designated as "machinery supplies," purchased feed and miscellaneous inputs.

Twenty-year data (1950-69 except 1951-70 for hired labor) were analyzed with the aid of simple equation least-squares multiple regression techniques for all inputs. In addition, a simultaneous-equation model is applied to hired labor data. The demand for each input is predicted through 1975.

This study indicates that hired farm labor employment depends heavily upon wage rates. Contrary to earlier national and regional

studies, the short-run demand for hired farm labor in Oregon during 1951-70 was found to be elastic, -1.2 to -1.5 and -1.5 to -2.6 in the single-equation and the simultaneous-equation demand models respectively. This implies that if farm wage rates rise, the number of workers employed declines in greater proportion than the wage rate rise. Conversely, if wage rates fall the number of workers employed will increase disproportionately. The number of hired workers employed on Oregon farms declined by 40.6 percent (37 thousand to 22 thousand) between 1950 and 1970. A further 25 percent decline is projected by 1975.

The demand for fertilizer and purchased feed are comparable in many ways. The demand for each is inelastic (-0.45 and -0.58) in the short-run, and moderately elastic (-1.05 to -1.35) in the long-run. The adjustment coefficient, which indicates the percent of the required adjustment that can be made in one year in feed or fertilizer purchases, in both cases are about the same--around 0.50. However, profitability of livestock enterprises as an independent variable (RL_t) is statistically significant in the demand equation for purchased feed, but profitability of farming as a variable (R_t) is not significant in the fertilizer models. Furthermore, fertilizer purchases continued to increase in spite of static or slightly decreasing crop prices. Although the input price variable is statistically significant in the demand models for both fertilizer and purchased feed, decreasing fertilizer prices have probably contributed heavily to the increase in the use of fertilizers in Oregon.

If the past declining trend in the "real" price of fertilizer continues and other relationships do not change materially, there will be a 43 percent (381.8 thousand tons to 547.5 thousand tons) greater consumption of fertilizer in Oregon over the next six years. Based on past experience, such an increase is undoubtedly within the capability of the fertilizer industry to meet the requirement. The expenditure for purchased feed is projected to be 9 percent greater in 1975 than in 1969 in terms of constant 1957-59 dollars. The increase becomes 25 percent when expressed in terms of what feed prices are expected to be in 1975 dollars.

Unavailability of data on annual capital outlay for the purchase of machinery and equipment by Oregon farmers is a serious problem in the estimation of the demand structure for farm machinery. However, annual inventories of machinery and equipment on Oregon farms is used as a substitute variable. The analysis indicates the demand for machinery and equipment inventories to be inelastic. The demand for "machinery supplies", a variable with considerable complementarity with machinery and equipment inventory, was also found to be inelastic. A 10 percent increase in the price of farm machinery or price of "machinery supplies" is associated with a 4.5 percent decrease in the total machinery and equipment inventory, and a 6.3 percent decrease in "machinery supplies" purchased.

The estimated elasticities may be biased due to high multicollinearity problems in their demand models. However, the prediction ability of these models is undoubtedly good. It is expected that there will be a $32 million increase (1957-59 dollars) in the value of machinery inventories on Oregon farms by 1975 over the 1969 level. The increase is $104 million in 1975 dollars. The expenditure for repairs and operating costs of motor vehicles and other machinery (machinery supplies) are expected to be fairly constant during this period in terms of 1957-59 dollars. This peculiarity of increasing inventory of machinery and equipment in 1957-59 dollars and a constant expenditure for "machinery supplies" is judged to be due to the fact that the machinery inventory effect and the price effect seem to cancel out and maintain the constant expenditure for "machinery supplies." Prices of "machinery supplies" have tended to decline over the period of the study. The projection of expenditure for "machinery supplies" in terms of current dollars indicates a 12 percent increase by 1975 which is wholly accounted for by expected inflationary tendencies in the economy.

In contrast to chemical fertilizer, purchased feeds, machinery and equipment inventories and "machinery supplies," miscellaneous inputs (interest, electricity, veterinary supplies and services, etc.) has a very high elastic demand. Due to the evidence of there being two distinct trends in expenditures for miscellaneous inputs, the data were analyzed on the basis of the two periods. The dummy variable approach developed by Damodar Gujarati fails to reject the null hypothesis of the discontinuity in the demand curve for miscellaneous inputs during the 1950-69 period at the 5 percent test level. The mean price elasticity of demand was found to be -1.22 for the period 1950-57 and -4.28 for the period 1958-69. Such a high elasticity is probably due to a strong complementarity between miscellaneous inputs and the increasing total agricultural plant size, and the substitution effect due to gradually falling relative prices of miscellaneous inputs.

A 23 percent increase (1957-59 dollars) in expenditure for miscellaneous inputs is projected by 1975 compared to 1969. The increase in terms of 1975 dollars amounts to 46 percent: from $72.8 million to $106.4 million.

It is anticipated that the information regarding the demand structure for farm production input factors discussed in this study will be useful to people involved in farm labor policy-making, and decision making in farm supply business firms, credit agencies and farming businesses in planning for the extension of their volume of operations in the next few years. The future demand for these farm inputs, among other factors, will largely depend on the trend of their "real" or relative prices. The projected amount of expenditures for these inputs in current dollars will be modified by any changes in the extent of inflationary tendencies in the economy.

An Econometric Analysis of the Demand for Selected Agricultural Inputs in Oregon

by

Ram Prakash Yadav

A THESIS

submitted to

Oregon State University

in partial fulfillment of

the requirements for the

degree of

Master of Science

June 1972

APPROVED:

Professor of Agricultural Economics
in charge of major

Head of Department of Agricultural Economics

Dean of Graduate School

Date thesis is presented July 27, 1971

Typed by Keitha Wells for Ram Prakash Yadav

ACKNOWLEDGEMENT

My sincere gratitude is expressed to my major professor, Dr. Grant E. Blanch for his guidance and counsel during my graduate study and for his criticism and encouragement during the writing of this thesis.

Special gratitude and appreciation are expressed to another member of my graduate committee, Dr. Timothy Hammonds, who introduced me to econometrics in the classroom and who has contributed generously of his talents and time providing close supervision in building econometric models.

The author is also thankful to Dr. Lyle D. Calvin, Chairman of the Department of Statistics, for serving as minor professor.

My study at Oregon State University would not have been possible without the Fulbright-Hays financial grant, administered by the Institute of International Education, and the grant of my study leave by His Majesty's Government, Nepal. I deeply appreciate this educational opportunity.

The cooperation of other faculty members and graduate students at Oregon State University is also appreciated.

Sincere gratitude and love is expressed to my parents, tillers of the soil in Nepal, who have encouraged me in innumberable ways in my strivings for an education.

TABLE OF CONTENTS

		Page
I.	Introduction	1
	Objectives	2
	Methodology	3
II.	Hired Labor	6
	Introduction	6
	Previous Hired Labor Studies	10
	Factors Affecting the Demand for Hired Labor	14
	Model of the Demand for Hired Farm Labor	16
	Statistical Results	22
	Demand Elasticities	27
	Economic Implication	28
III.	Fertilizer	31
	Introduction	31
	Previous Fertilizer Studies	34
	Specification of Demand Model for Fertilizer	37
	Statistical Results	41
	Price Elasticity of Demand and Implication	42
IV.	Farm Machinery	45
	Introduction	45
	Previous Machinery Demand Studies	46
	Factors Affecting the Quantity of Farm Machinery Purchased by Farmers	48
	Model of the Demand for Farm Machinery	50
	Statistical Results	52
V.	Repairs and Operating Costs of Motor Vehicles and Other Machinery	57
	Introduction	57
	Demand Model for Machinery Supplies	59
	Statistical Results	64
VI.	Purchased Feed	67
	Introduction	67
	Previous Feed Demand Studies	72
	Specification of the Demand Function	73
	Statistical Results	75

		Page
VII.	Miscellaneous Inputs	82
	Introduction	82
	Specification of the Demand Function	84
	Statistical Results	87
VIII.	Trends and Projections	92
IX.	Summary and Conclusions	102
	Future Research	109
	Bibliography	110

LIST OF TABLES

Table		Page
1.	Simple Correlation Coefficients of the Variables in the Demand Equation for Hired Farm Labor	18
2.	Single-Equation Demand Models for Hired Labor	24
3.	Simultaneous-Equation Demand Models for Hired Labor	25
4.	Simple Correlation Coefficients of the Variables in the Demand Equation for Fertilizer	39
5.	Single-Equation Demand Models for Fertilizer	40
6.	Single-Equation Demand Models for Farm Machinery	53
7.	Simple Correlation Coefficients of the Variables in the Demand Equation for Farm Machinery	54
8.	Single Equation Demand Models for Machinery Supplies	61
9.	Simple Correlation Coefficients of the Variables in the Demand Equation for Machinery Supplies	62
10.	Single-Equation Demand Models for Purchased Feed	76
11.	Simple Correlation Coefficients of the Variables in the Demand Equation for Purchased Feed	76a
12.	Simple Correlation Coefficients of the Variables in the Demand Equation for Miscellaneous Inputs	85
13.	Single-Equation Demand Models for Miscellaneous Inputs	88
14.	Projection of Selected Agricultural Production Inputs from 1970 through 1975. Oregon.	95

LIST OF FIGURES

Figure		Page
1.	Total Farm Labor in Oregon with Comparisons for Hired and Family Labor, 1950-1970	7
2.	Composite Farm Wage Index in Oregon (1957-59 = 100), 1950 to 1970	9
3.	Amount of Primary Plant Nutrients and Total Fertilizer Purchased by Oregon Farmers in Thousand Tons, 1950-1969	32
4.	"Real" price per ton of Fertilizer in Terms of Plant Nutrients and the Expenditures for Fertilizer in 1957-59 dollars. Oregon. 1950-1969.	33
5.	Expenditures for Repair and Operation of Farm Motor Vehicles and Other Machinery in 1957-59 Constant Dollars. Oregon. 1950-69.	58
6.	Illustration of Inelastic Demand for Machinery Supplies	63
7.	Expenditures for Purchased Feed in 1957-59 Dollars. Oregon, 1950-69.	68
8.	The Major Economic Relationships in the Feed-Livestock Economy	69
9.	Miscellaneous Production Expenditures by Oregon Farmers in 1957-59 dollars. 1950-69.	83
10.	Illustration of Elastic Demand for Miscellaneous Inputs	85

AN ECONOMETRIC ANALYSIS OF THE DEMAND FOR SELECTED AGRICULTURAL INPUTS IN OREGON

I. INTRODUCTION

Historically, empirical work dealing with agricultural factor markets has been neglected by agricultural economists when compared with product markets (36). A few studies have been made to quantify the market structure for hired labor, fertilizer, farm machinery, and feed on a national and regional level. However, essentially no work has been done on the state level. The present study is an attempt to quantify the demand structure for a few important but selected agricultural inputs in Oregon. They are: hired labor, fertilizer, farm machinery, feed, repair and operation of machinery, and other equipment (machinery supplies) and miscellaneous inputs.

There has been a marked change in the resource input combinations in the agricultural production process in the last two decades. Capital in the form of machinery and equipment has been substituted for labor very extensively due to their relative costs and improved technology. Mechanization has contributed to a 33.3 percent decrease in the number of farms in Oregon and to a 55.8 percent increase in the average size of farms during the 1950 to 1970 period. During the same period, fertilizer consumption increased by 354 percent, which is substituting a variable input for a fixed input; the hired labor force decreased by 40.6 percent; and the composite farm wage rate index increased by 81.7 percent. These changes in the farm economy and their impacts will certainly be carried over into the future agriculture of Oregon.

Anticipated new innovations and increases in farm wage rates will further accelerate the substitution of capital for labor. As technology advances, much machinery which now in use will become obsolete before it is physically worn out. Farmers will have to expand the size of their farms to fully and economically utilize large-capacity machinery. Thus, in order to provide information to farmers, businessmen, and government officials that might assist them in decision-making regarding the future use and need of these factors, it is necessary to quantify their market structure. The demand structure for these inputs is analyzed in this study.

Objectives

(1) To examine the most crucial factors affecting the demand for individual farm inputs in Oregon.

(2) To estimate short-run and in selected cases long-run elasticity of demand for these inputs.

(3) To make projections of the demand for these inputs from 1970 through 1975. Hired labor and fertilizer will be projected in

terms of number of workers and tons respectively. Feed, machinery supplies, and miscellaneous inputs will be projected in terms of total expenditure in 1957-59 dollars, and in current dollars, and farm machinery will be projected in terms of total value of inventories.

Methodology

A least-squares multiple regression technique is used to estimate the demand equations for these inputs. A single-equation demand model is used for all inputs in this study. However, a simultaneous-equation model is also applied to estimate the demand for hired labor. This model is employed on the assumption that the farm-wage rate and the quantity of labor employed are jointly-dependent endogenous variables.

Fertilizer price is considered as an "administered price" set in advance by the fertilizer producing firms, so the simultaneous-equation approach does not seem to be needed in this case (15, p. 601).

Only the demand for purchased feed is considered in the present study and not the total quantity of feed fed to livestock. Total quantity of feed includes both the purchased feed and the feed produced on the farm. An assumption is therefore made that given the price of feed, any demanded quantity will be supplied. This eliminates the need to consider a supply equation for this input.

Rojko, in his econometric analysis of dairy products for the dairy industry came to the conclusion that the single-equation approach gave results as good as the simultaneous-equation technique, when the statistical technique and the nature of data were not refined enough to specify a model that will ferret out several interrelationships (34, pp. 323-338).

Comparing several estimation methods, Christ summarizes the problem of choice of technique as follows: "for structural parameters, least-squares sometimes is preferable to simultaneous-equation method (probably especially when samples are small and specification error is present) and sometimes is not (probably especially in the reverse case)" (6, p. 480). In the present study, the sample size is only 20. Furthermore, it is difficult to specify the models for feed, machinery supplies, miscellaneous, and farm machinery according to their interrelationships among different variables. So a single-equation least-square estimation seems to be appropriate for this demand study.

For miscellaneous inputs, a dummy variable approach developed by Damodar Gujarati is applied to accomodate an *a priori* conjecture that the demand curve contains a discontinuity (18, 19). The price elasticity of demand for feed, machinery supplies and miscellaneous inputs is calculated by deriving a "proxy" quantity (dividing the total expenditure by the price index) and regressing each with the appropriate explanatory variables.

All of the price indices are expressed in terms of the base 1957-59 = 100, and are deflated by the U.S. consumer price index of 1957-59 = 100. The total expenditure for different inputs or any other data expressed in dollars also are deflated by the same consumer price index. Time series data for the period 1951 through 1970 are used for hired labor, and from 1950 to 1969, inclusive for other inputs. This decision is based entirely on the availability of data.

Sources of data, variables, and previous studies relative to the demand for each input are discussed in the respective chapter dealing with that input. Indices of prices paid for farm machinery, feed, machinery supplies, farm supplies, and other commodities used in farm production are not available for Oregon. Therefore, United States price data are used. The current operating expenditures covering the different input factors considered in this study are obtained from Farm Income, State Estimates 1949-69 (U.S. Dept. of Agriculture, Economic Research Service, FIS 216 Supplement/ August 1970).

II. HIRED LABOR

Introduction

The agricultural labor force consists almost solely of family labor and hired labor. The family labor includes farm operators and unpaid family workers. The hired labor force is made up of regular hired farm workers (those employed 150 days or more by one employer) and seasonal-hired farm workers. The farm labor force was about 7.2 percent of the total Oregon labor force in 1967 (31, p. 2).

There has been a significant decline in the number of persons employed on farms in Oregon in the last twenty years. In 1950, there were 119,000 workers on farms as family and hired labor, whereas, in 1970, only 68,000 such persons were on farms. There has been a decrease of about 43 percent in the total farm labor force. Although, 37,000 persons worked as hired labor in 1950, there were only 22,000 people so recorded in 1970. This is a 40.6 percent decrease in the hired labor force. Similarly, there has been a 44 percent decline in the family labor force. Figure 1 shows the total labor force with comparisons for hired labor and family labor from 1950 to 1970.

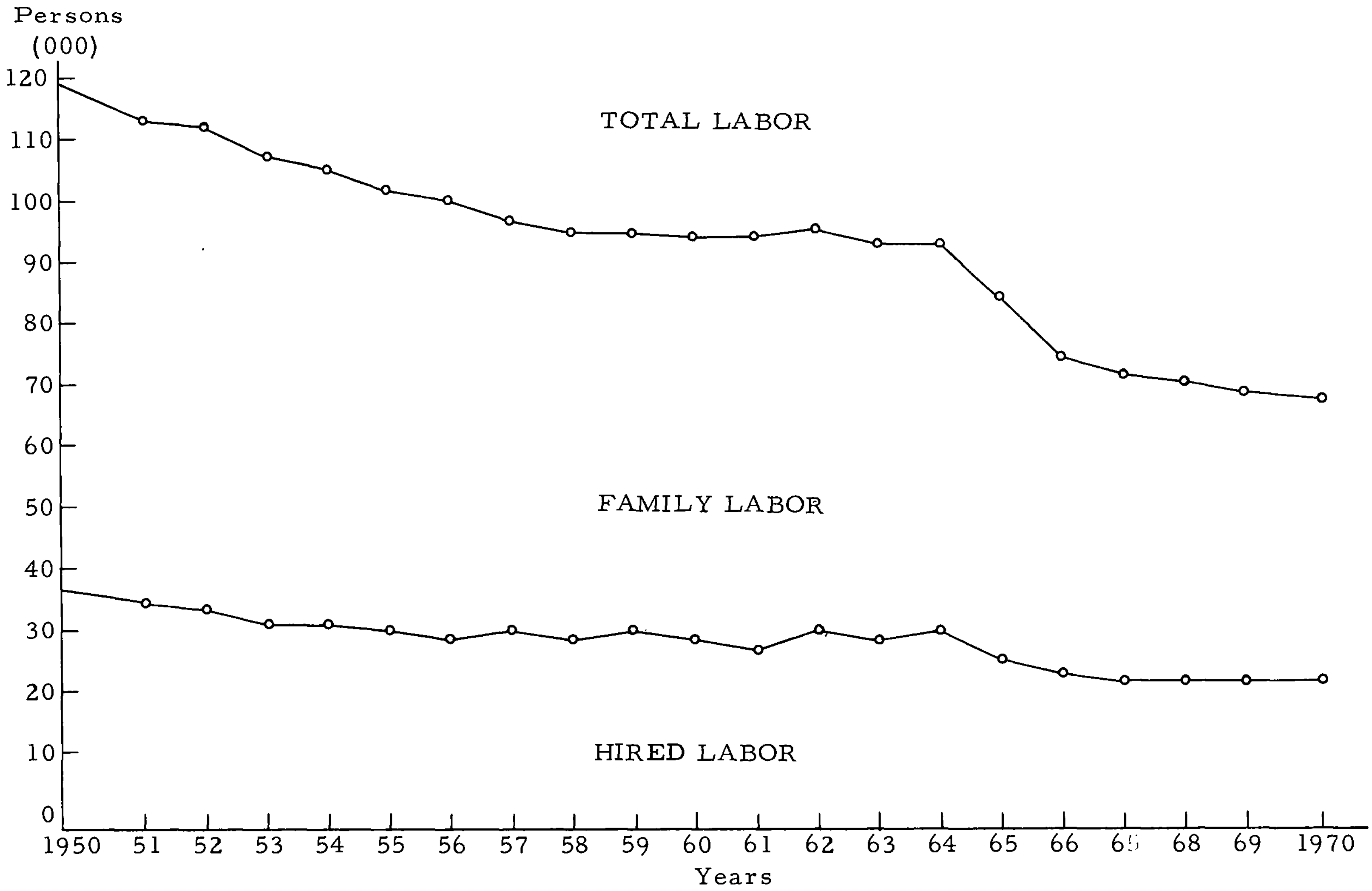

Figure 1. Total farm labor in Oregon with comparisons for hired and family labor, 1950-70 (persons employed during the last full calendar week ending at least one day before the end of the month).

During this period when the number of farm workers in Oregon was declining, the index of the composite wage rate paid to Oregon farm workers increased from 460 to 836 (1910-14 = 100). Figure 2 shows the trend in the rise of this composite wage rate index (1957-59 = 100) from 1950 to 1970.

The expenditure for hired labor in 1950 constituted 27.46 percent of the total current operating expenses of Oregon farmers and 20.04 percent of their total production expenses but in 1969, hired labor was only 18.23 percent and 11.64 percent respectively. Although expenditures for their services have decreased, hired workers play a very important role in the business of farming. They help in farming operations from land preparation until the final product is marketed.

