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Title: Changes in Input, Output, and Productivity of Oregon Farms

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Agriculture is the second most important industry in Oregon. It supplies food and fiber, labor and capital for nonfarm sectors and is a demander of nonfarm products. It is, therefore, important to find out what the records show about changes in productivity from 1950-1966.

Productivity is the ratio of output to input or a class of inputs. Each productivity ratio indicates the savings achieved as a result of changes in production efficiency and factor substitution.

Specifically, the objectives of this thesis are: (1) to determine Oregon's long term growth in agricultural output, changes in input combinations and factor productivity, (2) to estimate output increases that result from conventional inputs and the residual attributable to non-conventional input.

Using 1950=100, the indexes of value of total agricultural output, of livestock products, and of crops are 129, 128 and 136, respectively, while the projected indexes for 1975 are 145, 143 and 157,

respectively. On the other hand, the aggregate input index (or conventional input index) declined by five percent from 1950-1966. This means that the increase in agricultural output in Oregon for the past 16 years can be attributed to technical progress rather than to an increase in physical inputs. This permits the development of agriculture to contribute significantly to the overall economic growth of Oregon.

The size of farms increased from 335 acres in 1950 to 486 acres in 1966. The number of farms declined from 62, 600 in 1950 to 43, 500 in 1966. While the marginal rate of substitution of capital for labor is estimated to be 1. 34, the marginal value product of labor and capital are -. 43 and . 99, respectively. The index of per capita land area per man-hour of labor contributed more to labor productivity than capital intensity indicating further the need to decrease labor input in Oregon agriculture.

The most dramatic input increase was fertilizer with only 97, 000 tons used in 1950 as against 363, 000 tons in 1966. The most dramatic input decline was labor with 72. 1 million man-hours employed in 1950 and 47. 8 million man-hours in 1966.

The index of off-farm inputs and on-farm inputs increased by 39 percent and 7 percent, respectively, from 1950-1966, suggesting that off-farm inputs contribute more to aggregate productivity increases than on-farm inputs. Consequently, it was estimated that only two percent of the value of output in 1951 was due to technology while 26 percent was attributed to the same factor in 1966.

The technical progress implied by these disproportionate rates of increase in output and conventional input can be attributed in large measure, to shifts in production function associated with agricultural research, adoption of technical knowledge, skill and managerial competence of Oregon farm population.

Changes in Input, Output, and Productivity of Oregon Farms

by

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CHAPTER I

INTRODUCTION

Agricultural industry in Oregon has been influenced by many economic-oriented forces for the past two decades. These forces have brought many structural changes at the farm-firm level and productive efficiency of farmers has increased through adoption of science and technology. Land is being used more intensively by increased fertilizer application, by substitution of capital for labor, and by irrigation and/or drainage.

Gross statistics on the farm marketing receipts from Oregon's farms indicate increases. The pattern of agricultural development seems to emphasize that vigorous efforts on the part of researchers, extension workers and individual farmers will have higher rates of increases in the coming decade than in the past two decades.

The questions that will be answered in this study are: How much has production actually increased? What are the sources or relative importance of the various factors associated with the increases? What are the changes in the relative efficiency with which production has taken place? Answers to these questions should permit all to better comprehend and more fully evaluate the impact of science and technology on agricultural production processes. Furthermore, answers should permit more definitive and accurate projections of consequences of future policy decisions in relation to Oregon agriculture.

Source and Treatment of Data

Most of the basic data used in this study is found in publications and releases of the Statistical Reporting Service, Economic Research Service of the U.S. Department of Agriculture. Office of Economic Information, Oregon Cooperative Extension Service, and the U.S. Census of Agriculture for Oregon. However, the information is brought together so that changes in productivity and components that have occurred can be appraised.