It is believed that one of the reasons for the decline in family labor has been the adoption of mechanized farming resulting from, among other things, the "cost-price squeeze." Mechanized farming has also had its impact on hired farm labor. The innovation of new capital inputs from science and technology has permitted machines to displace hand labor with sharp increases in efficiency. Farm operators using traditional methods find it difficult to compete with operators of highly mechanized, large sized farms. So, they either enlarge their own operations, completely disappear from the farm community and seek non-agricultural employment, or they stay on

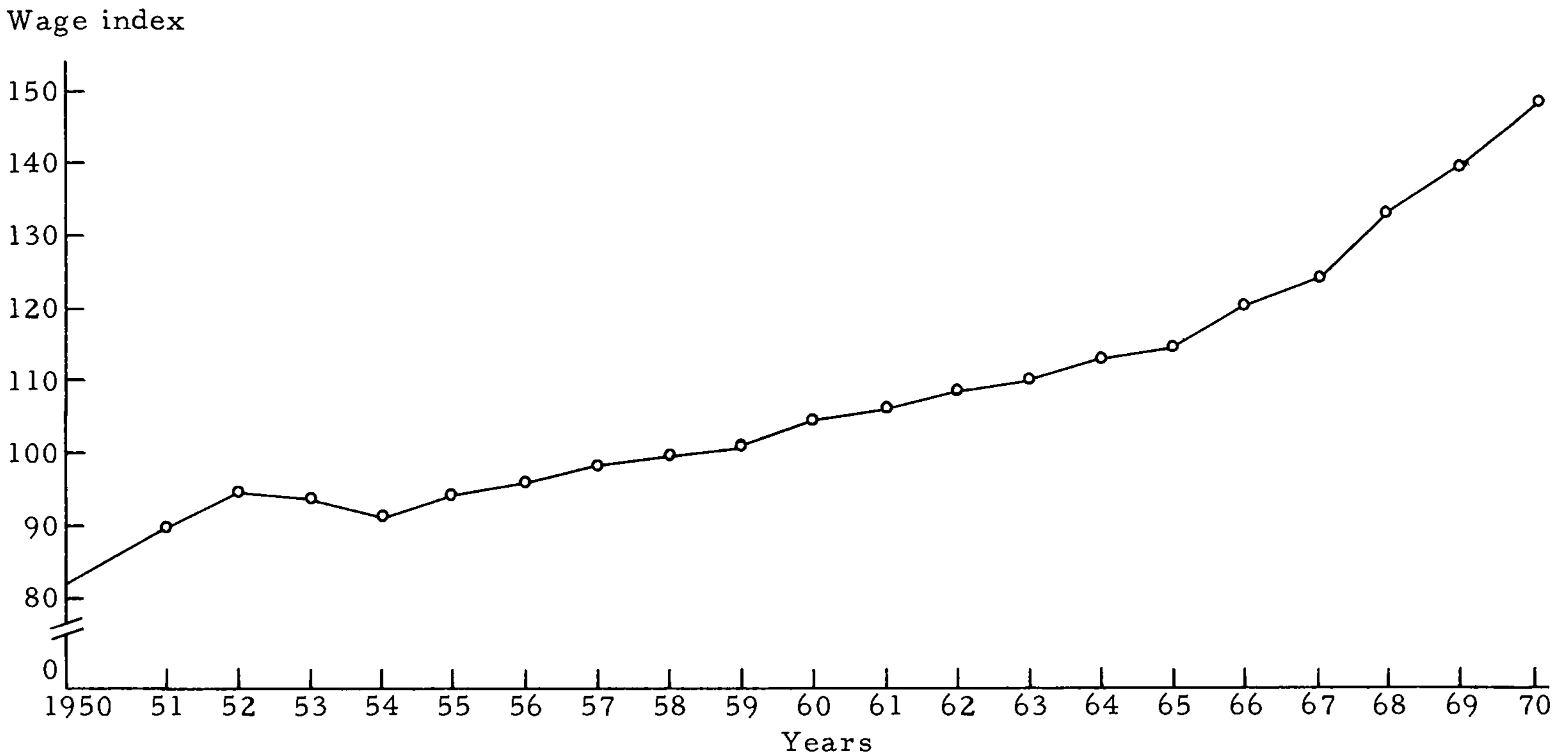

Figure 2. Composite farm wage index in Oregon (1957-59 = 100), 1950-70.

farms but work off the farm for the larger part of their living. Seasonal farm workers engaged in the fruit and vegetable enterprises so far have not been as adversely affected by mechanization.

> "Although the general long-term trend of the agricultural work force has been down, increased acreage of certain high labor using crops such as cherries, cane berries, various vegetables, and nursery crops has tended to erase the work decline largely caused by mechanization. This has resulted in a nearly stable annual average seasonal hired worker segment during the past few years" (31, p. 3).

However, continued efforts to develop harvesting machines for the more difficult crops such as strawberries and raspberries, and plant breeders efforts towards developing plant strains capable of being machine harvested drastically reduce the demand for seasonal laborers in the next ten years (33, p. 8).

Previous Hired Labor Studies

Griliches used a simple single-equation demand model for hired agricultural labor. He expressed the quantity of hired farm labor as a function of: (a) the "real" price of hired labor (index of farm wage rate divided by the index of prices received for all farm products) and (b) lagged hired farm employment. These two variables were significant and "explained" 98 percent of the total variation about the mean in his demand model. He obtained a short-run elasticity of demand for hired farm workers of -.11 and a long-run elasticity of -0.62 with a low adjustment coefficient of 0.18 (17, p. 316).

Heady and Tweeten estimated the demand function for hired farm labor by means of a conventional least-squares equation and by a limited-information-simultaneous-equation system. In their single-equation models, the demand for hired labor is specified as a function of: (a) the current year index of the farm wage rate of hired labor, deflated by the index of prices received by farmers for feed and livestock, expressed as a percent of the 1947-49 average; (b) the past year index of farm wage rate of hired labor, deflated by the past year index of prices received by farmers for feed and livestock, expressed as a percent of the 1947-49 average; (c) the current year index of farm wage rate, deflated by the index of prices paid by farmers for operating inputs and machinery, expressed as a percent of the 1947-49 average; (d) the past year index of the farm wage rate, deflated by the past year index of prices paid by farmers for operating inputs and machinery, expressed as a percent of the 1947-49 average; (e) the total stock of productive farm assets; (f) an index of government agricultural policies; and (g) time. National aggregate data for all variables from 1926 to 1959, excluding 1942 to 1945, were used in the analysis. The coefficients of b, e, f, and g were statistically significant. The single-equation model produced an R^2 of 98 percent. The distributed lagged variable was significant only if the total stock of productive farm assets was omitted from the equation (20, p. 219-222).

With the assumption that current agricultural employment and wage rates are mutually determined, a limited-information model was used by Heady and Tweeten. They expressed concern over the unusually large magnitudes of the coefficients in their demand model for which they blamed multicollinearity and underidentification (for detail see 20, p. 223-225).

They found for 1940-57, the short-run wage elasticities of demand at the mean in the range of -0.25 to -0.48 and the long-run elasticities in the range of -0.53 to -0.60. Their adjustment coefficients were in the range of 0.47 to 0.76 (20, p. 213-214).

G. Edward Schuh studied the market for hired farm labor by a simultaneous-equation model. He estimated the structural demand and supply equations for hired farm labor. In his conceptual model, the demand for hired farm labor is a function of: (a) the real wage rate of hired farm labor; (b) an index of prices received by farmers for all agricultural products; (c) index of the price paid for other inputs; and (d) a measure of technology. He treated the supply of hired farm labor as being the function of: (a) real wages of hired farm labor; (b) non-farm income; (c) the amount of unemployment in the economy; and (d) the size of the civilian labor force (35, p. 308). He also used lagged hired employment in agriculture in order to calculate long-run elasticities. A time trend was introduced in both the demand and supply equations. All coefficients were significant at the 1 percent level in the supply model. In the demand model, except for time and technology, the other variables were significant at the 5 percent level. The fitted demand equation "explained" 97 percent of the total variation (35, p. 313). His study showed that the short-run wage elasticity of demand for agricultural hired labor was -0.12 and the long-run elasticity was -0.40 with the adjustment coefficient 0.30 (35, p. 318).

Schuh and Leeds, in a region oriented study, found the short-run and the long-run wage elasticities of demand for hired farm labor to be -0.227 and -0.97 respectively for the Pacific region (37, p. 305).

Coffey's rough calculation for the short-run (1 to 2 years) and long-run (5 to 10 years) elasticity of demand for hired labor were -0.2 and -1.0 to -2.0 respectively (7, p. 1067).

In Martin H. Yeh's study of the Canadian agricultural labor market, the most crucial variables in the demand equation for farm labor were: wage rate, the parity ratio, the quantity of farm machinery as a main substitute for labor, and a time-trend variable, reflecting technological improvement. He also included a lagged dependent variable on the assumption that there is a time lag in adjustment (40, p. 1259).

Factors Affecting the Demand for Hired Labor

The following variables were considered in formulating a model for this study.

(a) The farm wage rate: A decrease in the quantity demanded for a commodity due to an increase in its price, ceterus paribus, is a conventional characteristic of the demand curve. This also applies to the demand curve for hired labor. In addition, an increased wage rate in an industrial sector tends to further accelerate the decrease in the demand for hired labor on farms due to the influenced rise in farm wage rates.

(b) The parity ratio: The ratio of the index of prices received by farmers for all commodities to the index of prices paid by farmers for production items is used as a yardstick of the relative profitability of farming (20, p. 218). There should be a tendency to hire more labor with higher parity ratios and vise versa.

(c) Size of farm: Operators of large mechanized and specialized farms are likely to keep those workers who possess the technical skills required for the operation of highly sophisticated farm machines and specialized farming practices (32, p. 9). Moreover, large-farm operators need more helping hands on their farms, as they cannot do all operations with family labor. Due to a more optimum combination of machinery and labor on large farms, laborers are more efficiently utilized. This results in increased output per unit of labor on big farms.

(d) Technological change: Advancement in technology has increased the productivity of capital, reducing the amount of capital for a given level of output when efficiently utilized. This has altered the optimum resource combination in favor of high substitution of capital for manpower in the production process. Another effect of technology is the expansion in the size of operations due to changes in the organizational structure of agricultural industries through vertical and horizontal integration among firms. This organizational improvement tends to reduce the manpower required for specified levels of output. However, the size effect tends to increase the number of hired workers on individual farms. On the one hand, improvement in technology provides incentive to substitute capital for labor, thereby reducing the need for manpower, but on the other, the size effect increased the requirement for hired labor. In the final analysis, however, substitution effect dominates the size effect and, consequently, results in a sharp decline in the demand for hired labor (4, p. 3-5).

The time-trend is an indicator of technological change. Heady and Tweeten found this variable to be significant at a probability level of 95 percent in only the Pacific region (20, p. 219).

(e) Demand for farm products: The demand for hired labor is a derived demand. So, ultimately, its demand depends upon the consumers' demand for farm commodities. The demand for farm commodities depends on consumers' income, their taste and preferences, commodity price, and the availability of substitutes. Finally, the consumers' demand for farm products indirectly guides the demand for hired labor (39, p. 17).

Model of the Demand for Hired Farm Labor

The demand for hired farm labor is specified as a function of the real farm wage rate, profitability in farming, price of substitute such as machinery, the employment situation in the economy and the magnitude of operations measured by the total productive assets. Thus the primary demand function may be expressed as follows:

$$DH_t = F(W_t, R_t, M_t, E_t, A_t) + e_t$$

where:

DH_t = The number of hired laborers (in 1000)[1]

W_t = The index of composite farm wage rates[2] in Oregon deflated by the U.S. consumer price index.

---

[1] Persons employed during the last full calendar week ending at least one day before the end of the month. Source: U.S.D.A., Statistical Reporting Service, Farm Labor, Washington. Various issues

[2] Ibid.

R_t = The index of prices[3] received for all farm products in Oregon deflated by the index prices paid for all commodities used in production in the U. S.

M_t = Index of U. S. farm machinery prices,[4] deflated by U. S. consumer's price index.

E_t = Unemployment rate[5]

A_t = Total productive assets.[6]

---

[3]Source: U. S. D. A., Statistical Reporting Service, Oregon price Report. Portland. Various issues.

[4]Source: U. S. D. A., Agricultural Statistics 1967. Washington, D. C., p. 564, and Agricultural Statistics 1970. Washington, D. C., p. 467.

[5]Source: Oregon Economic Statistics 1970, Bureau of Business and Economic Research, University of Oregon, Eugene, p. 16. Unemployment rate for 1970 is taken from Oregon Economic Indicator, p. 11. Oregon Quality Newsletter, Feb. 1971.

[6]The total value of productive assets controlled by Oregon farmers is not published. It was therefore necessary to calculate this variable. The value of land and buildings every year is taken from <u>Oregon Economic Statistics</u> 1970; the value of livestock and poultry is taken from <u>Livestock and Poultry Inventory</u>, and several issues of Agricultural Statistics; the value of machinery and equipment is computed by the following formula, which assumes Oregon has experienced the same annual ratio of depreciation of machinery and equipment to total current value of machinery and equipment as has existed in the U. S.

$$\frac{\text{Value of machinery and equipment in Oregon}}{\text{Depreciation of machinery and equipment in Oregon}} = \frac{\text{Value of machinery and equipment in U. S.}}{\text{Depreciation of machinery and equipment in the U. S.}}$$

TABLE 1. SIMPLE CORRELATION COEFFICIENTS OF THE VARIABLES IN THE DEMAND EQUATION FOR HIRED FARM LABOR.

	W_t	R_t	Time	DH_{t-1}	M_t	A_t	DH_t
W_t	1.00	-0.36	0.88	0.82	0.83	0.93	-0.89
R_t		1.00	0.72	0.63	0.73	0.64	0.64
Time			1.00	-0.89	0.98	0.95	-0.89
DH_{t-1}				1.00	-	-	0.93
M_t					1.00	0.91	-0.84
A_t						1.00	-0.91

The simple correlation coefficients shown in Table 1 indicate that the variable total production assets was highly correlated with the wage rate index and the price of farm machinery index. It was therefore deleted from the equation.

A regression was run with only four exogenous variables in the model. The results are shown in Table 2 under the designation equation 2.1. Only wage rate is significant at the 5 percent test level. The coefficient of machinery price has a negative sign, which is contrary to hypothetical expectations. However, the coefficient of machinery price is not significantly different from zero.

Unemployment rate and the price of machinery variables are deleted. Time is added with the assumption that it is an indicator

---

[6] continued All of these three component assets were added together by year and then deflated by the consumer price index to get an approximation of the actual total production assets held by Oregon farmers.

of technological change. The dependent variable lagged is also added as an independent variable with the notion that the demand for farm labor is not adjusted instantaneously to economic stimulus (40, p. 1259).

> "Distributed lags arise in theory when any economic cause produces its effect only after some lag in time, so that this effect is not felt all at once, at a single point of time, but is distributed over a period of time" (29, p. 306)

Thus, when we say that the amount of hired labor is a function of the wage rate, taking into account a distributed lag, we mean that the full effects of a change in the wages of hired labor are not felt instantaneously, but only after a certain period of time.

Let $\bar{D}H_t$ be the amount of hired labor demanded in long-run equilibrium. So, in a static situation, $\bar{D}H_t$ is a function of wage rate, parity ratio and time. If DH_t is the actual amount of hired labor, then in the absence of changes in explanatory variables, such as wage rate, parity ratio and time, upon which demand depends, the actual amount of hired labor would change in proportion to the difference between the long-run equilibrium amount and the actual amount. It is expressed by the following difference equation which is called an adjustment equation.

$$\text{(A)} \qquad DH_t - DH_{t-1} = \beta \ (\bar{D}H_t - DH_{t-1}) \qquad 0 \leq \beta \leq 1$$

where β is the coefficient of adjustment in an ordinary least-squares equation. The long-run demand function is given by:

(B) $\bar{D}H_t = \alpha_o + \alpha_1 W_t + \alpha_2 R_t + \alpha_3 T + e_t$

It is not possible to estimate the long-run equilibrium of hired labor, because wage rate, parity ratio and other variables are continuously changing. By integrating equation (B) and (A), a short-run demand function for hired labor is obtained.

$$DH_t = \alpha_o\beta + \alpha_1\beta W_t + \alpha_2\beta R_t + \alpha_3\beta T + (1-\beta) H_{Dt-1} + \beta e_t$$

where:

DH_t = the amount of hired labor in the current year

W_t = the "real" wage rate (the index of current composite wage rate is deflated by consumer price index).

R_t = the index of prices received for all farm products by farmers deflated by the index of prices paid by farmers for those items used in production.

T = Time trend, 1951 = 1, ---, 1970 = 20.

DH_{t-1} = the amount of hired labor in the previous year.

In the single equation model, the agricultural wage rate is predetermined in the agricultural labor market. This means that when farm employers are given the wage rate, they adjust the quantity of labor to be hired.

Simultaneous-equation model: It is believed that the price of hired farm labor and the quantity of labor employed are mutually determined. So, a simultaneous-equation model is used to derive the demand function for hired labor. Taking Nerlove-type distributed lag into consideration, the demand and the supply equations are given by

$$D = DH_t = \alpha_o\beta + \alpha_1\beta W_t + \alpha_2\beta R_t + \alpha_3\beta T = (1-\beta)\, DH_{t-1} + e_1$$

$$S = SH_t = \alpha_o'\beta' + \alpha_1'\beta' W_t + \alpha_2'\beta' E_t + \alpha_3'\beta' L_t + \alpha_4'\beta' T$$
$$+ (1-\beta')\, SH_{(t-1)} + e_2$$

where:

$DH_t = SH_t =$ the amount of hired labor in current year

E_t = percent of unemployment

L_t = Total labor force in thousands.[7]

The other variables are the same as in the previous models. Wage rate and the quantity of hired labor are assumed to be endogenous variables.

Identification: The number of predetermined variables excluded from the equation in question must be at least as great as the number of endogenous variables appearing in the equation less one.[8]

$$K - J \geq H - 1$$

where: K - J = number of predetermined variables that influence the equation without appearing in it.

[7] Source: Oregon Economic Statistics 1970.

[8] Christ, Carl F. Econometric Models and Methods. New York, 1966. pp. 326-327.

H - 1 = endogenous variable appearing in the equation less 1.

In the demand equation, K - J is 2, and H - 1 is 1, so it is over identified. In the supply equation, K - J is 1 and H - 1 is 1, so, it is just identified. Two-stage-least-squares method is used to solve the reduced equations.

Step 1: Wage rate is selected as the dependent variable, and all the predetermined variables in the model are used to compute the least-squares estimate for the wage rate.

$$W_t = a_0 + a_1R_t + a_2E_t + a_3L_t + a_4T + a_5H_{Dt-1} + e_t$$

$$W_t = \underset{}{70.12} - \underset{(-.046)}{.0046R_t} - \underset{(-2.49)}{0.745E_t} + \underset{(3.115)}{0.055L_t} - \underset{(-.76)}{0.232T} - \underset{(-.32)}{0.044DH_{t-1}}$$

$$R^2 = .96$$

Step 2: The least-squares regression for the demand equation is computed by using the "predicted" wage rate in the place of actual wage rate. The result is presented in Table 3.

Statistical Results

A. Single equation models: The statistics of the single equation models of the demand function for hired labor are presented in Table 2. The t values are included in parenthesis under the regression coefficients. The equation number is indicated in the first column. Form and methods are shown in column 2. O. L. S.

refers to original observation introduced in models in linear form. Log L.S. refers to observation in logarithmic form. The value of R^2 is included in the last column. When a space is blank under an independent variable column, the corresponding variable is omitted from that equation. * means statistically significant as the 5 percent level and ** means significant at the 1 percent level.

Equation 2.2 includes W_t, R_t, Time, and the dependent variable lagged. The signs of the coefficient of R_t and W_t are consistent with the hypothesis, although they are not significantly different from zero at the 5 percent level. Time is highly correlated with other variables as indicated in the simple correlation coefficient Table 1. Deleting the time variable for equation 2.3, the coefficient of wage rate becomes highly significant at 1 percent level. Each of the equations 2.2 and 2.3 "explain" 91.8 percent of the total variation in the amount of farm labor hired in Oregon.

Equation 2.4 and 2.5 are the logarithmic forms of equation 2.2 and 2.3 respectively. All coefficients in equation 2.5 display signs expected from theory. Variables W_t and DH_{t-1} are highly significant. The trend variable is not significant in any of the equations shown in Table 2. Probably the lagged dependent variable and the real wage rate are masking the influence of the trend variable, since they are highly intercorrelated. The trend variable

TABLE 2. SINGLE EQUATION DEMAND MODELS FOR HIRED LABOR

Regression coefficients, t value in parentheses, R^2 value and elasticities of demand functions for hired labor in Oregon, 1951-70.

Equation number	Form and method	Constant (α_0)	Real wage rate index (W_t)	Ratio of prices received to prices paid index (R_t)	Unemployment rate percent (E_t)	Price of machinery index (M_t)	Time-trend	Number of hired workers in previous year $DH_{(t-1)}$	Adjustment coefficient $(1-DH_{t-1})$[a]	Elasticity at mean wage rate short-run	Elasticity at mean wage rate long-run	R^2 value
2.1	O. L. S.[b]	80.58	-0.6238 (-2.1987)*	0.1631 (1.465)	0.1463 (0.2169)	-0.0539 (0.29)						.798
2.2	O. L. S.	52.7578	-0.4054 (-1.530)	0.0178 (0.1755)			0.0061 (0.2369)	0.5319 (3.278)**	.47	-1.494	-3.178	.918
2.3	O. L. S.	52.4531	-0.3995 (-3.1306)**	0.0156 (0.2951)				0.5312 (3.4238)**	.47	-1.474	-3.136	.918
2.4	Log. L. S.[c]	9.3062	-1.225 (-1,856)*	-0.4149 (-0.6511)			-0.0516 (-0.713)	0.516 (3.0113)**	.48	-1.225	-2.552	.923
2.5	Log. L. S.	8.41	-1.5278 (-3.07)**	0.0182 0.0957				0.5718 (3.8117)**	.43	-1.5278	-3.553	.920

[a] $(1-DH_{t-1}) = \beta$, adjustment coefficient (29).

[b] O. L. S. = ordinary least-squares in original observation

[c] Log. L. S. = ordinary least-squares in logarithmic form

* significantly different from 0 at the 5% test level

** significantly different from 0 at the 1% test level

TABLE 3. SIMULTANEOUS EQUATION DEMAND MODELS FOR HIRED LABOR.

Regression coefficients, t value in parenthesis and elasticities of the demand function for hired labor in Oregon, 1951-70.

Equation number	Form and method	Constant (α_0)	"Predicted" real wage rate index (W_t)	Ratio of prices received to prices paid index (R_t)	Time-trend (T)	Number of hired workers in previous year $DH_{(t-1)}$	Adjustment coefficient ($1-DH_{t-1}$)	Elasticity at mean wage rate short-run	Elasticity at mean wage rate long-run
3.1	O. L. S.	74.25	-0.7224 (-2.027)*	0.1168 (0.9366)	0.2518 (0.844)	0.4817 (3.017)**	0.52	-2.62	-5.038
3.2	O. L. S.	57.684	-0.4437 (-3.338)**	0.0212 (0.4096)		0.4882 (3.089)**	0.51	-1.609	-3.155
3.3	Log. L. S.	9.575	-1.51 (-1.99)*	-0.223 (-0.3278)	-0.0304 (-0.3954)	0.50 (2.924)**	0.50	-1.51	-3.02
3.4	Log. L. S.	9.394	-1.72 (-3.279)**	0.035 (0.1884)		0.52 (3.39)**	0.48	-1.72	-3.583

*significantly different from 0 at the 5% test level

**significantly different from 0 at the 1% test level acts like a guard against specification bias in the coefficient of the lagged variable. "Introducing the trend variable will pick up the effects of those omitted variables that are correlated with time and eliminate at least that part of the specification bias" (35, p. 313).

Farm wage rate is the principal explanatory variable in each equation of Table 2. The coefficients of lagged dependent variable are used to calculate the adjustment coefficient and then the long-run elasticities of the demand for hired labor.

In all equations shown in Table 2, the coefficient of the lagged dependent variable, hired farm labor, is highly significant. A test was made to determine whether , the coefficient of adjustment, is significantly different from zero. This is done by testing whether the coefficient of the lagged variable ($1-\beta$), is significantly different from one. In all the models, the coefficients of the lagged variable are significantly different from one at the 5 percent level.

B. Simultaneous-equation models: The statistics of the simultaneous-equation models of the demand function for hired farm labor are presented in Table 3. Equation 3.1 includes the trend variable. The coefficient of the trend variable is again insignificant in the demand equation. It is omitted in equation 3.2. Its presence gives rise to multicollinearity problems which affect the parameter estimate of the other variables. In both 3.1 and 3.2 equations, the coefficient of the lagged dependent variable and the wage rate are highly significant. The R_t variable is not significantly different from zero, although it shows a positive sign as hypothesized. Equations 3.3 and 3.4 are log transformations of equations 3.1 and 3.2 respectively. Values of R^2 are not relevant for the simultaneous-equations and therefore, are not reported (3).

Demand Elasticities

The coefficient of adjustment and the demand elasticities for hired farm labor with respect to wage rates are presented in Tables 2 and 3. The coefficient of adjustment indicates the percent of the discrepancy between equilibrium employment and actual employment (35, p. 318). The coefficient of adjustment is obtained by subtracting the coefficient of lagged hired employment from one.

In the single equation models, the short-run wage rate elasticities at the mean range from -1.2 to -1.5. This implies that a 10 percent increase in "real" wage rate has been associated with 12 to 15 percent decline in the demand for hired farm workers.

The long-run wage elasticity of demand is obtained by dividing the short-run wage elasticity of demand by the coefficient of adjustment. The long-run wage elasticities of demand vary from -2.5 to -3.5. The coefficient of adjustment varies from 0.43 to 0.48. In the simultaneous-equation models the short-run elasticity of demand for farm labor with respect to agricultural wage rate ranges from -1.5 to -2.6 and the long-run wage elasticity of demand varies from -3.0 to -5.0. In both models the demand for hired labor with respect to wage rate is moderately elastic in the short-run and highly elastic in the long-run.

The projection of demand for hired farm labor in Oregon through 1975 is given in Chapter VIII.

Economic Implication

The present analysis of demand for hired farm labor in Oregon indicates that the short-run demand for hired farm labor with respect to the real wage rate is moderately elastic and the long-run demand is highly elastic. The short-run wage elasticity of demand ranges from -1.2 to -1.5. This means that a ten percent increase in the wage rate leads to a twelve to fifteen percent decrease in the quantity of hired labor demanded in the agricultural sector, other things remaining constant.

There has been a considerable structural change in agriculture in recent years. Due to the scientific and technological revolution in farming in the last one and a half to two decades, new capital inputs such as machinery and equipment have been easily substituted for labor as labor became relatively expensive and a relatively scarce commodity.

It is observed in a regional study that those regions whose major products are dairy, poultry, fruits and vegetables, as in New England, the Middle Atlantic and the Pacific, have the highest labor demand elasticities relative to other regions (36, p. 384).

It is expected that further increases in farm wage rates might accelerate less labor intensive crops and stress more mechanization (7, p. 1070). The cost of production for labor intensive crops such as vegetables and fruits might increase relative to crops permitting machine harvesting. So the production of high labor intensive crops is likely to decrease relatively and consequently, the market price for those products may increase. The demand for fruits and vegetables in consumer's diet is expected to continue to rise as personal incomes increase.

Among the hired labor force, a few are hired as full-time, regular hired farm workers and many of them are seasonally employed. Many of them are unskilled and of a low educational level. They are willing to work even at lower wage rates as there is no alternative job for them (7, p. 1072). An increase in farm wage rates might benefit a few full-time hired laborers, but as far as the majority of seasonal labor is concerned, they might be adversely affected in the long-run as machinery might be substituted for them and drastically reduce their employment opportunities.

Other implications of higher farm wage rates may be to increase the demand for research to develop harvesting machines for more difficult crops such as strawberries and raspberries, and for plant breeders to "design" plants with characteristics that are adopted to machine harvesting.

III. FERTILIZER

Introduction

Fertilizer is one of the widely used agricultural inputs. Its use has increased tremendously in the last two decades in Oregon. The primary plant nutrients[9] have increased by 461.5 percent and total fertilizer[10] by 353.6 percent between 1950 and 1970. Figure 3 shows the consumption of fertilizer in terms of primary plant nutrients and total fertilizer from 1950 to 1969. The expenditures for fertilizer have increased about 200 percent during this period. The expenditure for fertilizer by Oregon farmers constituted only 4 percent of the current farm operating expenses and 3 percent of the total farm production expenses in 1950. By 1969, it had gone up to 7 percent and 4.6 percent respectively. The "real" price of fertilizer[11] fell by 61 percent in the same period. Figure 4 shows the "real" price of fertilizer per ton and the total expenditure for fertilizer in 1957-59 dollars from 1950 to 1969.

---

[9] The primary plant nutrients include N, P_2O_5 and K_2O.

[10] Total fertilizer tonnage includes inert material.

[11] See footnote 13, page 39.

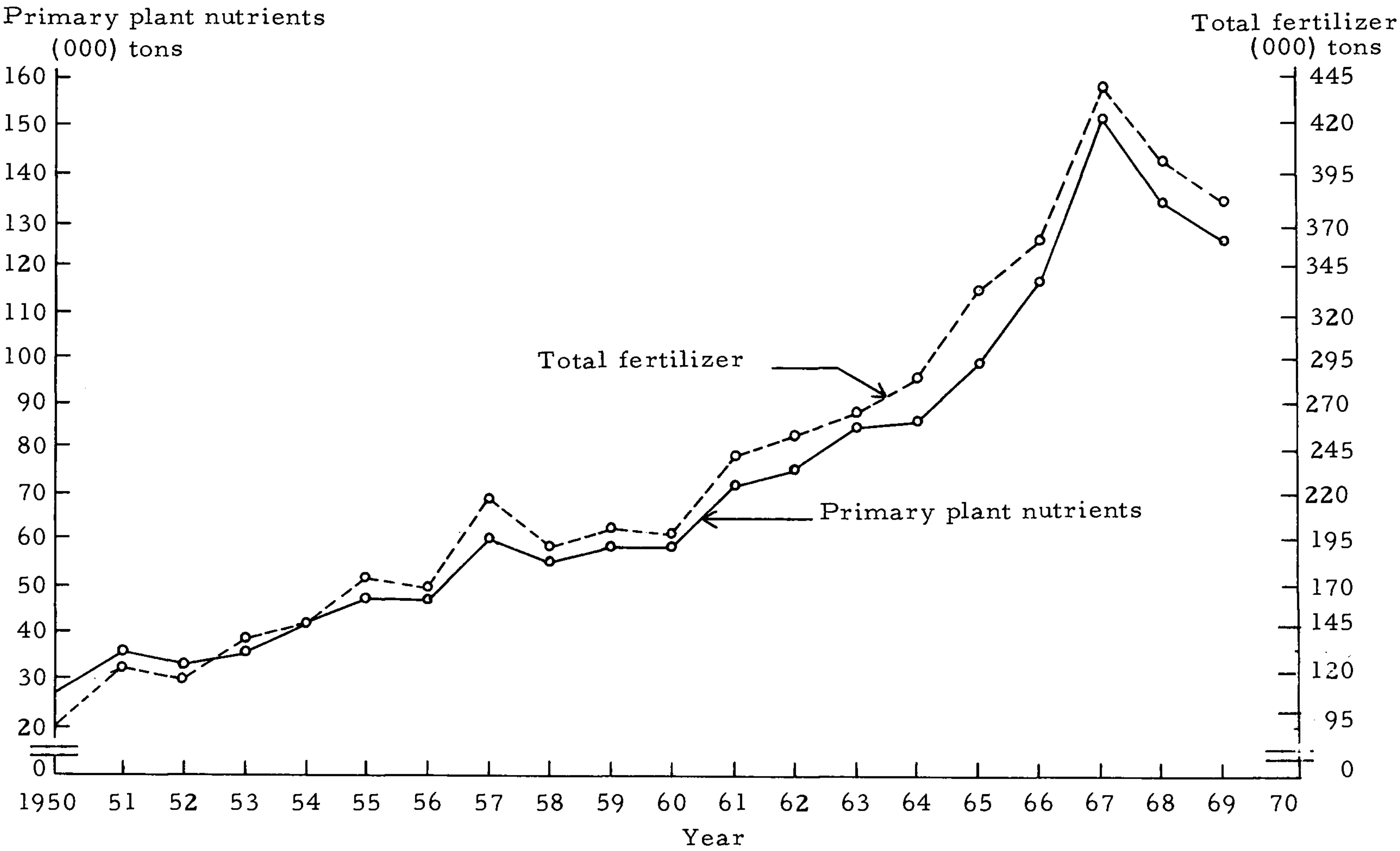

Figure 3. Amount of Primary plant nutrients and total fertilizer purchased by Oregon farmers in thousand tons, 1950-69.

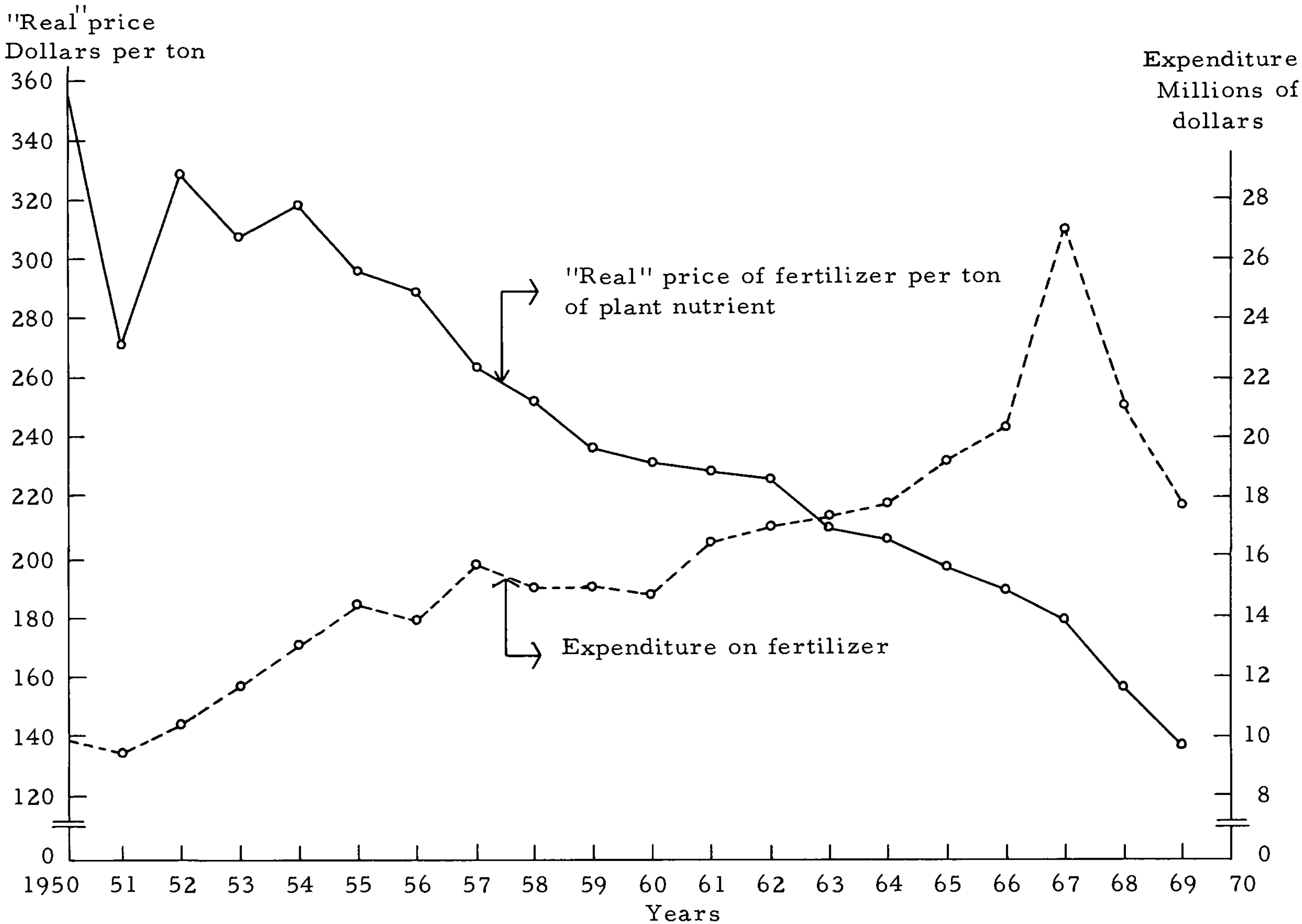

Figure 4. "Real" price per ton of fertilizer in terms of plant nutrients and the expenditure for fertilizer in 1957-59 dollars, Oregon, 1950-69.

Previous Fertilizer Studies

There have been several studies made with respect to the demand for fertilizer on both national and regional levels.

Griliches's single-equation econometric model specifies that the demand for fertilizer is a function of the "real" price of fertilizer (the price of a plant nutrient unit relative to the price received for all crops), and the lagged amount of fertilizer. His single-equation model using data from 1911 to 1956 is in logarithms of the variable. It "explained" 98 percent of the total variation in the amount of primary plant nutrients used with all the variables significantly different from zero. His short-run elasticity of demand for fertilizer with respect to its "real" price was -0.5 and the long-run elasticity of demand was -2.0. His coefficient of adjustment is approximately 0.25 (15, pp. 591-606). He later applied the same model for each of the nine regions and found the short-run and the long-run elasticities to be -0.659 and -3.23 respectively, with an adjustment coefficient of 0.20 for the Pacific region (13, p. 94).

Heady and Yeh used single-equation least-squares models to estimate the national and regional demand function for fertilizer. They identified the demand for fertilizer as a function of: (a) fertilizer price index at planting time, deflated by the general wholesale price index for the current year, with 1910-14 used as the base period; (b) average crop price index, lagged one year, deflated by the general wholesale price index; (c) total cash receipts from farming lagged one year; (d) cash receipts from crops and government payments only lagged one year; (e) total acreage of cropland; (f) time; (g) time squared; and (h) an income fraction, indicating trends in income over the previous three years (21, p. 333). Their first equation using data for the time period 1928-56, with a, c, e, and f as independent variables "explained" 98.8 percent of the total variation. All variables were significantly different from zero except e (total acreage of cropland).

These same researchers ran a second six-variable demand function for the period 1910-56 with a, b, d, e, and f as independent variables. It "explained" 86.5 percent of the variation in fertilizer used with only a and f being significant. They found the mean price elasticity of demand for fertilizer to be -0.49 in their first equation and -1.71 in their second equation (21, pp. 333-334).

Again, Heady with Tweeten specified the total national purchase of fertilizer material and the total national purchase of plant nutrients (N, P_2O_5, and K_2O), by U.S. Farmers as a function of: (a) the fertilizer price index in the previous calender year; (b) the crop price index in the previous calender year; (c) the U.S. price index for land in the previous calender year; (d) the ratio of fertilizer price to the price of land in previous calender year; (e) the index of cash receipts for crops for the previous calender year; (f) the number of crop acres per farm in the U.S. for the current year; (g) the total cropland acreage for the U.S. in the past calender year; (h) the cash receipts from farming for the U.S. in the past calender year; (i) time; and (j) the stock of total productive farm assets on January 1 of the current year. They deflated all prices by the index of wholesale prices and used data for the period 1926-1960, excluding 1944-50.

The demand equation for national purchases of fertilizer materials by U.S. farmers with a, b, c, g, and i as independent variables produced an R^2 of 0.981. Variables a, b, and c were significant at the 1 percent test level and i at the 5 percent test level. The demand equation for total national purchase of plant nutrients by U.S. farmers with a, b, c, and i as independent variables had a coefficient of determination (R^2) of 0.987 and all regression coefficients were significant at the 1 percent test level. They estimated the short-run and long-run elasticities of demand with respect to fertilizer price to be -1.4 to -1.5 and -2.3 to -2.6 respectively (20, pp. 163-169).

Using cross-sectional data, Griliches found the price of labor and the price of land to be significant variables in explaining interstate variability in the use of plant nutrients. His results indicated that land is a substitute for and labor a compliment to fertilizer (16).