In original form most of the agricultural output values are in current dollars. Different price indexes (which will be identified in each case) are used to deflate or inflate with 1950=100. This is necessary because changes in value of agricultural products represent changes in physical volume of output, changes in the prices of physical volume of output, or changes in both output and prices. Since the performance of the Oregon agricultural economy is to be measured in terms of output, it is necessary to remove the element of changing prices in the measurement.

Secondly, average price index for the year is used. This helps to avoid exceptional price ratios.

In effect, the use of constant prices as a common unit makes it possible to employ ratios of productivity which embrace all corresponding output and input elements.

Concept of Productivity

The well-being of the agricultural population is basically determined by the amount of final products and services produced per capita and the cost of inputs used to produce them. The total production depends, first, on total resources used; second, on the relationship between physical quantities of output and input; and, third, on the relative bargaining power between agriculture and non-agricultural sectors. This project will make use of all these factors to determine the production of the agricultural sector in Oregon.

Generally, the purpose of productivity measurement is not to determine a single relationship between output and input *per se* but to determine differences between two or more relationships. It may also be necessary to compare trends of productivity for different products or between different sectors.

By a combination of various concepts of output and input, many relationships can be determined. The unique properties of various measures make them useful for the purpose for which they are designed.

The essence of productivity measurement is to facilitate a comparison of different situations such as:

(1) For practically identical products (or groups of products) over time or geographically.

(2) For nonidentical products (or groups of products) over time or geographically.

The first can lead to an assessment of the differences in absolute amount or in a percentage change.

There is no need to compare absolute amounts in the second situation. Doing so will be to include in productivity the relative bargaining power between different sectors of the economy.

Finally, there are two categories of ratios: "aggregate productivity ratio" which includes all corresponding input items in its ratio with output; and "partial ratios" which use single input categories to relate to output (12). Both of these categories will be used in this study to show a spectrum of productivity ratios demonstrating savings in a particular cost element over time as productive efficiency and factor substitutions change. For when proportions have varied, changes in the ratio of output to one input or class of inputs reflect inter-factor substitution and changes in overall productive efficiency.

Methodology

In order to measure productive efficiency, the author will relate aggregate output to aggregate corresponding inputs to reflect changes in factor efficiency and changes in output resulting from changes in the application of intermediate inputs (12)--for example, use of weed killers. This method does not treat gains in productivity in the production of these intermediate products. The causes (exogeneous or endogeneous to the farm sector) which bring about the productivity increase is another question, different from productivity gain assessment. (8)

Aggregate output will also be related to classes of inputs in order to find the extent farm output is explained by conventional inputs. Two approaches will be used. First, index numbers are compared; and, second, is the use of Cobb-Douglas production functions and/or linear functions.

Aggregation problems will be ignored in this study. Consequently, the results are presumed relevant to the average Oregon farmer, both in yield and behavior. In short, by using a Cobb-Douglas function, the author is fitting a micro-theory to micro-variables without postulating a macro-theory.

Different projections will be made. An examination of such long-run projections prompt three objections. (12) First, decisions on long-run commitments make projections necessary, though they may be implicit in the decision itself. Second, no one can foresee the future, so the author is aware of the limitations of this tool. Third, elaborate economic projections require more work than can be justified, even in an affluent society.

However, these projections will assume that the trends from 1950-1966 are indicative in a general way, of the future trends, given no unusual developments.

Review

The cause of rising productivity in the United States has been hypothesized in many ways. Henry Parkes said that it is because of abundance of land and other natural resources. (18) Loomis and Barton said that it is because of "new knowledge" and other closely related forces such as changing prices, specialization, and institutional structures. (9) Specifically, it has been shown that productivity has been accelerating at a constant rate of 3.5 percent yearly since 1919.

This increase is not without its effects. It forms a background to the rapidly decreasing relative prices of farm products and the consequent welfare effect. It necessitates the rapid rate of labor out-migration from agriculture which was at its peak of 5 percent yearly in the 1950's.