Specification of Demand Model for Fertilizer

On the basis of previous studies, several variables are included in the model to explain the demand for fertilizer by Oregon farmers. In the final analysis, of course, certain of these variables may be found to be statistically insignificant or may be causing multicollinearity problems and thus are eliminated. A primary demand equation in general form is as follows:

(A) $QF_t = F(P_t, R_t, L_t T, QF_{t-1}) + e_t$

where:

QF_t = total purchase of primary plant nutrients (N, P_2O_5 and K_2O) by Oregon farmers in current year ending June 30.[12]

P_t = "real" price of fertilizer[13]

---

[12]Source: U. S. D. A., Crop Reporting Board. Consumption of commercial fertilizers in the United States. Washington, D. C. several issues. and Oregon Crop and Livestock Reporting Service. U. S. D. A., SRS, Consumption of fertilizer. Nov. 2, 1970.

[13]Absolute price of fertilizer is calculated first by dividing total expenditure for fertilizer by the total primary plant nutrients. "Real" price is obtained by deflating absolute price by the consumer price index. Total expenditures for fertilizer is obtained from U. S. D. A., E. R. S. (unpublished) through Office of Economic Information. O. S. U. Extension Service.

R_t = index of price received for all farm commodities in Oregon divided by the index of prices paid for all commodities used in production in the U. S.

L_t = index of average value per acre of farm land[14] in Oregon deflated by consumer price index. 1957-59 = 100.

T = Time, 1950 = 1, ---, 1969 = 20.

QF_{t-1} = lagged quantity of total primary plant nutrients.

e_t = error term.

A demand equation for fertilizer is estimated using annual data from 1950 through 1969. The equation is linear in the logarithms of the variables. Griliches points out that,

> "a Cobb-Douglas production function between farm output and fertilizer, land and other inputs, profit maximization by individual farmers and constant returns to scale, imply a demand function for fertilizer in logarithms of the variables" (15, p. 596 footnote).

Variable L_t is included in the original model because it is assumed that fertilizer may be substituted for land (20, p. 165). Time is included to measure technological change. An adjustment equation is introduced to bridge the gap between the actual and

---

[14] Source: U. S. D. A. , E. R. S. , Farm real estate market development, several issues.

equilibrium[15] consumption of fertilizer, and estimate the long-run price elasticity of demand (29, 30).

The long-run demand function is defined as follows:

(B) $Q^D F_t = a_0 + a_1 P_t + a_2 R_t + a_3 L_t + a_4 T + e_t$

where $Q^D F_t$ is the equilibrium fertilizer consumption.

Adjustment equation is defined as:

(C) $QF_t - QF_{t-1} = \beta (Q^D F_t - QF_{t-1})$

where QF_t is the actual consumption. Then the short-run demand function is derived by combining (B) and (C) and solving for QF_t.

(D) $QF_t = \beta a_0 + \beta a_1 P_t + \beta a_2 R_t + \beta a_3 L_t + \beta a_4 T + (1-\beta) QF_{t-1} + \beta e_t$

Variables L_t (index of farm land prices in Oregon) and T (time) are highly correlated with other variables, as indicated in the simple correlation coefficients, Table 4. So these two variables are eliminated and a regression is run with the remaining variables. The result is presented in Table 5.

TABLE 4. SIMPLE CORRELATION COEFFICIENTS OF THE VARIABLES IN THE DEMAND EQUATION FOR FERTILIZER.

	P_t	R_t	L_t	Time	QF_{t-1}	QF_t
P_t	1.00	0.64	-0.96	-0.85	-0.94	-0.94
R_t		1.00	-0.72	-0.89	-0.76	-0.77
L_t			1.00	0.92	0.98	0.98
Time				1.00	0.94	0.92
$QF(t-1)$					1.00	0.97

[15] The long-run equilibrium quantity is not observable and cannot be estimated directly.

TABLE 5. SINGLE EQUATION DEMAND MODELS FOR FERTILIZER

Regression coefficients, t values in parentheses, adjustment coefficient, and elasticities of demand for fertilizer in Oregon, 1950-69.

Equation number	Form and method	Log of constant (α_o)	"Real" price of fertilizer (P_t)	Ratio of prices received to prices paid index (R_t)	Quantity of fertilizer in previous year $QF_{(t-1)}$	Adjustment coefficient $(1-QF_{t-1})$	Elasticity of demand "real" price of fertilizer short-run	long-run	R^2
5.1	Log. L. S. Amount of total primary plant nutrients	9.8374	-0.6449 (-1.97)*	-0.932 (-1.62)	0.5334 (2.933)**	0.47	-0.645	-1.372	0.96
5.2	Log. L. S. Amount of total fertilizer materials	9.58	-0.5816 (-2.208)*	-0.796 (-0.464)	0.5041 (2.933)**	0.50	-0.5816	-1.163	0.95

Log L. S. = ordinary least-squares in logarithmic form

* = significantly different from 0 at the 5% test level

** = significantly different from 0 at the 1% test level

Statistical Results

The coefficients, t-values, adjustment coefficients, short-run and long-run price elasticity of demand and coefficient of determination (R^2) values are presented in Table 5. Equation 5. 1 and 5. 2 estimate the demand function for primary plant nutrients and the total amount of fertilizer materials respectively. In both equations, "real" price of fertilizer and the distributed lags are highly significant. The sign of their coefficients are consistent with theory.

Variable R_t (ratio of farm prices received to prices paid) is not significantly different from zero in both equations. However, the negative coefficients of R_t implies that the lower the profitability of farming, the higher the demand for fertilizer. Although this observation is contradicting the theoretical hypothesis, it may be consistent with actual phenomenon. Data show that the parity ratio, an indicator of profitability of farming, has had a decreasing trend in the last several years whereas the demand for fertilizer has experienced an increasing trend. This incongruity may be explained by, first, fertilizer being a divisible and probably relatively cheaper input than others may be easily and profitably substituted in the production process to maintain or increase total output; second, new varieties of crops highly responsive to heavy doses of fertilizer have been developed and recommended by agricultural experiment stations to the farmers to increase production and catch up the loss in cash flow incurred by them due to unfavorable product prices.

Price Elasticity of Demand and Implication

Equation 5.1 indicates that the short-run and long-run "real" price elasticity of demand for the primary plant nutrients are -0.64 and -1.37 respectively. The adjustment coefficient is estimated to be 0.47. Equation 5.2 indicates a short-run and long-run "real" price elasticity of demand for the total fertilizer materials to be -0.58 and -1.16 respectively. The adjustment coefficient is 0.50. Both equations give very similar results for the estimation of coefficients, elasticities and adjustment coefficients.

The price elasticity of demand indicates that in the short-run, for every one percent increase in the "real" price of fertilizer, there is about 0.64 percent decrease in the demand for the primary plant nutrients and about 0.58 percent decrease in the demand for the total fertilizer materials. Since the adjustment coefficient of equation 5.1 is 0.47 and 0.50 in equation 5.2, there is the possibility that 47 percent of the total long-run adjustment to the equilibrium level of the demand for primary plant nutrients to take place in one year. Similarly, 50 percent of the total long-run adjustment to the equilibrium level of the demand for the total fertilizer materials is made in one year. Thus the long-run elasticities are about 47 percent and 50 percent greater than the short-run elasticities for both the demand for the primary plant nutrients and the total fertilizer materials respectively.

The projection of total fertilizer materials demanded by farmers in Oregon through 1975 is given in Chapter VIII.

The "real" price of fertilizer nutrients is a significant factor in the increase of consumption of fertilizers. In addition, improved seed varieties, irrigation facilities, row cropping by machine and other improved farming practices also tend to increase fertilizer productivity. Theoretically, the use of fertilizer is to be influenced by the profitability of farming. However, this study indicates that fertilizer purchase continued to increase in spite of static or slightly decreasing crop prices. Of course, decreasing fertilizer prices have contributed to the heavier use.

The government's policy of acreage allotment for certain farm crops and restricted use of land for some purposes invites farmers to use more variable inputs such as fertilizer and other improved technology to substitute for land.

It is conceivable that the "real" price of fertilizer has decreased due to several developments. Research done by private industry and other government research organizations have certainly contributed significantly towards higher nutrient concentration of fertilizer. These research organizations have also improved the management towards distribution and application process, with information on fertilizer rates, placement and time of application. These several improvements have helped to increase the crop response realized from a given tonnage of fertilizer. In other words, they have lowered the net "real" price per ton of plant nutrients purchased by farmers (20, p. 156).

Thus the future demand for fertilizer would be largely determined by the technological advancement in the fertilizer manufacturing process directed towards lowering the net "real" price of fertilizer, the development of high fertilizer responsive crops, increase in irrigation facilities, continuous row crops and other improved practices.

IV. FARM MACHINERY

Introduction

One of the primary agricultural inputs which has revolutionized agricultural production is farm machinery. This and other external and internal forces have brought about considerable structural changes within the farm economy. According to John R. Brake, there are four major factors for these changes:

> "The first is innovation, including increased mechanization, new inputs, new methods of production, new markets, and new marketing procedures. The second factor is specialization. The third factor has been changing relative prices of inputs and changing prices between inputs and products. Forth has been improved management potential" (5, p. 1536).

The application of new technology, especially the farm machinery, largely depends on the economic climate in agriculture. William A. Cromarty outlines four main important factors relating to decision-making in the farm production process (8, pp. 16-19):

1) Farm decision variables: The individual farmer has control to a certain extent over the quantity of crops and livestock produced and how much inputs are to be purchased.

2) Farm market variable: Prices of inputs and outputs are predominant factors in the decision-making.

3) Predictands: Decisions are also largely influenced by the expectations regarding the future markets.

4) Initial data: To a great extent, the farmer's decision depends on his tangible assets such as inventories, equipment, cash, securities, and debt and intangible assets such as credit rating, management ability, and other physical and psychological attributes.

Previous Machinery Demand Studies

Cromarty used a single-equation model for the demand function of farm machinery. "Least-squares" procedures were used to fit the equation. In his model, the quantity of farm machinery demanded is expressed as a function of: (a) the wholesale price index for farm machinery; (b) the index of prices received by farmers for crops and livestock; (c) the index of prices paid by farmers for items used in production; (d) the value of farm machinery at the beginning of each year; (e) the asset position of farmers at the beginning of the year; (f) realized net farm income for the previous year; (g) the average acreage of cropland per farm; and (h) an index of farm labor cost. The time series data from 1923-54, inclusive, were used. The fitted equation "explained" 95 percent (adjusted $R^2 = 0.95$) of the total variation about the mean of the dependent variable. The variables c, e, and h were significant in the equation (8, pp. 38-39).

Heady and Tweeten built a model of the demand for all farm machinery. Their model specifies the machinery purchase every year as a function of: (a) the ratio of the price index of farm machinery to prices received by farmers for crops and livestock; (b) the ratio of the price index of all farm machinery to the hired labor wage rate; (c) the stock of productive farm machinery at the beginning of the calender year; (d) the total productive assets at the beginning of the calender year, including real estate, machinery, livestock, feed, and cash held for productive purposes; (e) the past year ratio of equities to liabilities; (f) past yeat net farm income; (g) an index of government agricultural policies, years of price support were assigned a value of +1 and years of acreage allotments or production control were assigned a value of -1; and (h) time.

A "least-squares" technique was used to fit the demand equation to the annual data from 1926 to 1959, excluding 1942 and 1947. The fitted demand equation "explained" 97 percent of the total variation about the mean of the dependent variable. Only a, e, and h were significant. The elasticity of annual investment with respect to machinery price was approximately unity in the short-run (20, pp. 290-299).

Factors Affecting the Quantity of Farm Machinery Purchased by Farmers

A considerable increase in capital use and a significant decrease in labor use are due to the following reasons:

(1) Increase in the wages of labor in the non-farm sector has influenced the wage rate in the agricultural sector. So, there has been a significant rise in the wage rate of labor in agriculture. The trend of the rise in wage rate has continued every year (20, p. 264).

(2) The marginal rate of substitution of capital for labor has been increasing, due to the development of science and technology (20, p. 264).

(3) There has been a continuous modification in the construction of farm machinery and implements to meet the need of agricultural practices (8, p. 77).

(4) The characteristics of a conventional demand function also applies to the quantity of farm machinery purchased in relation to the price of machinery. Other things being equal, an increase in price has a negative effect on the purchase of machinery.

(5) Net farm income is another important factor. The level of investment and the level of profits are highly correlated. "A rise in profits, moreover, indicates improvement in business condition

which calls for expansion of capacity and enhances the state of business 'confidence'"(10, p. 129). Heady and Tweeten argue that

> "theoretically, the decision to purchase a durable resource is made if the present value of discounted future earnings from the asset is greater than the purchase price. Because expected future earnings from durable resources probably tend to be based on past earnings, the lagged value of net farm income in the demand function may be important" (20, p. 271).

The financial capabilities and abilities of farmers to pay for the asset is largely determined by the flow of their past net incomes and their stock of total assets. Credit agencies grant loans more on the basis of the ability of farmers to repay the loan than by the profitability of the specific investment (20, p. 272).

Kendrick and Jones found a very high degree of correlation between net cash income before capital expenditure and fixed farm productive investment over the period 1910-41. The regression equation indicates that a 10 percent change in net cash income is associated with a 10.8 percent change in investment (24, p. 17).

(6) The equities and liabilities ratio of farmers is another measuring index of the farmer's willingness to take risks and his ability to repay a loan. A financial loss which is of little concern to the farmer with a high equity to liabilities ratio might bankrupt the farmer with a low equity. A farmer with a high equity to liabilities ratio finds the door of external credit institutions always open with

a big welcome sign. Thus, an equity-liability ratio is another important variable which determines the farmer's risk-taking behavior in terms of investment, and also, in the appraisal of the capability of the farmer to repay the loan by the outside credit agency (20, p. 273).

(7) A rise in the price of farm crops and livestock and improvements in the design and efficiency of machinery increases the earning power of machinery (8, p. 25).

(8) It is often hypothesized that a larger average farm size induces mechanization and specialization.

> "Increasing intensity of land use often coincides with the development and use of additional machinery. Crop specialization and intensity of use are difficult to measure and 'average size of farm' is used as an associated measure to represent them" (9, p. 325).

Model of the Demand for Farm Machinery

In this study, a single equation demand model for all farm machinery is specified as:

$$QM_t = F(P_t, W_t, R_t, F_t, Y_t, A_t, M_t, T) + e_t$$

where:

QM_t = purchase of all machinery by Oregon farmers

P_t = the price index for farm machinery

W_t = the index of farm wage rates

R_t = the Oregon index of prices received for all farm products divided by the U.S. index of prices paid for all commodities used in farm production

F_t = average size of farms

Y_t = net farm income

A_t = the total productive assets of farmers at the beginning of the year

M_t = the stock of productive farm machinery at the beginning of the calender year.

T = time

e = error term.

The unavailability of data indicating the purchase of all farm machinery by Oregon farmers in each year is a significant problem in the estimation of the demand function for farm machinery. Computed data for the total values of machinery and equipment (machinery inventories) are used for the dependent variable QM_t.[16]

A heroic assumption is made in that the regression line fitted to the machinery inventory data is assumed to be very close to what the regression line would have been had the purchase data of farm machinery been available and used. All price indices and other

---

[16] The procedure for computing this series is explained in Chapter II, page 17, footnote 6.

variables measured in dollar are deflated by the consumer price index in the model. The time period covered is from the year 1950-1969, inclusive. The model used is:

$$QM_t = F(P_t, W_t, R_t, F_t, Y_t, A_t, T) + e_t$$

where QM_t is machinery inventories substituting for the annual capital outlay for machinery and equipment by Oregon farmers.

Statistical Results

Table 6 displays the results of the machinery demand analysis. In equation 6. 1, R_t, F_t and A_t are highly significant. The signs of these significant coefficients are consistent with theory. The price of machinery and the farm wage rate are insignificant. The simple correlation coefficients of the variables used in the model and shown in Table 7 indicates there are very high multicollinearity problems in the model.

Deleting time and net farm income variables for equation 6. 2, the price of machinery becomes significant with expected coefficient signs. The coefficient of the farm wage rate is neither significant nor consistent with the theory. Cromarty's study also shows a negative sign on the farm wage rate coefficient which does not support the hypothesis that machinery is substituted for labor as farm wages rise(8, p. 40). Time, farm wage rate and net farm income are

TABLE 6. SINGLE EQUATION DEMAND MODELS FOR FARM MACHINERY

Regression coefficients with t values in parentheses, and elasticities of demand for machinery inventory, Oregon, 1950-69.

Equation number	Form and methods	Constant (α_0)	Price index of farm machinery (P_t)	Farm wage rate index (W_t)	Ratio of prices received to prices paid index (R_t)	Size of farm (F_t)	Net farm income (Y_t)	Total assets (A_t)	Time (T)	Elasticities at mean: Price of machinery	Elasticities at mean: Ratio of prices received to prices paid	R^2
6.1	O. L. S. Total machinery inventory	-569.79	1.19 (.6417)	0.3095 (.1645)	1.8087 (2.5678)*	0.9286 (3.210)**	-.1754 (-1.35)	0.0765 (2.719)**	-7.377 (-1.45)			.973
6.2	O. L. S. Total machinery inventory	-95.34	-1.115 (-1.859)	-1.7877 (-1.38)	1.8528 (2.826)*	0.6897 (3.3406)**		0.0655 (2.2948)*		-0.45	0.75	.965
6.3	O. L. S. Total machinery inventory	-1.49.72	-1.2435 (-2.039)*		1.41 (2.39)*	0.635 (3.04)**		0.0454 (1.79)*		-0.50	0.57	.960

*significantly different from 0 at the 5% test level

**significantly different from 0 at the 1% test level

TABLE 7. SIMPLE CORRELATION COEFFICIENTS OF THE VARIABLES IN THE DEMAND EQUATION FOR FARM MACHINERY.

	P_t	W_t	R_t	F_t	Y_t	A_t	T	QM_t
P_t	1.00	.83	-.74	.94	-.83	.91	.98	.87
W_t		1.00	-.42	.80	-.54	.93	.86	.88
R_t			1.00	-.85	.92	-.64	-.78	-.62
F_t				1.00	-.89	.93	.98	.92
Y_t					1.00	-.71	-.85	-.71
A_t						1.00	.95	.96
T							1.00	.91

eliminated for equation 6.3, the rest of the variables are significant at 5 percent level without any loss in the R^2 value.

The average farm size is positively related to the machinery inventories and is also significant at the 1 percent level of confidence. This supports the hypothesis that as the average farm size increases, total machinery inventories also increase. Cromarty's study also indicates the positive relation between the size of farm and the purchase of machinery (8, p. 40)

Because of the very high multicollinearity problem, it is not possible to estimate the true value of the parameters. But its predictive power is good. The elasticity, estimated from this model may not represent the real elasticity of demand for machinery purchases. However, the elasticity of demand for total machinery inventories with respect to machinery price is -0.45 and the elasticity of demand for total machinery inventories with respect to profitability of farming (R_t) is 0.75.

Cromarty's study indicates that the elasticity of demand with respect to machinery price is -1.0, and his elasticity of demand for machinery purchase with respect to prices received by farmer was 0.70 (8, p. 40).

The projections of value of machinery inventories through 1975 is given in Chapter VIII.

This study indicates that a 10 percent change in the price of farm machinery is associated with a 4.5 percent change in the opposite direction for machinery inventory, and a 10 percent change in the profitability of farming (R_t) is associated with 7.5 percent change in the same direction for machinery inventory. The change in the value of machinery inventory, however, is determined by the purchase value of machinery, previous stock of machinery and its depreciation values. The increase in the value of machinery inventory may be due to greater purchase value of machinery than its total depreciation values and the decline in the value of machinery inventory may be due to smaller purchase value of machinery than its total depreciation value.

The value of depreciation depends upon replacement rates which are largely determined by the rate of development of new, more efficient machinery and the durability of machinery. Thus, a rise or fall in the depreciation value depends upon the degree of new innovations in farm machinery which will cause the machinery to be obsolete before it is physically worn out, and the durability of machinery. On the other hand, the purchase of new farm machinery will depend, in addition to technological advance, upon the profitability of farming and credit availability.

One limitation of this study is to predict the purchase values of machinery due to unavailability of appropriate data.

It is not possible to conclude from the results of this analysis that increases in farm wage rates will result in increases in machinery inventories. The analysis, however, does indicate that farm size and machinery inventories increase together, but it fails to designate which is cause and which is effect.

V. REPAIRS AND OPERATING COSTS OF MOTOR VEHICLES AND OTHER MACHINERY

Introduction

The expenditure on repairs and operation of motor vehicles and other machinery includes expenditure for petroleum, fuel, oil, tires, license, insurance, repairs to auto, truck and tractor, and other farm machinery. In short, they may be grouped together and called "machinery supplies."