Kendrick made the most comprehensive effort to specify yearly changes in the ratio of net farm output to net farm input in agriculture (7) on a national scale. Others who have contributed to this knowledge are G. Warren, F. Pearson and F. Strauss of which a review of their methods shows significant similarities between their estimates of productivity.

CHAPTER II

OUTPUT: ANALYSIS AND PROJECTIONS

The consequences of input changes are in changes in output, if broadly defined but not necessarily at a uniform ratio. Changes in agricultural output between two dates reflect both long-term fundamental changes in agricultural supply functions and short-term irregular disturbances. The causes of change and their interpretations are, therefore, different. Hence, most empirical studies do not hypothesize the exact influence of the time pattern of agricultural production because it is almost impossible to test with rigor.

This chapter will discuss the growth rate of total agricultural production in Oregon during the study period. Further analysis will be done at disaggregated levels of output in order to identify where the growth (or slack) is occurring.

Projections will be done using two methods where necessary. First, since most of the data show definite trends, the average annual growth rate will be found by

$$\frac{\Delta Q}{Q_o} \times \frac{1}{16} \times \frac{100}{1}$$

where ΔQ = change in value between 1950 and 1966.

Q_o = value in 1950.

This average will be used for projection.

The second method will use the simple least squares regression.

Total Output Analysis

Table 1 and Figure 1 show the trend and annual growth rate of total value of farm production from 1950 to 1966 at 1950 prices. Disregarding annual fluctuations, value of output increased by about 29 percent, an average annual rate of about 1.8 percent. If this average yearly growth rate continues, the index of total value of agricultural production will be 145 in 1975 if 1950=100. When the least squares method is used, the predicted index is 140.

The year-to-year growth rate was dominated by short-term fluctuations. The sharpest rise was in 1955 with 8.4 percent; the greatest drop was 5.1 percent in 1957.

A possible explanation of these year-to-year changes may be that agricultural production in Oregon, as a rule, is vulnerable to natural conditions because crop production tends to be location specific. It is impossible to mitigate localized influences of early frost, lack of rain or "cool" summers.

Livestock and Livestock Products

Table 2 and Figure 2 show the trend and annual growth rate of value of livestock and livestock products and their major categories from 1950 to 1966 at 1950 prices. There was a 28 percent increase

Table 1. Total Farm Production and Rate of Growth and Price Index: Oregon, 1950-1967 at 1950 prices.

Year	Value*	Index of total value 1950=100	Growth rate	Price index
	(Mil. Dol.)			
1950	399.7	100		100
1951	405.7	102	2.0	115
1952	388.4	97	-4.9	114
1953	412.9	103	6.2	100
1954	426.6	107	3.9	93
1955	463.3	116	8.4	91
1956	470.1	118	1.7	91
1957	447.2	112	-5.1	92
1958	446.3	112	0.0	94
1959	476.7	119	6.3	93
1960	447.4	112	-5.9	96
1961	447.8	112	0.0	95
1962	467.7	117	4.5	95
1963	469.8	118	0.9	93
1964	477.8	120	1.7	92
1965	501.8	126	5.0	96
1966	514.8	129	2.4	102
1967	523.1	131	1.6	102

* Includes value of home consumption.

Source: Farm Income, State Estimates, U.S.D.A.

during the period, giving an average annual growth rate of about 1.7 percent. The output index, using this average annual growth rate is projected to be 143 in 1975 if 1950=100 (or 144, with least squares method).

The greatest yearly growth was in 1955 with a 10.7 percent increase; the greatest drop was a 7.5 percent decrease in 1957.