Expenditures for machinery supplies increased 68 percent between 1950 and 1969. In 1950, machinery supply expenditures by Oregon farmers constituted 16.4 percent of their total current operating expenses and 11.9 percent of their total production expenses. By 1969, they constituted 17.6 percent and 11.3 percent respectively. This indicates that the proportion of production expenditure on machinery supplies has been fairly constant. Figure 5 shows the expenditure for repairs and operation of motor vehicles, and other machinery in 1957-59 constant dollars for the period of the study.

The inputs of machinery supplies are complements to the machinery inventories. Increases in machinery inventories will tend to cause an increase in machinery supplies. Therefore, machinery

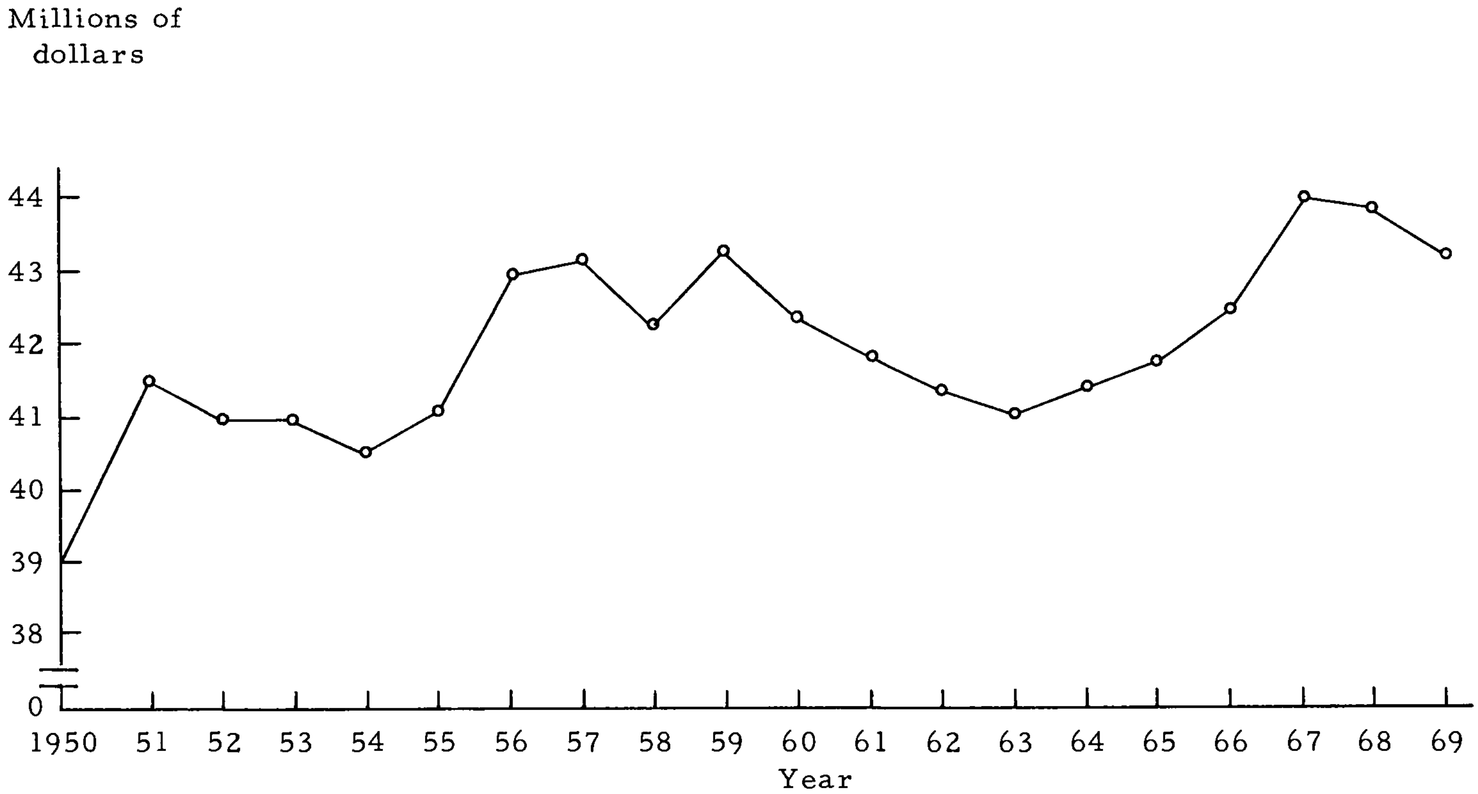

Figure 5. Expenditures for repair and operation of farm motor vehicles and other machinery in 1957-59 constant dollars, Oregon 1950-69.

inventory is a major explanatory variable in the demand analysis for machinery supplies. In addition, the price of machinery supplies may be an important factor.

Demand Model for Machinery Supplies

Quantity of machinery supplies demanded is specified as a function of current and past year price of machinery supplies, current and past year prices received by farmers for all commodities deflated by the prices paid for production inputs, the total machinery inventory, time and lagged quantity of machinery supplies.

It is difficult, if not impossible, to compute the total quantity of machinery supplies. Data on total expenditures for machinery supplies in Oregon are available.[17] Total expenditure is deflated by the consumer price index and is regressed with all independent variables selected in the demand function. Thus, the single equation demand model is as follows:

$$EMS_t = F(P_t, P_{t-1}, R_t, R_{t-1}, M_t, T, EMS_{t-1}) + e_t$$

where:

EMS_t = total annual expenditure for repair and operation of motor vehicles and other machinery deflated by consumer price index, in millions of dollars.

---

[17]Source: U.S.D.A., E.R.S. (unpublished) from Office of Economic Information. O.S.U. Extension Service.

P_t = "Real" price of machinery supplies in current year (the price index of machinery supplies is deflated by consumer price index).

P_{t-1} = "Real" price of machinery supplies in previous year.

R_t = Index of current prices received for all farm commodities in Oregon divided by the U.S. index of prices paid for all commodities used in production.

R_{t-1} = R_t in previous year.

M_t = total value of motor vehicles and other machinery deflated by the consumer price index.

T = time, 1950 = 1, ---, 1969 = 20

EMS_{t-1} = lagged total expenditure for machinery supplies.

A single equation demand function for machinery supplies is estimated for the period 1950-1969.

Statistical Results

Regression coefficients, with t value in parenthesis below each coefficient, elasticities and R^2 values are presented in Table 8. Wherever a space is blank, the corresponding variable is omitted. Total expenditure for machinery supplies is the dependent variable in equation 8.1 to 8.3. Equation 8.1 "explains" 71.9 percent of the total variation about the mean of the dependent variable. Variables P_t and R_t are significantly different from zero at 5 percent test level.

TABLE 8. SINGLE EQUATION DEMAND MODELS FOR MACHINERY SUPPLIES

Regression coefficients, t value in parentheses, R^2 value and price elasticity of demand for machinery supplies, Oregon, 1950-69.

Equation number	Form and method	Constant (α_0)	Price of machinery supplies index (P_t)	Price of machinery supplies in previous year index (P_{t-1})	Ratio of prices received to prices paid index (R_t)	Ratio of prices received to prices paid in previous year index (R_{t-1})	Machinery inventory (M_t)	Time (T)	Expenditure for machinery supplies in previous year (QMS_{t-1})	Price elasticity of demand for machinery supplies	R^2 value
8.1	O. L. S. Total expenditure	-42.37	0.4288 (2.4018)*		0.1712 (2.1753)*		0.035 (1.5405)	0.4357 (1.9604)	0.2796 (1.32)	Inelastic	0.719
8.2	O. L. S. Total expenditure	-54.36		0.663 (2.71)*		0.1337 (1.56)	0.1011 (3.487)**	0.348 (1.49)	-0.283 (-1.03)		0.766
8.3	O. L. S. Total expenditure	-35.28		0.4746 (2.92)*		0.085 (1.18)	0.07756 (4.33)**	0.218 (1.10)			0.748
8.4	O. L. S. "Proxy" quantity	480.66	-2.851 (-2.791)**		0.4145 (1.1353)		0.703 (2.1176)*		0.0174 (0.0613)	-0.6335	0.934
8.5	O. L. S. "Proxy" quantity	485.74	-2.871 (-3.068)**		0.416 (1.184)		0.719 (3.7138)**			-0.6379	0.93

*significantly different from 0 at 5% test level

**significantly different from 0 at 1% test level

Machinery inventory is significant at the 10 percent level in equation 8.1. Equation 8.2 "explains" 76.6 percent of the variation with P_{t-1}[18] and M_t being highly significant at the 1 percent level.

Simple correlation coefficients presented in Table 9 indicates that there is a multicollinearity problem in the model.

TABLE 9. SIMPLE CORRELATION COEFFICIENTS OF THE VARIABLES IN THE DEMAND EQUATION FOR MACHINERY SUPPLIES

	P_t	P_{t-1}	R_t	R_{t-1}	M_t	T	EMS_{t-1}	EMS_t
P_t	1.00	0.96	0.46	0.55	-0.88	-0.90	-0.53	-0.50
P_{t-1}		1.00	0.48	0.52	-0.91	-0.88	-0.50	-0.46
R_t			1.00	0.93	-0.62	-0.78	-0.56	-0.41
R_{t-1}				1.00	-0.66	-0.84	-0.52	-0.52
M_t					1.00	0.91	0.75	0.71
T						1.00	0.64	0.60
EMS_{t-1}							1.00	0.72

Deleting the dependent variable lagged by one year as an independent variable from equation 8.2 gives equation 8.3. It is seen from equation 8.3 that R^2 is dropped to 0.748 from 0.766 (adjusted $\bar{R}^2$ values are almost the same in equation 8.3 and 8.2), the value of the coefficients decrease and the t values for P_{t-1} and M_t increase.

The positive coefficient of price of machinery supplies in the current year implies that the total expenditure or the total revenue

---

[18]It is observed that the presence of P_t with R_{t-1} decreases R^2 value to .64 and also the t value for other variables. Only M_t is barely significant at 5 percent level of significance.

is increased, if the price is increased. This indicates that the demand for machinery supplies is inelastic. Figure 6 illustrates the inelastic demand for machinery supplies.

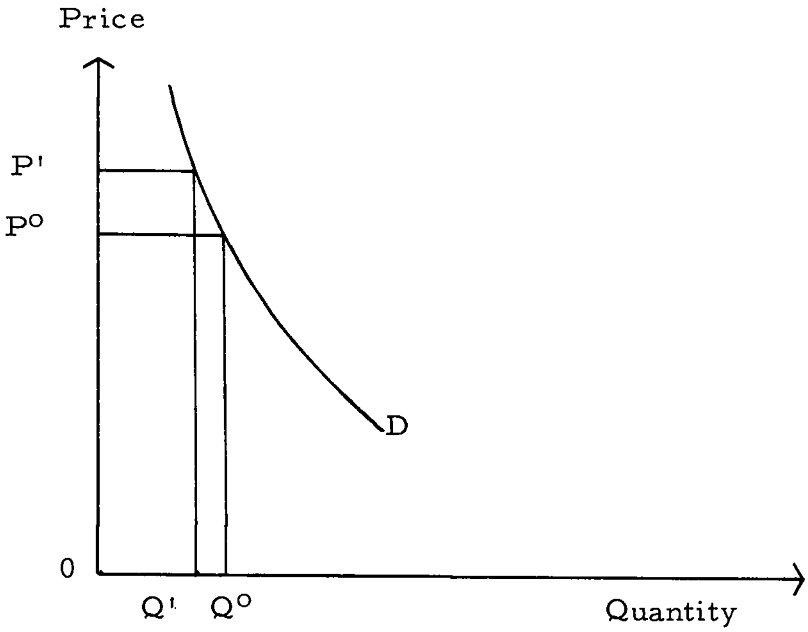

Figure 6. Illustration of inelastic demand for machinery supplies.

Suppose the initial price is P^o, then the quantity bought is Q^o, and the total expenditure or revenue is P^oQ^o. Now if the price is increased to P', the total expenditure is $P'Q'$. Although the quantity is diminished to Q', the total expenditure $P'Q'$ is greater in the second time period than the first time period expenditure of P^oQ^o. Thus, the regression of explanatory variables with the total expenditure as a dependent variable can simply tell us whether the demand is elastic or inelastic. But we are not in a position to estimate the price elasticity of demand from those equations. Expenditure elasticity can be computed with respect to Pt. It is 0.98 which simply means that one percent increase in price of machinery supplies may result in 0.98 percent increase in the total expenditure for the machinery supplies.

In order to compute the price elasticity of demand, we need to have the price coefficient in terms of quantity.

$$\eta_P = \frac{\Delta Q}{\Delta P} \cdot \frac{\bar{P}}{\bar{Q}}$$

Regressing explanatory variables with the total expenditure gives rise to the price coefficient in terms of $\frac{\Delta TR}{\Delta P}$ but not $\frac{\Delta Q}{\Delta P}$. This is why the expenditure elasticity may be computed from the price coefficient but not the price elasticity of demand.

$$\eta_{Expenditures} = \frac{\Delta TR}{\Delta P} \cdot \frac{\bar{P}}{\bar{TR}}$$

Heedy and Tweeten have calculated the price elasticity of demand for machinery supplies which seems to be expenditure elasticity (1, p. 383). They have also used total expenditure as a dependent variable.

In order to calculate the price elasticity of demand for machinery supplies the following procedure is applied. The total expenditure is divided by the price index of machinery supplies to create a "proxy" for the total quantity of machinery supplies. The same exogenous variables are regressed with the "proxy" quantity. The statistical results are presented in Table 8 in equation 8.4 and 8.5. These equations "explain" about 93 percent of the total variation about the mean of the dependent variable. P_t and M_t are highly significant in equation 8.4 and 8.5. Deleting the lagged dependent variable included as an independent variable for equation 8.5, there is an increase in the t value of all the remaining coefficients. Time is eliminated from all equations as it is highly correlated with all other variables. In these two equations, the price of machinery supplies coefficient gives the value of $\frac{\Delta Q'}{\Delta PI}$ and so the price elasticity of demand is calculated.[19] The price elasticity of demand for machinery supplies is -0.63. This result verifies the inelastic demand for machinery supplies found in equations 8.1 and 8.3.

---

[19] A simple hypothetical example can be cited to show how the price elasticity calculated from the actual quantity and price is the same if calculated from a "proxy" quantity and the price index. A "proxy" quantity is obtained by dividing the total expenditure by the price index.

Example:

Q	P	TR	PI	$Q' = \frac{TR}{PI}$
600	$2	$1200	100	12
400	$4	$1600	200	8

Here, Q = actual quantity
P = price in dollars
TR = total revenue or total expenditure
PI = price index
Q' = "proxy" quantity

The analysis of the demand for machinery supplies indicates that the purchases are directly related to the machinery inventory and inversely related to purchase price. A 10 percent increase in price of machinery supplies is associated with 6.3 percent decrease in the purchase of machinery supplies. Due to a high complimentarity between machinery inventory and machinery supplies, as the purchase of farm machinery increases, the demand for machinery supplies also increases. Moreover, the repair parts will depend somewhat on the complexity of machinery. As the complexity and sophistication of machinery increases due to technological advancement, the farmers might not be able to repair them themselves and must take them to the repair shop. Thus, it will cause an increase in the expenditure for machinery supplies.

The projection of the demand for machinery supplies in Oregon through 1975 is given in Chaper VIII.

---

19 continued

$$\eta_D = \frac{\Delta Q}{\Delta P} \cdot \frac{\bar{P}}{\bar{Q}} = \frac{-200}{2} \cdot \frac{3}{500} = -0.6$$

$$\eta_D = \frac{\Delta Q}{\Delta PI} \cdot \frac{\overline{PI}}{\bar{Q}} = \frac{-4}{100} \cdot \frac{150}{10} = -0.6$$

VI. PURCHASED FEED

Introduction

Purchased feed includes feed grains, protein concentrates, and roughage. Every year from 1950 through 1969 in Oregon, about 20 to 25 percent of the total current farm operating expenses was spent to purchase feed. Figure 7 shows the expenditure on feed in 1957-59 dollars during that period.

In order to estimate the demand for purchased feed, one needs to know about economic relationships in the feed-livestock economy. The interrelationship between supplies of feed, animal units, production of livestock, and prices of feed and livestock is illustrated in Figure 8. Items in boxes are physical in nature and those in circles are economic. Arrows show the direction of influence.

Supply of feed, in the short-run, is not influenced by economic stimuli but by physical factors such as the feed crop acreage, and yield per acre which depends mainly upon cultural practices and the weather. However, the feed supply affects the other items in the feed-livestock economy (12, pp. 22-23).

Animal units fed and feed fed per animal unit are grouped together because they are determined by the same factors. They are influenced by both economic and physical factors. If the demand

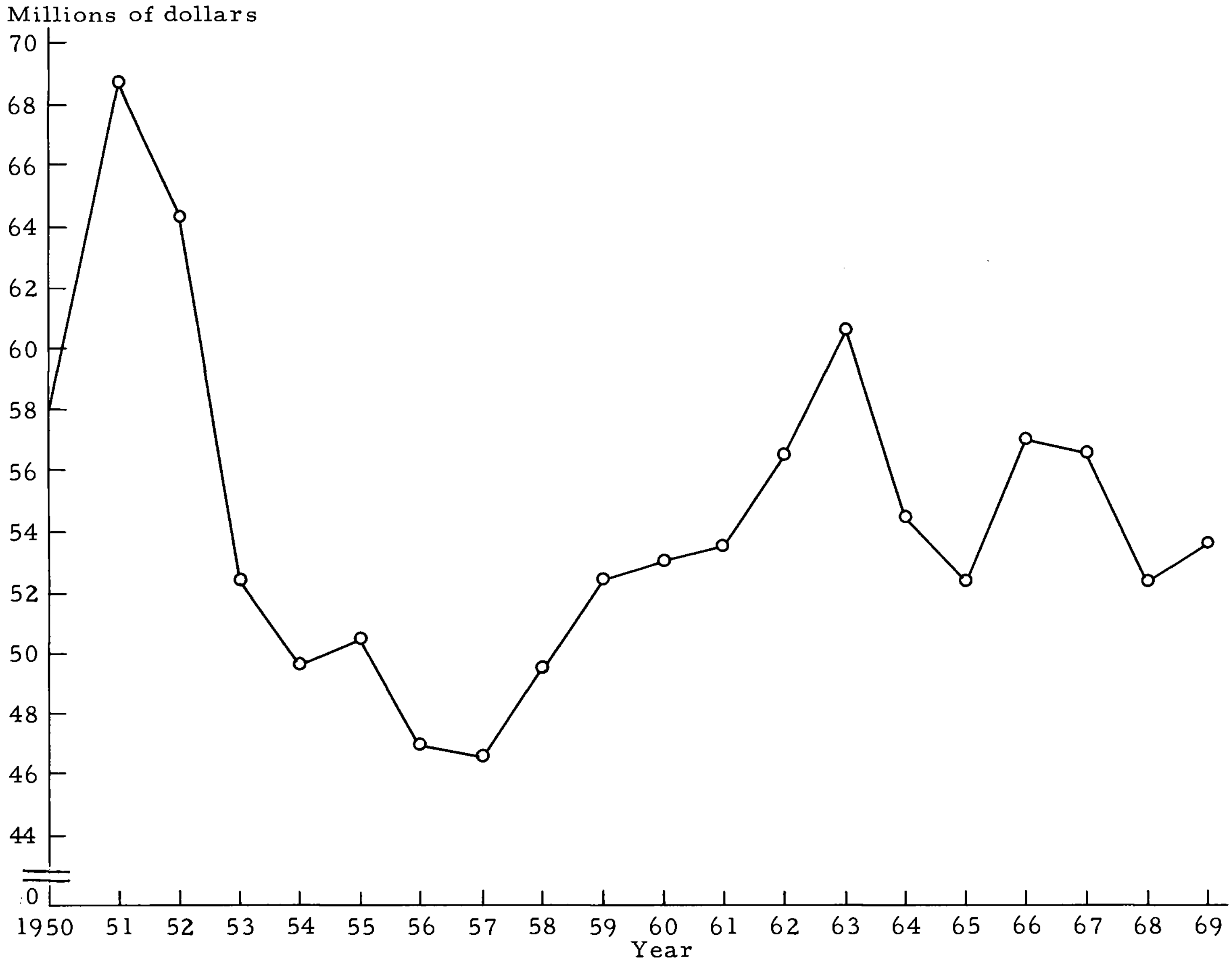

Figure 7. Expenditures for purchased feed in 1957-59 dollars, Oregon, 1950-69.

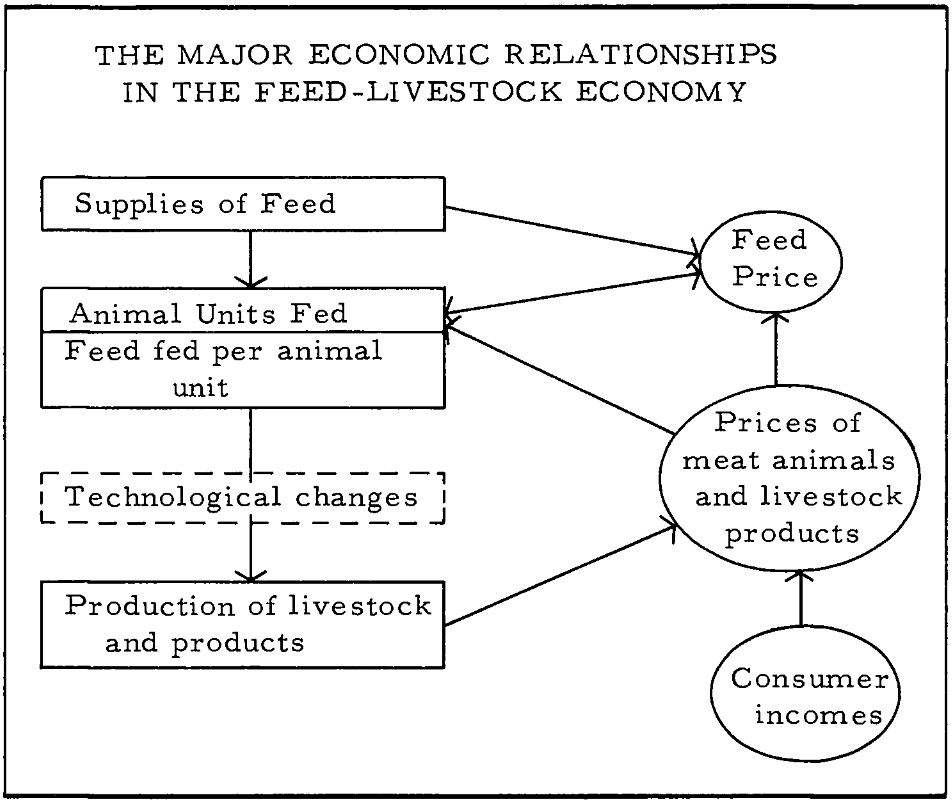

Figure 8. Supplies of feed, animal units fed, and prices of feed and livestock and livestock products are closely related.

Source: Foote, Richard J. *et al.* The Demand and Price Structure for Corn and Total Feed Concentrates. U. S. D. A. Technical Bulletin no. 1061. October 1952. p. 22.

for livestock and livestock products rises due to increase in consumers income, farmers generally increase their milk and beef production by increasing the amount of feed fed per animal in the short-run. This strategy does not maximize long-run profits due to the law of diminishing returns. In the long-run, they probably will be better off by expanding the number of animals and feeding the same amount of feed to the larger number. Jensen (23) for dairy cows, Atkinsen and Klein (1, 2) for hogs and Nelson (27, 28) for beef cattle have found that an increase in the quantity of feed if fed to an expanded number of animals instead of being fed to a given number of animals at a higher rate, yields a greater quantity of livestock products. Time of adjustment in the expansion of livestock inventories is largely determined by the availability of breeding stock and the degree of impact of economic stimuli (12, p. 23).

The number of animal units fed during any given year depends mainly upon the supply of feed and the ratio of livestock and feed prices (12, p. 23). Hildreth and Jarrett point out that

> "the number of animals held at the beginning of the t^{th} period depends on the price of livestock products in the previous period, the price of feed in the previous period, and unspecified factors of the previous period which influence producers expectations for the present period" (22, p. 11).

The quantity of feed fed per animal unit depends on the number of animal units fed in addition to the supply for feed and the livestock-feed price ratio (12, p. 23).

The production of livestock and livestock products during the current year depends upon the number of animal units fed, the rate of feeding per head, and technological factors such as breeding and methods of feeding (12, p. 28). Hildreth and Jarrett had the following variables in their production relation equation: amount of feed grains fed to livestock, amount of protein feed fed to livestock, beginning inventory of livestock on farm, quantity of roughage fed to livestock and time (22, p. 65).

Prices of meat animals and livestock products are mainly influenced by the supply of livestock products in the market and the demand for livestock which again, usually depends on consumers disposable income (11, p. 19).

"Feed prices are determined mainly by the supply of feed, the number of animal units to be fed, and the level of livestock prices" (12, p. 30). "Given the marginal productivity function of feed stuff, the price of livestock will determine the price of feed for any particular volume of feed supplies" (25, p. 83). The marginal productivity of feed stuffs means the amount of livestock obtained from the last unit of feed fed to animals.

Previous Feed Demand Studies

According to Richard J. Foote, the quantity of feed grains fed to livestock in the U.S. is specified as a function of: price received by farmers for feed grains,[20] number of grain-consuming animal units fed during the year, and price received by farmers for livestock and livestock products. All variables expressed as first differences of logarithms, "explained" about 83 percent of the variation about the mean of the dependent variable. A single-equation least-squares technique was applied to fit the data for the period 1922-42, with each year beginning in October (11, pp. 27-28).

Hildreth and Jarret considered the following variables in their demand model for feed grains: price of feed grains, price of protein feed, price of livestock and livestock product, the quantity of feed grains fed to livestock, beginning inventory of livestock on farms, and the amount of roughages consumed by livestock (22, p. 64-66). They used both single and simultaneous-equation models. In the single equation model, the above mentioned exogenous variables "explained" 96 percent of the total variation about the mean of the

---

[20] It was assumed to be representative of the general price level for all feeds, in cents per bushel.

quantity of feed grains fed to livestock in the U.S., taken as the dependent variable (22, p. 91). Their feed grain unit was in terms of total digestible nutrients (TDN). They failed to judge the superiority of one method over the other on the basis of their empirical results.

Rojko, in his econometric analysis of dairy products for the dairy industry came to the conclusion that the single-equation approach gave results as good as the simultaneous-equation technique, when the statistical technique and the nature of data were not refined enough to specify a model that will expel several interrelationships (34, pp. 323-338).

Heady and Tweeten specified the demand for purchased feed as a function of feed prices, livestock prices, prices paid by farmers, stock of productive assets, government policies, weather and time. Their single-equation demand model, using data from 1926-59, excluding 1942 to 1945, "explained" 98 percent of the annual variation about the mean of the purchased quantity of feed[21] (20, pp. 385-391).

Specification of the Demand Function

For this study quantity of feed demanded by Oregon farmers is considered as a function of current and past year price of feed,

---

[21] The quantity was derived by dividing expenditure data by prices paid by farmers for feed (20, p. 386).

current and past year prices received by farmers for livestock and livestock products deflated by the price paid for production inputs, the total livestock inventory, time and lagged quantity of feed fed to livestock. Data on the quantity of feed purchased every year is not available. However, the total expenditure for feed is deflated by the consumer price index and is regressed with all other predetermined variables as above mentioned in the demand function. A Nerlove-type distributed lag model is used assuming that unobserved random disturbances are serially independent.

$$EF_t = F(P_t,\ P_{t-1},\ R_t,\ R_{t-1},\ L_t,\ T,\ EF_{t-1}) + e_t$$

where:

EF_t = total expenditure for feed deflated by the consumer price index for current year, in millions of dollars.

P_t = "Real" price of feed in current year (the price index of feed deflated by consumer price index).

P_{t-1} = "Real" price of feed in past year.

R_t = Index of prices[22] received for livestock and livestock products divided by the index of prices paid for all commodities used in production in current year.

R_{t-1} = R_t in previous year.

---

[22]Source: Oregon Crop and Livestock Reporting Service. U. S. D. A., S. R. S. Oregon price report. several issues.

L_t = total value of January 1 inventory of livestock and poultry[23] deflated by consumer price index, in millions of dollars.

T = time, 1950 = 1, ---, 1969 = 20.

EF_{t-1} = lagged total expenditure for purchased feed.

A single demand equation for feed is estimated for the period of 1950-1969.

Statistical Results

Table 10 presents the empirical results of the single-equation demand model for purchased feed. In equation 10. 1 and 10. 2, P_t P_{t-1}, RL_t and lagged dependent variables are highly significant. The livestock inventory and time variables are not significant at 5 percent test level in any of the equations. The simple correlation coefficients of variables in the demand equation for purchased feed are presented in Table 11.

The positive sign of the P_t (feed price index) coefficient implies that during a given year, the short-run demand for feed is inelastic.[24] However, the negative sign of the lagged price fails to indicate

---

[23]Source: U. S. D. A. , Agricultural Statistics, 1949-1961, and U. S. D. A. , Crop Reporting Board, Agricultural Marketing Service, Livestock and poultry inventory; several issues.

[24]See Chapter V, p. 62-66.

TABLE 10. SINGLE EQUATION DEMAND MODELS FOR PURCHASED FEED

Regression coefficients t value in parentheses, R^2 value and the price elasticity of demand for feed, Oregon, 1950-69.

Equation number	Form and method	Constant (α_0)	Feed price index (P_t)	Feed price in previous year index (P_{t-1})	Ratio of prices received for livestock and livestock products to price paid index (RL_t)	Ratio of prices received for livestock and livestock products to prices paid in previous year (RL_{t-1})	Livestock inventory (LA_t)	Time (T)	Lagged dependent (EF_{t-1})	Adjustment coefficient ($1-EF_{t-1}$)	Price elasticity short-run	Price elasticity long-run	R^2 value
10.1	O. L. S. Total expenditure	14.74	0.524 (3.15)**	-.517 (3.34)**	0.3127 (3.006)**	-0.254 (1.356)	0.0342 (0.9921)	-0.0306 (-0.0789)	0.512 (2.46)*	.59	Inelastic		0.87
10.2	O. L. S. Total expenditure	13.91	0.5388 (3.98)**	-0.6126 (-4.55)**	0.2319 (2.70)*		0.003 (0.114)		0.474 (3.15)**	.53	Inelastic		0.855
10.3	Log. L. S. Total expenditure	0.808	1.098 (4.485)**	-1.26 (-4.88)**	0.401 (2.711)*		0.0439 (0.474)		0.472 (3.39)**	.53	Inelastic		0.869
10.4	O. L. S. "Proxy" quantity	294.68	.0002 (.0006)	-2.41 (-1.638)	2.74 (2.95)*	-1.04 (-0.6019)	0.1611 (0.5258)	1.245 (0.3356)	0.5382 (2.769)**	.46	-.482	-1.05	0.95
10.5	O. L. S. "Proxy" quantity	325.8	-.263 (-.225)	-2.88 (-2.427)*	2.39 (3.28)**		0.024 (0.112)		0.569 (4.48)**	.43	-.576	-1.34	0.947
10.6	O. L. S. "Proxy" quantity	166.28	-2.2887 (-2.120)*		2.65 (3.10)**		0.0704 (0.2704)	2.09 (0.553)	0.58 (2.988)**	.42	-.45	-1.07	0.926

* = significantly different from 0 at 5 percent test level

** = significantly different from 0 at 1 percent test level

TABLE 11. SIMPLE CORRELATION COEFFICIENTS OF VARIABLES IN THE DEMAND EQUATION FOR PURCHASED FEED.

	P_t	P_{t-1}	RL_t	RL_{t-1}	LA_t	T	$EF_{(t-1)}$	EF_t
P_t	1.00	0.95	0.64	0.79	0.16	-0.92	0.42	0.38
P_{t-1}		1.00	0.56	0.74	0.41	-0.91	0.83	0.18
RL_t			1.00	0.80	0.46	-0.58	0.32	0.62
RL_{t-1}				1.00	0.58	-0.70	0.59	0.53
LA_t					1.00	1.25	0.60	0.68
T						1.00	-0.15	-0.16
$EF_{(t-1)}$							1.00	0.61

whether the demand in period t-1 is elastic or inelastic.[25] Only

---

[25]A simple hypothetical example can be cited to show how the sign of P_{t-1} fails to indicate an *a priori*, whether the demand is elastic or inelastic

Example:

Time period	Q	P	TR	PI	Q'
1	600	$ 2	1200	100	12
2	400	$ 4	1600	200	8
3^a	300	$ 5	1500	250	6
3^b	300	$ 6	1800	300	6
3^c	150	$12	1800	600	3
3^d	150	$10	1500	500	3

$$Q' = \frac{TR}{PI}$$

where:

Q = Actual quantity
P = price in dollar
TR = total revenue
PI = price index
Q' = "proxy" quantity
3^a, 3^b, 3^c, 3^d, the same third time period with four different situations.

Now, taking into account of P_{t-1}, and PI_{t-1}, we have

Time period	Q_t	P_{t-1}	TR_t	PI_{t-1}	Q'_t
2	400	$2	1600	100	8
3^a	300	$4	1500	200	6

25 continued

where:

P_{t-1} = price in dollars in previous time period

PI_{t-1} = price index in previous time period

$$\eta DP_{t-1} = \frac{\Delta Q_t}{\Delta P_{t-1}} \cdot \frac{\overline{P}_{t-1}}{\overline{Q}_t} = \frac{-100}{2} \cdot \frac{3}{350} = -.428$$

$$\eta EDI_{t-1} = \frac{\Delta TR_t}{\Delta PI_{t-1}} \cdot \frac{\overline{PI}_{t-1}}{\overline{TR}_t} = \frac{-100}{100} \cdot \frac{150}{1550} = -.097$$

$$\eta DPI_{t-1} = \frac{\Delta Q'_t}{\Delta PI_{t-1}} \cdot \frac{\overline{PI}_{t-1}}{\overline{Q}'_t}$$

$$= \frac{-2}{100} \cdot \frac{150}{7}$$

$$= -.428$$

Here the demand is inelastic, whereas the sign of P_{t-1} coefficient with total revenue is negative.

Time period	Q_t	P_{t-1}	TR_t	PI_{t-1}	Q'_t
2	400	2	1600	100	8
3^b	300	4	1800	200	6

$$\eta DP_{t-1} = \frac{\Delta Q_t}{\Delta P_{t-1}} \cdot \frac{\overline{P}_{t-1}}{\overline{Q}_t} = \frac{-100}{2} \cdot \frac{3}{350} = -.428$$

$$\eta EPI_{t-1} = \frac{\Delta TR_t}{\Delta PI_{t-1}} \cdot \frac{\overline{PI}_{t-1}}{\overline{TR}_t} = \frac{200}{100} \cdot \frac{150}{1700} = +.176$$

$$\eta DPI_{t-1} = \frac{\Delta Q'_t}{\Delta PI_{t-1}} \cdot \frac{\overline{PI}_{t-1}}{\overline{Q}'_t}$$

$$= \frac{-2}{100} \cdot \frac{150}{7}$$

$$= -.428$$

25 continued

Here the demand is inelastic with respect to P_{t-1}, whereas the sign of P_{t-1} coefficient with total revenue is positive.

Time Period	Q_t	P_{t-1}	TR_t	PI_{t-1}	Q'_t
2	400	2	1600	100	8
3[c]	150	4	1800	200	3

$$\eta DP_{t-1} = \frac{\Delta Q_t}{\Delta P_{t-1}} \cdot \frac{\overline{P}_{t-1}}{\overline{Q}_t} = \frac{-250}{2} \cdot \frac{3}{275} = -1.36$$

$$\eta EPI_{t-1} = \frac{\Delta TR_t}{\Delta PI_{t-1}} \cdot \frac{\overline{PI}_{t-1}}{\overline{TR}_t} = \frac{200}{100} \cdot \frac{150}{1700} = +.176$$

$$\eta DPI_{t-1} = \frac{\Delta Q'_t}{\Delta PI_{t-1}} \cdot \frac{\overline{PI}_{t-1}}{\overline{Q}'_t} = \frac{-5}{100} \cdot \frac{150}{5.5} = -1.36$$

Here the demand is elastic with respect to P_{t-1}, while the sign of P_{t-1} coefficient with total revenue is positive.

Time period	Q_t	P_{t-1}	TR_t	PI_{t-1}	Q''_t
2	400	2	1600	100	8
3[d]	150	4	1500	200	3

$\eta DP_{t-1} = -1.36$, $\eta EPI_{t-1} = -.097$ $\eta DPI_{t-1} = -1.36$

Here the demand is elastic with respect to P_{t-1}, while the sign of P_{t-1} coefficient with total revenue is negative.

a negative sign of the current price would inply an elastic demand.[26] The coefficient of adjustment varies from 0.49 to 0.53 in the equations presented. It means there is a possibility that about 49 to 53 percent of the total long-run adjustment to the equilibrium level of the purchase of feed to take place in a year. Rojko points out that the time needed for adjustment in the production of livestock by changing the rate of feeding is short compared to that needed to increase the "herd" of livestock (34, p. 325).

It is conceivable that given the number of animals on farms and assuming the marginal productivity of livestock using feed stuffs is at equilibrium, a rational producer will tend to decrease the quantity of feed demanded, if the feed price rises and other conditions remain unchanged. However, in the very short-run, an immediate adjustment is not practiced, due to lack of full information about the marginal productivity of livestock in using feed stuffs. But with the lapse of time, farmers may be able to make adjustments by disposing of inefficient animals, by expanding the acreage of their home grown feed or by reducing the rate of feeding per animal.

RL_{t-1} is deleted for equation 10.2 because it is not significant and has a negative coefficient which is inconsistent with theory.

---

[26] See Chapter VII, pp. 89-90.

Equation 10.3 is the logarethmic form of equation 10.2. RL_t is significant in all equations at the 5 percent test level. This supports the hypothesis that when the livestock enterprise is profitable, farmers buy more feed. The demand for feed is a derived demand and is largely determined by the price of livestock and livestock products.

The total expenditure on feed is also regressed with all the explanatory variables mentioned in equations 10.1 and 10.2 when livestock inventory as an independent variable is replaced with the total grain-and-roughage-consuming animal units for Oregon. The animal unit variable does not improve the explanatory ability of the models any further and is also insignificant. This result suggests that the demand for purchased feed is not greatly influenced by the total number of livestock units.

To compute the elasticity of demand for feed, a "proxy" quantity of feed is computed by dividing the total expenditure for feed by the index of feed prices. The "proxy" quantity of feed, then, is regressed with all the explanatory variables in equation 10.1. The result is presented in the appropriately labelled column in Table 10. Variables P_{t-1}, R_t and the lagged dependent are highly significant. P_t is not significant in the presence of P_{t-1} in the equation 10.5, but when P_{t-1} is deleted from the equation, it becomes significant as shown in equation 10.6

Price elasticity of demand for purchased feed is computed both with respect to P_t and P_{t-1}. The demand elasticity with respect to current price of feed is -0.45 and with respect to past year price of feed varies from -0.48 to -0.57. Thus again it is confirmed that the price elasticity of demand for feed is inelastic. The coefficient of adjustment in equation 10.4 to 10.6 varies from 0.42 to 0.46. The long-run price elasticity of demand varies from -1.05 to -1.34. Foote, et. al. analysis indicated a coefficient of demand elasticity for feed prices between -0.4 and -0.5 in the short-run (12, p. 39), which is very comparable with the present study. Hildreth and Jarrett obtained average estimates from single and simultaneous equations of the demand elasticity of feed grains with respect to feed prices to be -0.76 (22, p. 93). Heady and Tweeten found the total demand elasticities with respect to current and past year feed prices to be -0.8 and -1.3 respectively (20, p. 389).

As RL_t is significant in all equations, the elasticity of demand with respect to profitability of livestock enterprise is calculated. It is approximately 0.45. This indicates that a ten percent increase in profitability will increase the quantity of feed demanded by 4.5 percent. Foote (11, p. 3), Heady and Tweeten (20, p. 389), and Hildreth and Jarret (22, p. 93) found a one percent change in livestock price to be associated with 0.5, 0.8, and 1.04[27] percent change in the demand for feed.

A projection of the demand for purchased feed through 1975 in Oregon is given in Chapter VIII.

This study answers two important questions: one, how do changes in prices of livestock and livestock products affect the demand for purchased feed, and second; how does change in the feed price affect the demand for purchased feed. It can be concluded from this study, that demand for purchased feed is directly related to the prices of livestock and livestock products and inversely related to the price of feed. The total number of animal units does not greatly influence the demand for purchased feed.