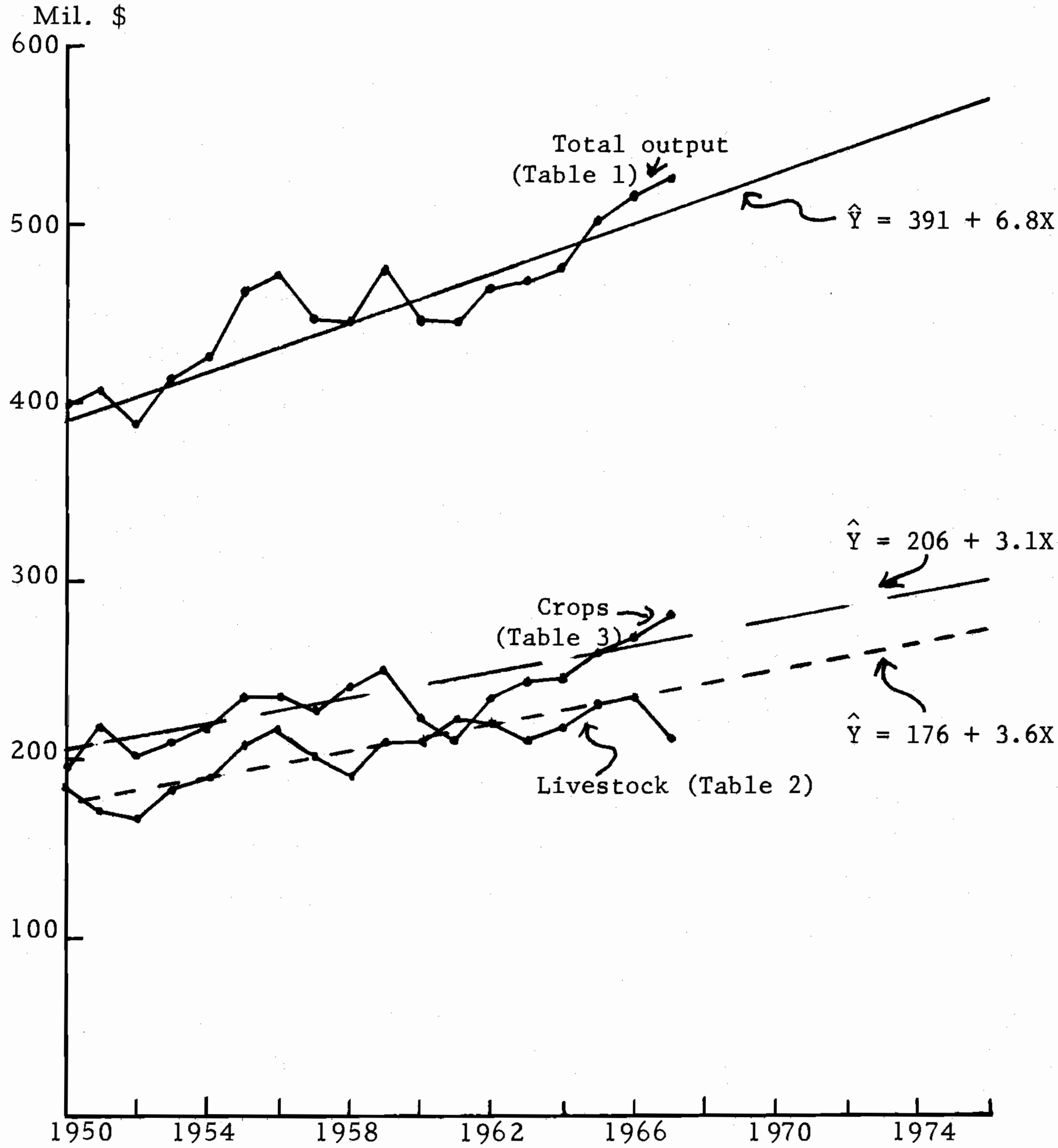

Figure 1. Value of Total Agricultural Output and Two Output Categories at 1950 Prices.

Table 2. Cash Receipts from Livestock Products and Price Index: Oregon 1950-1967 at 1950 Prices.

	Total*			Categories			
Year	Receipts (Mil. Dol.)	Index	Rate	Meat animals (Mil. Dol)	Dairy products (Mil. Dol.)	Poultry products	Price index
1950	183.6	100		92.0	48.8	38.3	100
1951	171.5	93	-6.6	82.9	44.3	40.4	123
1952	167.3	91	-2.4	73.1	50.3	39.8	111
1953	182.3	99	9.0	75.8	56.9	46.2	95
1954	188.2	103	3.2	86.7	57.0	40.6	87
1955	208.3	113	10.7	101.0	55.7	46.0	83
1956	216.7	118	4.0	102.5	57.8	48.1	81
1957	200.5	109	-7.5	98.4	54.3	39.1	87
1958	191.5	104	-4.5	100.8	47.9	36.4	96
1959	211.4	115	10.4	118.9	49.8	35.3	93
1960	211.1	115	-0.1	110.5	53.2	40.0	91
1961	223.3	122	5.8	123.3	52.5	39.8	87
1962	222.6	121	-0.3	128.1	52.0	35.2	89
1963	211.6	115	-4.9	116.4	49.1	36.8	87
1964	219.9	120	3.9	123.5	51.8	35.8	84
1965	232.6	127	5.8	140.0	50.0	35.0	88
1966	234.1	128	0.6	142.8	48.4	37.4	89
1967	212.0	115	-9.4	125.6	46.2	30.6	88

* Excludes perquisites.
Source: Statistical Reporting Service, U. S. D. A.

The "Meat Animal" category shows an increase of about 55 percent while "Dairy Products" and "Poultry Products" categories are relatively stable. If this rate continues, "Meat Animals" is projected to be 172 million dollars in 1950 prices or an output index of 189 if 1950=100. On the other hand, no significant change is expected from dairy and poultry product categories if one uses the 1950-1966 output pattern as the basis for the projection.