---

[27] 1.04 is the average estimate from their single and simultaneous equations for four equations.

VII. MISCELLANEOUS INPUTS

Introduction

Miscellaneous operating inputs include short-term interest, pesticides, electricity and telephone (business share), livestock marketing charges (excluding feed and transportation), containers, milk hauling, irrigation, grazing, binding materials, horses and mules, harness and saddlery, blacksmithing and hardware, veterinary services and medicines, crop fire, wind and hail insurance, miscellaneous dairy, nursery green house, apiary and other supplies (17, p. 84). The expenditure on miscellaneous items by Oregon farmers increased by 183 percent between 1950 and 1969. It constituted 12.86 percent of the total current operating expenses and 9.38 percent of the total production expenses in 1950, and 23.33 percent of the total current operating expenses and 14.90 percent of the total production expenses in 1969.

Miscellaneous inputs are directly related to the magnitude of the total farming operations. Inventories of total productive assets are assumed to be primary explanatory variables. The price of farm supplies is another important variable. There is a tremendous substitution of miscellaneous inputs for other inputs in the production process depending upon the price of different factors. Figure 9 shows

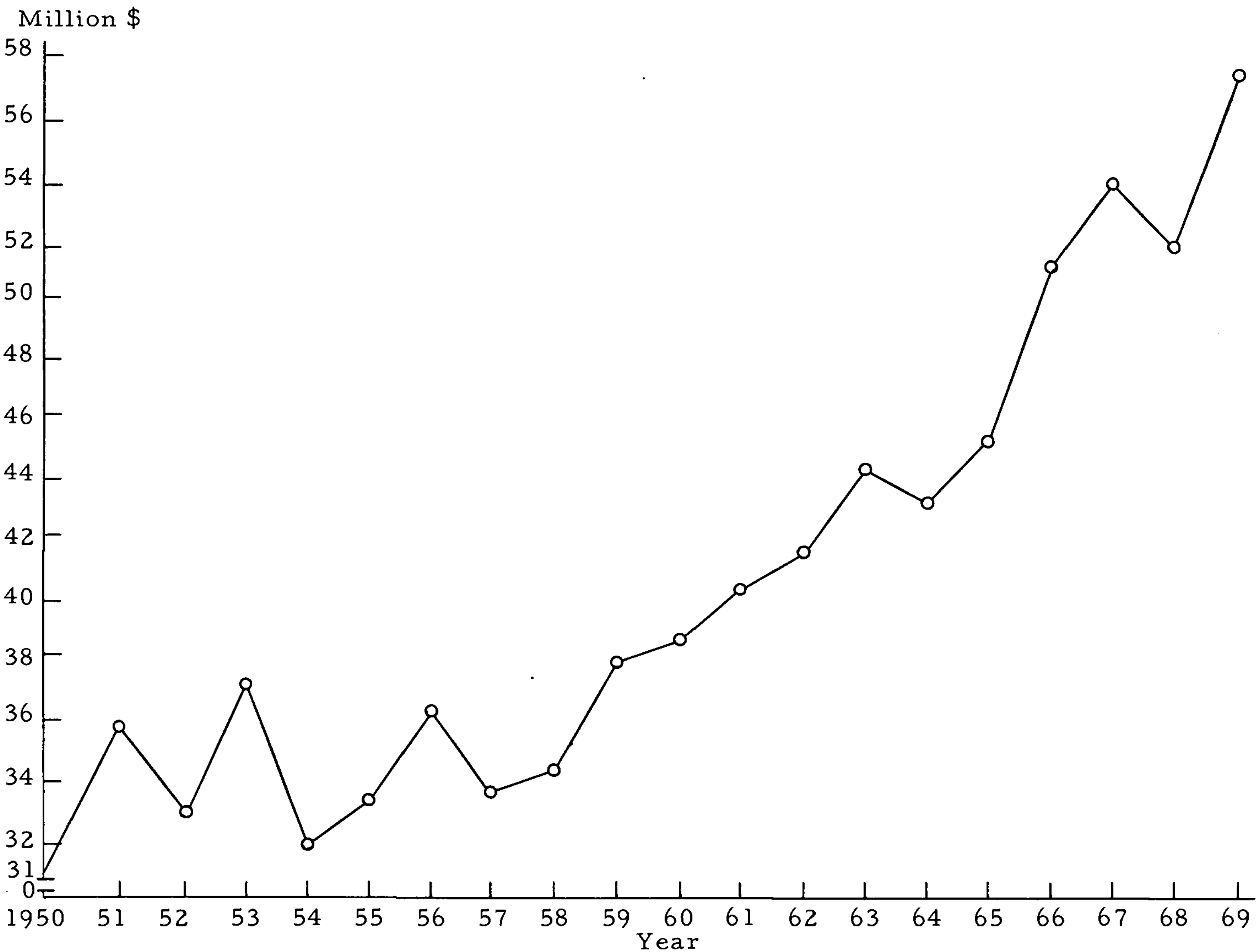

Figure 9. Miscellaneous production expenditures by Oregon farmers in 1957-59 dollars.

the miscellaneous expenditures in 1957-59 dollars from 1950 through 1969.

Specification of the Demand Function

The demand for the quantity of miscellaneous items used by Oregon farmers is considered to be a function of current price of farm supplies, past year prices received for all farm products deflated by the price paid by farmers for production inputs, the inventory value of farm production assets, time, time squared, and the lagged quantity of miscellaneous inputs in 1957-59 dollars.

Actual quantity of miscellaneous inputs is difficult to compute. However, total expenditures for miscellaneous farm input items in Oregon is available in Farm Income State Estimates 1949-1969 (38). The total expenditures in 1957-59 constant dollars is computed, deflating the actual expenditure by the consumer price index, and is regressed with other explanatory variables specified in the demand function. Thus, the primary demand model is as follows:

$$EM_t = F(P_t, R_{t-1}, A_t, T, T^2, EM_{t-1}) + e_t$$

where:

EM_t = the total expenditure for miscellaneous farm inputs in millions of 1957-59 dollars.

P_t = "Real" price of farm supplies in current year (the price index of farm supplies for the U.S. is deflated by the consumer price index).

R_{t-1} = index of prices received for all products divided by the index of prices paid for all commodities used in production in previous year.

A_t = inventories of the total productive assets in millions of dollars, deflated by the consumer price index.

T = time

T^2 = time squared, to catch up the sharp rise in the expenditure.

EM_{t-1} = the lagged total expenditure for miscellaneous inputs.

A single demand equation for the miscellaneous inputs is estimated for the 1950-1969 period. The simple correlation coefficients of different variables are presented in Table 12.

TABLE 12. SIMPLE CORRELATION COEFFICIENTS OF VARIABLES IN THE DEMAND EQUATION FOR MISCELLANEOUS INPUTS.

	P_t	R_{t-1}	A_t	T	T^2	EM_{t-1}	EM_t
P_t	1.00	0.88	-0.89	-0.98	-0.93	-0.86	-0.87
R_{t-1}		1.00	-0.70	-0.84	-0.71	-0.60	-0.59
A_t			1.00	0.95	0.95	0.94	0.94
T				1.00	0.97	0.92	0.92
T^2					1.00	0.96	0.96
EM_{t-1}						1.00	0.92

It is self-evident from this table that there are multicollinearity problems. In the step-wise regression analysis, the variable time squared intered first. This indicates that time is certainly an important factor to be considered. But due to such a high correlation among variables, it is not possible to estimate accurate coefficients.

The plotted miscellaneous expenditure data in Figure 9 indicates there is a possibility of two linear regressions with different intercepts and slopes of the coefficients. The dummy variable approach developed by Damodar Gujarati, City University of New York, is applied to test whether in fact the intercept and the slope of the price coefficient are significantly different in these two time periods (18, 19). The data are divided into two groups: one group is from 1950 to 1957, and the other group is from 1958 to 1969. Equations 13. 1(a) and 13. 1(b) are explicitly stated as:

13. 1(a) $EM_{t1950-57} = a_0 + a_1P_t + a_2R_{t-1} + a_3A_t + e_1$

13. 1(b) $EM_{t1958-69} = a_0' + a_1'P_t + a_2'R_{t-1} + a_3'A_t + e_1'$

The following hypothesis are to be tested.

$a_o = a_o'$ and $a_1 = a_1'$.

Putting these two groups in one equation

13. 1 $EM_{ti} = a_o + a_1P_{it} + a_2R_{it-1} + a_3A_{it} + a_4D + a_5(DP_{it}) + e_i$

$i = 1950, 1951 ---, 1969$

where:

D = 0, if the observation lies in the first group from 1950 to 1957.

= 1, if the observation lies in the second group from 1958 to 1969.

The dummy variable D is introduced in equation 13.1 in both additive and multiplicative forms. If $\hat{a}_4$ is statistically significant, then the intercept value for the second group is obtained by $\hat{a}_0 + \hat{a}_4$. If $\hat{a}_4$ is statistically insignificant, $\hat{a}_0$ is then also the intercept of the second group. In other words, both groups will have the same intercept. Similarly, if $\hat{a}_5$ is statistically significant, then the slope value of the price of farm supplies for the second group is obtained by $\hat{a}_1 + \hat{a}_5$ with $\hat{a}_1$ being the slope of the price of miscellaneous farm supplies for the first group. If $\hat{a}_5$ is statistically insignificant, the a_1 is also the slope of P_t in the second group. In this case, both groups will have the same coefficient for the price of farm supplies.

Time, time squared and the lagged dependent variables are eliminated in this analysis because they are highly correlated among themselves and with other variables. However, the effect of these variables can be trapped by the dummy variable.

Statistical Results

The coefficients, t value, elasticity and R^2's are presented in Table 13. Equation 13.1 shows that the differential intercept

TABLE 13. SINGLE EQUATION DEMAND MODELS FOR MISCELLANEOUS INPUTS

Regression coefficients, t value in parentheses, R^2 values and price elasticity of demand for miscellaneous items, Oregon, 1950-69.

Equation number	Form and method	Constant (α_o)	Price of farm supplies index (P_t)	Ratio of prices received to prices paid in previous year index (R_{t-1})	Value of total assets (A_t)	Dummy (D_1)	Dummy multiplied by price of farm supplies index (D_1P_t)	Price elasticity	R^2	Period
13.1	O. L. S. Total expenditure	8.01	-0.1205 (-0.344)	-0.1333 (0.6212)	0.0115 (2.36)*	96.70 (2.144)*	-.962 (-2.14)*	Elastic	.96	
13.1(a)	O. L. S. Total expenditure	8.01	-0.1205 (-0.344)	0.1333 (0.6212)	0.0115 (2.36)*			Elastic		1950-57
13.1(b)	O. L. S. Total expenditure	104.71	-1.08 (4.39)**	0.1333 (0.6212)	0.0115 (2.36)*			Elastic		1958-69
13.2	O. L. S. "Proxy" quantity	418.04	-5.10 (-p.5244)	1.9731 (0.9632)	0.1085 (2.3438)*	1275.55 (2.9629)*	-12.7684 (-2.9746)*		.983	
13.2(a)	O. L. S. "Proxy" quantity	418.04	-5.10 (-1.5244)	1.9731 (0.9632)	0.1085 (2.3438)*			-1.22		1950-57
13.2(b)	O. L. S. "Proxy" quantity	1693.70	-17.8684 (5.93)**	1.9731 (0.9632)	0.1085 (2.3438)*			-4.28		1958-59

*significantly different from 0 at 5 percent test level

**significantly different from 0 at 1 percent test level coefficient a_4 and the differential slope coefficient a_5 are highly significant. This verifies that the intercept and the coefficient of the price of farm supplies in the second period from 1958 to 1969 are different from those of the first period of 1950 to 1957. Equation 13. 1(a) and 13. 1(b) indicate two time periods in Table 13. The coefficient of the total value of productive assets (A_t) is highly significant in equation 13. 1. Although variable R_{t-1} is not statistically significant, its sign turns out as theoretically expected.

The negative coefficient of the price of farm supplies indicates that when price is increased, the total expenditure will be diminished. It means that the demand for miscellaneous inputs is elastic. Figure 10 represents the elastic demand for miscellaneous farm inputs. Suppose the initial price and the quantity are p^o and q^o. So the total expenditure is p^oq^o.

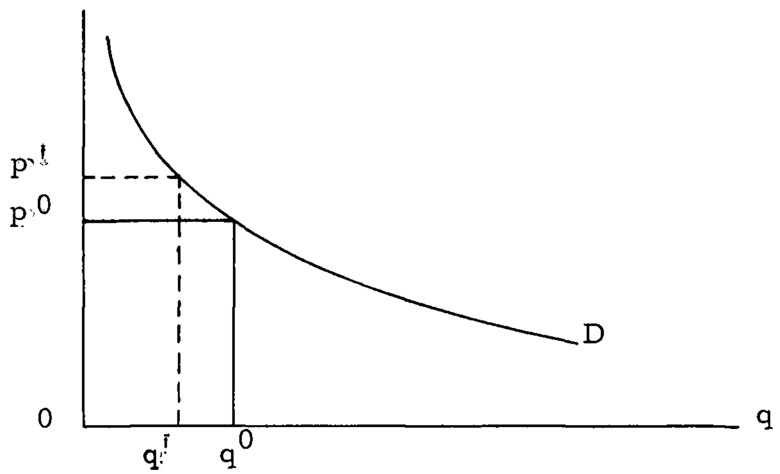

Figure 10. Illustration of elastic demand for miscellaneous inputs.

If the price is increased to p^1, the total expenditure is p^1q^1 which is less than p^oq^o. A decrease in the total expenditure due to a rise in price means the demand for the commodity q is elastic. The negative coefficient of the farm supplies implies an elastic demand for the miscellaneous items in Oregon agriculture.

In order to estimate the price elasticity of demand for miscellaneous inputs, a "proxy" quantity of miscellaneous items is created.[28] The dummy variable approach is repeated by replacing the dependent variable, total expenditures for miscellaneous items in equation 13. 1 by the "proxy" quantity of miscellaneous items purchased. Now, equation 13. 2 has the same explanatory variables which were in equation 13. 1. Equation 13. 2 also shows that the differential intercept coefficient and the differential slope coefficient of the price of farm supplies are highly significant. The coefficient of the total value of productive assets is again significant in this equation. Equation 13. 2(a) and 13. 2(b) indicates the equations for the time period 1950-57 and 1958-59 respectively. The mean price elasticity of demand for miscellaneous factors is computed and presented in Table 13. It is -1. 22 for the period 1950-57 and -4. 28 for the period 1958-69. These values of the price elasticity verifies the elastic demand for miscellaneous items in equations 13. 1(a) and 13. 1(b).

---

[28]See detail in Chapter V pp. 64-66.

The demand for a specific miscellaneous input would be expected to be highly elastic because of the availability of close substitutes. The demand for an input will be more elastic, the greater is its share in the total cost (28, p. 319). Miscellaneous expenses constitute a large share of total current operating expenses of Oregon farmers.

The stock of productive assets is the proxy of total agricultural plant size. The coefficient of total productive assets is significant in all equations at the 5 percent test level. One can speculate that the purchase of miscellaneous inputs would increase because of strong complementarity among resources as the total agricultural plant size increases. "The great increase in their (miscellaneous inputs) use unquestionably stems from both their favorable real price and increase in productivity" (20, p. 372). A decline in the "real" price of farm supplies may be due to technological change or decreasing costs in non-agricultural industries which supply the inputs. A fall in the price of farm supplies may encourage their use and further research towards increasing their productivity and lowering the real price even further.

The projection of demand for miscellaneous inputs in Oregon through 1975 is given in Chapter VIII.

VIII. TRENDS AND PROJECTIONS

The accuracy of prediction depends upon the forecasting ability of the models and the exactness of the predicted exogenous variables. Point forecasts from this study are made for the demand for hired labor, total fertilizer, machinery supplies, purchased feed, and miscellaneous expenditure through 1975. Also, the value of total machinery inventories are predicted through 1975. The observation period for hired labor is from 1951 to 1970 but for the other inputs it is from 1950 to 1969. The predictive period is from 1970 to 1975 in all cases except for hired labor, where it is from 1971 to 1975.

Although economic predictions are of a great value for the guidance of economic policy makers, one is to be aware of the shortcomings of these predictions. A point prediction of a variable as defined by Christ "is a statement that the value of that variable will be found to be equal to a given number, perhaps under specified circumstances" (6, p. 292). He points out two sources of error in the point prediction:

> "first, the disturbances in the prediction period produce a random deviation of the actual value from the expected value; second, the disturbances in the observation period produce a random deviation of the point prediction from the true expected value" (6, p. 293).

In order to predict the value of endogenous variables, the value of all of the explanatory variables used in the prediction are approximately known by regressing those explanatory variables with time and time squared.

The "real" farm wage rates, in the last several years indicate an upward trend and this is expected to be continued through 1975. The parity ratio, the price of motor supplies and the price of feed have shown a slightly downward trend in the last several years. However, this trend is expected to continue through 1975 for the price of motor supplies and the price of feed, but a slight increasing trend is expected for the parity ratio through 1975. The "real" price of fertilizer and the price of farm supplies have shown a declining trend throughout the period of 1950 to 1969 and this trend would continue through 1975 as predicted in both cases.

The value of machinery inventories and the value of total farm assets have indicated a moderate rise in the last several years and this trend is expected through 1975. The size of farm has increased significantly in the last twenty years, but is expected to stabilize through 1975 as indicated by its prediction.

The observation period data of LR_t (ratio of prices received for livestock and livestock products to the prices paid for all commodities used in production) and LA_t (value of total livestock inventory) do not indicate any definite trend. From 1951 to 1955, there was a sharp decline in LR_t and after that it showed a zig-zag trend. The data for LA_t indicated a zig-zag trend from 1949 to 1969. Their average values for the period 1955 to 1969 are used in the predictive model for every year.

Table 14 shows the projection of the agricultural inputs discussed in this thesis from 1970 to 1975. Hired labor and fertilizer are projected in terms of number of workers and tons respectively. Machinery inventory, expenditures for machinery supplies, purchased feed and miscellaneous inputs are projected in terms of 1957-59 dollars and in current dollars[29] of the respective year.

The future demand for hired farm labor is predicted by the simultaneous demand equation 3.4. It is estimated 16.3 thousand people will be hired on Oregon farms in 1975. This indicates that in 1975, 5,700 fewer people will be hired by Oregon farmers than were hired in 1970. The trend for hired labor was moderately declining from 1950 to 1967. But, for the last four years, it was fairly stable as shown in Figure 1. The predicted values, however, shows a further decline in the demand for hired labor. The number of workers that will in fact be employed by Oregon farmers during

---

[29]In order to convert 1957-59 dollar values into current dollars of each respective year, the consumer price index (1957-59 = 100) values for the period 1949 to 1970 are regressed with time and time squared. The consumer price index values through 1975 are predicted. The predicted 1957-59 dollar values for these inputs are multiplied by the predicted value of consumer price index of the respective year. The predicted consumer price index for 1975 is 146.9; the actual consumer price index for 1969 and 1970 are 127.7 and 135.3.

TABLE 14. PROJECTION OF SELECTED AGRICULTURAL PRODUCTION INPUTS FROM 1970 THROUGH 1975. OREGON.

Items	Unit	1970	1971	1972	1973	1974	1975
Number of hired workers	1,000	22.0[a]	20.54	19.4	18.33	17.30	16.33
Quantity of total fertilizer	1,000 tons	406.3	430.4	455.5	482.4	512.6	547.5
Machinery inventory	million dollars (1957-59)	305.2	311.2	317.6	323.8	330.5	337.0
Machinery inventory	million dollars (current)	392.8	411.1	430.7	450.7	472.6	495.0
Machinery supplies	million dollars (1957-59)	42.4	42.3	42.3	42.2	42.0	42.0
Machinery supplies	million dollars (current)	54.6	55.9	57.4	58.7	60.0	61.7
Purchased feed	million dollars (1957-59)	56.5	57.0	57.4	57.7	58.0	58.4
Purchased feed	million dollars (current)	72.7	75.3	77.8	80.3	82.9	85.8
Miscellaneous inputs	million dollars (1957-59)	59.4	61.9	64.5	67.0	69.7	72.4
Miscellaneous inputs	million dollars (current)	76.4	81.8	87.5	93.2	99.7	106.4

[a]The 22.0 thousand workers in 1970 is the actual number.

the next five years, depends heavily upon what happens to wage rates. This study shows an elastic demand for hired labor. If farm wage rates rise sharply through unionization or other arbitrary means the number of workers employed is expected to decline in greater proportion than the wage rate rise. Significant economic and social implications become quite apparent.

The demand for total fertilizer in 1975 would be 547.5 thousand tons as forecast by equation 5.2. This amount would be about 43.4 percent greater than the consumption of fertilizer in 1969. Equation 5.1 is used to predict the total primary plant nutrients (N_2, P_20_5 and K_20). These elements combined will amount to 199 thousand tons which is 54.7 percent greater than the use of nutrients in 1969. These data suggest a continuation of the trend toward stronger formulation of fertilizers as they are applied. Improved technology in both manufacturing and application makes this possible.

The trend in the consumption of fertilizer by Oregon farmers is definitely upward as shown in Figure 3. This trend would continue as predicted by the variables in the identified model.

A 43.4 percent increase in the demand for fertilizers by Oregon farmers during the next six years is a significant increase. It is important to analyze whether the fertilizer manufacturing industries and the fertilizer distributing agencies are capable of meeting this requirement. In 1967, the total consumption of fertilizer in Oregon was 441.668 thousand tons in comparison to 268.452 thousand tons in 1963. This was a 64 percent increase in the demand for fertilizer during the 1963 to 1967 period. As the fertilizer industries had been able to meet the 64 percent increase in the demand for fertilizers during a four-year period previously, it is undoubtedly within the capability of the fertilizer industry to meet this 43.4 percent increase in the demand for fertilizer in 1975.

The total value of all machinery and equipment on Oregon farms would be $337 million in terms of the 1957-59 dollar and $495 million in terms of current dollars by 1975. This prediction is based on variable relationships expressed in equation 6.3.

In terms of current dollars, the 1975 projection constitutes a 26.6 percent increase over 1969. However, great confidence in this prediction is not possible because of data limitations pertaining to annual capital outlays for machinery and equipment by Oregon farmers. It is fairly certain farmers will continue to substitute machinery for hired labor when it is economically advantageous to do so. Furthermore, organizing of farm labor with possible strikes or strike threats creates circumstances that will induce farmer to go to mechanized types of agriculture as a means of reducing reliance on hired labor. This will tend to bolster inventories of machinery and equipment on Oregon farms in the years ahead. It will also push research toward designing machinery to perform farm operations that now must be done by hand. These uncertainties, among others, can sharply modify the inventory values of machinery and equipment on Oregon farms by 1975.

Expenditures on repairs and operation of motor vehicles and other machinery (machinery supplies) are expected to be fairly constant during the six years from 1969 in terms of 1957-59 dollars. This is based on the prediction resulting from the variable relationships as shown in equation 8. 3. The expenditures are projected to be $42 million in terms of 1957-59 dollars in 1975. The predicted value of machinery and equipment inventory by equation 6. 3 is used as a predetermined variable in equation 8. 3.

While the expenditure for machinery supplies in 1957-59 dollars appears to be fairly constant, the picture naturally changes when current year dollars are considered. When allowing for price level changes, the $42 million becomes $61. 7 million by 1975. This represents a 12 percent increase over 1969 and is accounted for almost wholly by projected inflationary tendencies in the economy.

The expenditure on machinery supplies in the last several years has been fluctuating around $42 million as shown in Figure 5. The relationships among the variables affecting this phenomenon suggest the same level will continue through 1975. Although the inventory value of machinery and equipment on Oregon farms is predicted to rise by $32 million in terms of 1957-59 dollars in the period 1970-75, the machinery supplies expenditure tends to be constant in 1957-59 dollars. The reason for this phenomenon is the following: The rise in machinery inventory naturally can be expected to increase the expenditure for machinery supplies because of the complementarity between the two. On the other hand, the price effect tends to reduce the expenditure for machinery supplies due to an inelastic demand for machinery supplies and a declining trend in their price. In the final analysis, the machinery inventory effect and the price effect seem to cancell out and maintain the constant expenditure for machinery supplies.

The future expenditure for machinery supplies, however, largely depends upon the future trend of price of machinery supplies, the extent of increase in machinery inventory, the degree of complexity or sophistication[30] of new machines due to technological development in machinery production and the age[31] of machinery in use.

---

[30]As farm machines become more sophisticated, it is beyond the farmer's ability to repair and so the repair expenses increase.

[31]Older machines may require more repairs than the new ones.

In 1975, Oregon farmers will be spending about \$58.4 million in 1957-59 dollars and \$85.8 million in 1975 dollars to buy feed for their livestock, according to projections made by using equation 10.3. This represents a 25 percent increase over 1969 in terms of current dollars. Whereas in terms of constant dollars of 1957-59, it is only 9 percent increase over 1969. Thus, 16 percent is accounted for by inflation in the economy.

The expenditure for feed in the last several years has been highly fluctuating. There has been no distinct trend of expenditures in constant dollars for feed in previous years as shown in Figure 7. However, the predictive model indicates a slight upward trend in coming years. The positive effect of the lagged dependent variable tends to increase the expenditure for purchased feed, whereas, the decreasing trend of the "real" price of feed tends to reduce the expenditure for feed due to the inelastic demand for purchased feed. Finally, the upward trend in the expenditure of feed is probably due to the fact that the dependent variable lagged in the equation outweighs the price effect. Thus, the future expenditure for purchased feed may depend upon the trend of these two variables keeping the value of RL_t variable constant in the prediction period.

As far as miscellaneous production expenditures are concerned, it is estimated they will rise to \$72.5 million in 1957-59 dollars during 1975. This is a 23 percent increase over 1969. From 1950 to

1957, miscellaneous production expenditures fluctuated around $35 million. After 1957, there was a clear-cut upward trend in the miscellaneous expenses as shown in Figure 9. This upward trend rate is expected to continue over the next several years. The predicted levels of expenditure by 1975 are based on relationships expressed in equation 13. 1(b). The predicted expenditure by 1975 will be $106. 4 million in terms of 1975 dollars. This represents a 46 percent increase over 1969 in terms of current dollars. Thus, when we take into account of inflationary trend in the economy, the picture of these projections is very different. Because of the strong complementarity effect of an increasing agricultural plant size and the substitution effect due to a fall in the relative prices of miscellaneous inputs the total expenditure for miscellaneous items has been increasing rapidly, and is expected to continue along the same path.

IX. SUMMARY AND CONCLUSIONS

The purpose of this study is to estimate empirically, the demand structure for the major farm production inputs in Oregon. The farm inputs selected for study are: hired labor, chemical fertilizer, farm machinery, machinery supplies, purchased feed and miscellaneous input items.

A least-squares multiple regression technique is used to analyze the demand function for these inputs. A single-equation demand function is used for all inputs. In addition, a simultaneous-equation model is applied for hired labor. For miscellaneous inputs, a dummy variable approach developed by Damodar Gujarati is applied to accomodate an _a priori_ conjecture that the demand curve contains a discontinuity. A Nerlove-type distributed lag is also taken into consideration in building many of these models.

The demand for these inputs are predicted from 1970 through 1975. Hired labor and fertilizer are projected in terms of number of workers and tons respectively. Farm machinery and equipment inventories, expenditures for machinery supplies, purchased feed, and miscellaneous inputs are projected both in 1957-59 dollars and in current dollars of each respective year.

The demand for hired farm labor is declining. There were 40.6 percent fewer people hired on Oregon farms in 1970 than in 1950.

Based on the findings of this study, it is estimated there can be a 25 percent further decline in the number of hired workers employed on Oregon farms between 1971 and 1975.

Farm "real" wage rates and the lagged dependent variables are statistically significant in both the single-equation demand function and the simultaneous-demand equation in "explaining" the variation over time in the demand for hired farm workers. A trend variable is not significant in any of the equations. The short-run wage elasticities varies from -1.2 to -1.5 and -1.5 to -2.6 in the single-equation demand models and the simultaneous-equation demand models respectively. The long-run wage elasticity is calculated by dividing the short-run wage elasticity of demand by the coefficient of adjustment. The long-run wage elasticity of demand varies from -2.5 to -3.5 and -3.0 to -5.0 in the single-equation demand models and the simultaneous-equation demand models respectively.

Both models indicate an elastic demand for hired farm labor with respect to wage rates. This result is in contrast to the various national demand studies which indicate an inelastic demand for hired farm labor with respect to wage rates.

The implication of the findings of this study is that while an increase in wage rates might permanently benefit some full-time and indespensable hired workers in farming, as far as the aggregate seasonal and full-time relatively unskilled labor force is concerned, it might be adversely affected in the long-run through shrinkage of employment possibilities. Machinery might be substituted for them and their employment in farming would be reduced drastically. Further, as hired labor becomes more expensive, farmers may find it more profitable to produce products that are less labor intensives.

Fertilizer is another important input extensively used by farmers in Oregon. Models to "explain" the demand for the primary plant nutrients and the total fertilizer are developed separately in logarethemic form using the same "explanatory" variables. In both models, the "real" price of fertilizer and the lagged dependent variables are highly significant. Each equation "explain" 95 percent of the total variation in the amount of fertilizer used in Oregon. The short-run and the long-run elasticity of demand for the primary plant nutrients are -0.64 and -1.372, and for total fertilizer, -0.58 and -1.16 respectively. The short-run inelastic demand implies that farmers cannot immediately adjust the consumption of fertilizer to the economic stimulus, as many of their production decisions have already been made. However, the long-run elastic demand implies that in the course of time, they are able to adjust the purchase of fertilizer to the long-run equilibrium quantity. The high coefficient of adjustment (.50) indicates a quick adjustment of the current quantity of fertilizer consumed to the long-run equilibrium quantity. The results of the elasticity analysis are comparable to the study made by Griliches on the basis of national and regional data.

The models predict that there could be about 43.4 percent greater consumption of fertilizers and 54.7 percent greater use of the primary plant nutrients in Oregon in 1975 compared in 1969. The main reason for such an increase in the consumption of fertilizer is probably a decline in the "real" price of fertilizer. There has been a 61 percent decrease in the "real" price of fertilizer in the last twenty years.

Unfortunately, the data on the purchase of all farm machinery by Oregon farmers in each year are not published. This makes it difficult to develop a good model for the demand for farm machinery in Oregon. However, computed data on total machinery inventories are used in the demand equation. Due to high multicollinearity problems in the model, the estimates of regression coefficients may be seriously biased, but the predictive power ($R^2 = 0.96$) of the model is undoubtedly good, if the joint distribution of the explanatory variables stays the same in the forecasting period as it was in the observation period (6, p. 389).

Oregon farmers would have \$337 million 1957-59 dollars or \$495 million 1975 dollars worth of machinery inventories in 1975 as predicted by this study. Price index of machinery, ratio of prices received to prices paid variable (R_t), size of farm and total assets are statistically significant in the equation at the 5 percent test level. The elasticity of the total machinery inventory with respect to price of machinery and profitability variable (R_t) are -0.45 and 0.75. A 10 percent increase in the price of farm machinery is associated with 4.5 percent decrease in the total machinery inventory, and a 10 percent increase in the profitability of farming (R_t) is associated with 7.5 percent increase in total machinery inventory. The analysis fails to support the hypothesis that increases in farm wage rates will result in increases in machinery inventories. However, it does support the expectation that increases in farm size will result in increases in machinery inventories.

The expenditure on machinery supplies has been fluctuating around \$42 million in 1957-59 dollars during the last several years. It is predicted to be approximately \$42 million in 1957-59 dollars or \$61.7 million in 1975 dollars in 1975. The demand for machinery supplies is estimated to be inelastic, as indicated by the positive coefficient of the price index in the equation with the total expenditure for machinery supplies as the dependent variable. This is supported by the price elasticity of -0.63. The inelastic demand implies that decreases in the price of machinery supplies will reduce the total expenditure for machinery supplies. However, increases in machinery inventories counter-balances the reduction in the total expenditure due to its complementarity relationships with machinery supplies.

In order to compute the price elasticity of demand for machinery supplies, a "proxy" quantity is obtained by dividing the total expenditure for machinery supplies by its price index. Then, the "proxy" quantity is regressed with the independent variables in the model. The regression coefficient of the price index thusly obtained is used to compute the price elasticity.

The demand for purchased feed which includes feed grains and protein feeds, is considered in this study. As the demand for feed is a derived demand, it depends largely on the prices of livestock and livestock products. The price of feed in t and t-1 period, and the profitability of livestock enterprises are statistically significant in the equation. The number of livestock units or the livestock inventory fails to show any influence on the demand for purchased feed. In the short-run, the demand for feed is inelastic but is elastic in the long-run. The price elasticity in the short-run varies from -0.45 to -0.57. In the long-run, it varies from -1.05 to -1.35. The average coefficient of adjustment is about 0.48. The coefficient of adjustment indicates that 48 percent of the required adjustment in feed purchases can be made in one year.

A moderately upward trend in the demand for feed, as indicated by the predictive equation indicates a forecast of $58 million of 1957-59 dollars in expenses for feed in 1975. This would be $85.8 million in 1975 dollars, which constitutes a 25 percent increase over 1969 in terms of current dollars.

The expenditures for miscellaneous farm input items increased by 183 percent between 1950 and 1969 in terms of current dollars. They are expected to be about $72.5 million in 1957-59 dollars in 1975. This compares to $106.4 million in 1975 dollars. The projection constitutes an increase of about 46 percent in current dollars and about 23 percent in 1957-59 dollars over 1969 expenditures.

The dummy variable approach developed by Damodar Gujarati fails to reject the null hypothesis of the discontinuity in the demand curve for miscellaneous inputs at the 5 percent test level. The mean price elasticity of demand for miscellaneous items is -1.22 for the period of 1950-57 and -4.28 for the period of 1958-69. This indicates a highly elastic demand for miscellaneous inputs. Such a high elastic demand is probably due to a strong complementarity effect between miscellaneous imputs and the increasing agricultural plant size, and the substitution effect due to a fall in relative prices of miscellaneous inputs. A fall in the price of these particular farm supplies may encourage their use and further research towards increasing their productivity and lowering their relative supply price.

Future Research

This study indicates that the demand for hired farm labor in Oregon was elastic during the 1951-1970 period. Several national studies show the demand for hired farm labor to be highly inelastic. All of the national studies use earlier than 1950 data. There has been a tremendous change in the resource structure and organization of agriculture in the United States in these last two decades. In view of the findings of this study, it is important to empirically analyze the demand for hired labor in various states by using different time period combinations but particularly including data after 1950. Such studies would independently test the results found in this study. Furthermore, policy-making at the state-level relative to hired farm workers would be more meaningful using state data rather than having to rely upon the results of national-demand models.

BIBLIOGRAPHY

1. Atkinson, L. Jay and John W. Klein. Feed consumption and marketing weight of hogs. Washington, D.C., 1945. 22 p. (U.S. Dept. of Agriculture. Technical Bulletin no. 894)

2. ________________. Feed consumption and the production of pork and lard. Washington, D.C., 1946. 21 p. (U.S. Dept. of Agriculture. Technical Bulleton no. 917)

3. Basmann, R.L. Letter to the editor. Econometrica 30:824-826. 1962.

4. Bishop, C.E. Dimensions of the farm labor problem. In: Farm labor in the United States, ed. by C.E. Bishop. New York, Columbia University Press, 1967. p. 1-17.

5. Brake, John R. Impact of structural change in capital and credit needs. Journal of Farm Economics 48:1536-1549. 1966.

6. Christ, Carl F. Econometric models and methods. New York, John Wiley and Sons, 1966. 705 p.

7. Coffey, Joseph D. National labor relations legislation: possible impact on American agriculture. American Journal of Agricultural Economics 51:1065-1047. 1969.

8. Cromarty, William A. The demand for farm machinery and tractors. East Lansing, 1959. 72 p. (Michigan. Agriculture Experiment station bulletin no. 275)

9. ________________. The farm demand for tractors, machinery and trucks. Journal of Farm Economics XLI:323-331. 1959.

10. Dernburg, Thomas F. and Duncan M. McDougall. Macro-economics. New York, McGraw-Hill Book Company, 1968. 438 p.

11. Foote, Richard J. Statistical analyses relating to the feed-livestock economy. Washington, D.C., 1953. 41 p. (U.S. Dept. of Agriculture. Technical Bulletin no. 1070)

12. Foote, Richard J. et. al. The demand and price structure for corn and total feed concentrates. Washington, D.C., 1952. 79 p. (U.S. Dept. of Agriculture. Technical Bulletin no. 1061)

13. Griliches, Zvi. Distributed lags, disaggregation, and regional demand function for fertilizer. Journal of Farm Economics XLI:90-102. 1959.

14. ________________. The demand for a durable input: farm tractors in the United States, 1921-57. In: The demand for durable goods, ed. by Arnold C. Harberger. Chicago, University of Chicago Press, 1960. p. 181-207.

15. ________________. The demand for fertilizer: an economic interpretation of a technological change. Journal of Farm Economics XL:591-606. 1958.

16. ________________. The demand for fertilizer in 1954: an inter-state study. Journal of the American Statistical Association 54:377-384. 1959.

17. ________________. The demand for inputs in agriculture and a derived supply elasticity. Journal of Farm Economics 41: 309-322. 1959.

18. Gujarati, Damodar. Use of dummy variables in testing for equality between sets of coefficients in two linear regressions: a note. The American Statistician 24(1):50-52. 1970.

19. ________________. Use of dummy variables in testing for equality between sets of coefficients in linear regressions: a generalization. The American Statistician 24(5):18-22. 1970.

20. Heady, Earl O. and Luther G. Tweeten. Resource demand and structure of the agricultural industry. Ames, Iowa State University Press, 1963. 515 p.

21. Heady, Earl O. and Martin H. Yeh. National and regional demand functions for fertilizer. Journal of Farm Economics XLI:322-348. 1959.

22. Hildreth, Clifford and F. G. Jarrett. A statistical study of livestock production and marketing. New York, 1955. 156 p. (Cowles commission for research in economics. monograph no. 15)

23. Jensen, Einar et. al. Input-output relationships in milk production. Washington, D.C., 1942. 88 p. (U.S. Dept. of Agriculture. Technical Bulletin no. 815)

24. Kendrick, John W. and Carl E. Jones. Farm capital outlays and stock. Survey of Current Business 33(8):16-23. 1953.

25. Lorie, James H. Causes of annual fluctuations in the production of livestock and livestock products. Chicago, University of Chicago Press, 1947. 105 p.

26. Marshall, A. Principles of economics. 8th ed. London, Macmillan and Company, 1964. 731 p.

27. Nelson, Aaren G. Input-output relationships in fattening cattle. Journal of Farm Economics 28:495-514. 1946.

28. ______________. Relation of feed consumed to food products produced by fattening cattle. Washington, D.C., 1945. 36 p. (U.S. Dept. of Agriculture. Technical Bulletin no. 900)

29. Nerlove, Marc. Distributed lags and estimation of long-run supply and demand elasticities: theoretical considerations. Journal of Farm Economics 40:301-311. 1958.

30. Nerlove, Marc and William Addison. Statistical estimation of long-run elasticities of supply and demand. Journal of Farm Economics 40:861-880. 1958.

31. Oregon State Employment Service. Annual farm labor report 1967. Salem. 52 p.

32. ______________. Annual farm labor report 1968. Salem. 48 p.

33. Oregon. Employment Division. State Employment Service. Annual rural manpower report 1969. Salem. 84 p.

34. Rojko, Anthony S. Econometric models for the dairy industry. Journal of Farm Economics 39:323-338. 1957.

35. Schuh, G. Edward. An econometric investigation of the market for hired labor in agriculture. Journal of Farm Economics 44: 307-321. 1962.

36. Schuh, G. Edward. The agricultural input markets--a neglected area of agricultural policy and economic research. In: Marketing and economic development readings in agribusiness research, ed. by C. J. Miller. Lincoln, University of Nebraska Press, 1967. p. 367-395.

37. Schuh, G. Edward and John R. Leeds. A regional analysis of the demand for hired agricultural labor. In: Papers and proceedings of the Regional Science Association, ed. by Morgan D. Thomas. vol. 11. Philadelphia, 1963. p. 295-308.

38. U.S. Dept. of Agriculture. Economic Research Service. Farm income state estimates 1949-1969. Washington, D.C., August 1970. 134 p.

39. ________________. Economic Research Service. Hired farm labor. Washington, D.C., 1971, 34 p. (Statistical Bulletin no. 462)

40. Yeh, Martin H. The labor market with particular reference to Canadian agriculture. Journal of Farm Economics 49:1257-1267. 1967.