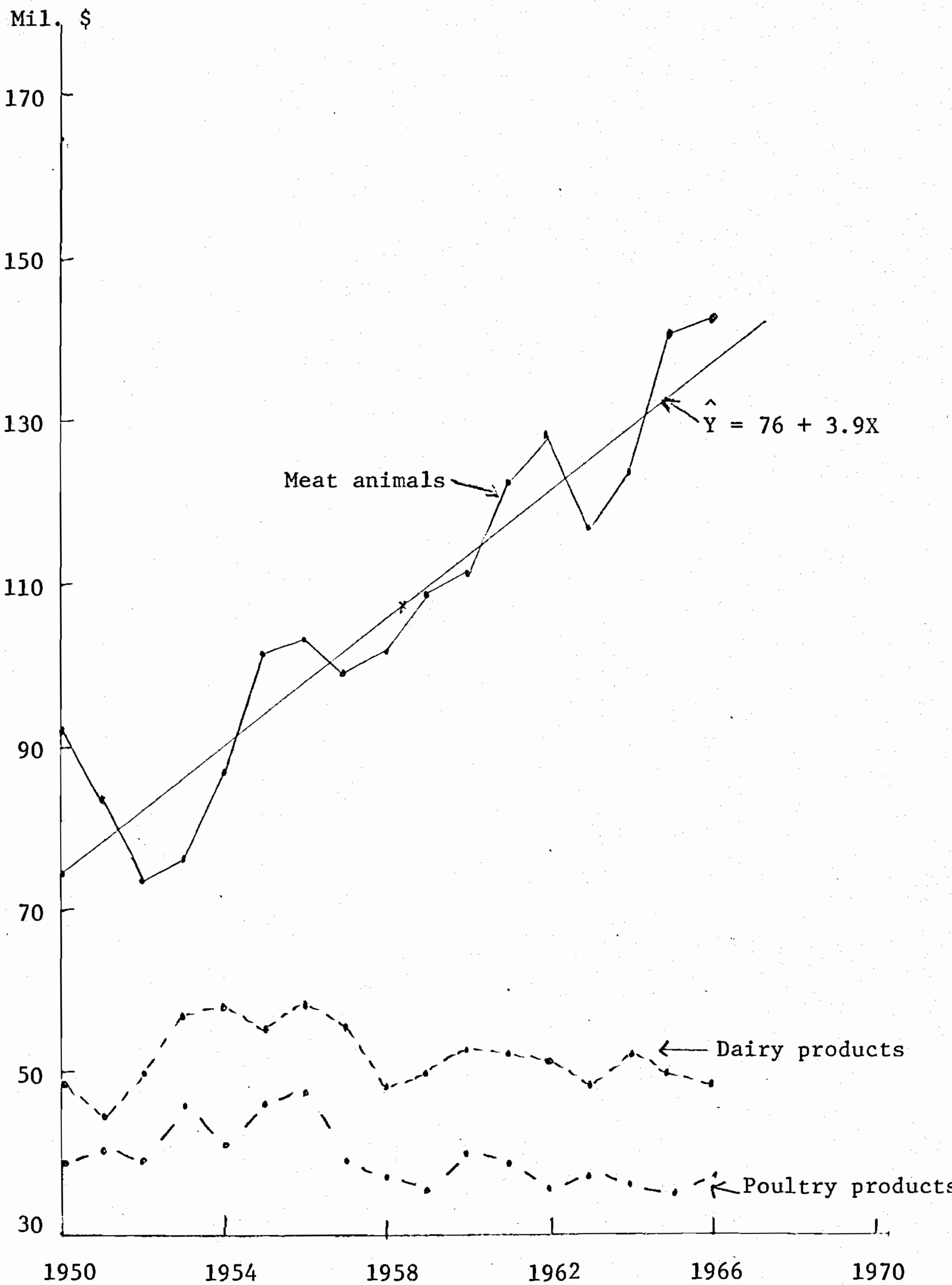

Figure 2. Trend in Livestock and Livestock Products Cash Receipts, Oregon, 1950-1966 at 1950 Prices.

<u>All Crops</u>

Trends in deflated cash receipts for "All Crops" and three sub-categories are shown in Table 3 and Figure 3. There was a 36 percent increase in output during the study period, or an annual average of 2. 3 percent. If this trend continues, the projected cash receipts in 1975 is about 309 million dollars in 1950 prices or an output index of 157 on the basis of 1950=100. On the other hand, the least squares method projected 285 million dollars in 1950 prices. The output index projected by least squares is 145 with 1950-100.

The yearly changes in "Grain and Hay" cash receipts have been very random and no regression line of any significance could be fitted.

The "Fruits, Berries and Nuts" category shows significant increases in cash receipts from 1960 to 1966. Two regression lines were fitted: the first from 1950 to 1966 and the second from 1960 to 1966. The first projects cash receipts of 60 million dollars and the second 90 million dollars, both in 1950 prices, or an output index of 184 and 276, respectively, with 1950=100. The second projection is more realistic since the income elasticity of demand for this category is relatively high.

The "Truck Crops and Potatoes" category has about 7 percent

Table 3. Cash Receipts From Crops and Price Index: Oregon, 1950-1966 at 1950 Prices.

Year	Total*			Categories			Price index
	Receipts (Mil. Dol.)	Index	Rate	Grains and hay (Mil. Dol.)	Fruits, berries and nuts (Mil. Dol.)	Truck crops and potatoes (Mil. Dol.)	
1950	197.1	100		65.2	32.6	29.0	100
1951	218.1	111	10.7	80.0	30.6	39.0	107
1952	201.6	102	-7.6	75.7	29.6	37.4	117
1953	211.7	107	5.0	82.0	33.4	33.8	104
1954	218.1	111	3.0	83.1	34.0	34.7	99
1955	234.1	119	7.3	79.2	36.3	35.9	99
1956	235.4	119	0.6	84.5	30.3	42.1	100
1957	227.9	116	-3.2	86.2	31.6	41.0	92
1958	241.1	122	5.8	80.3	30.2	46.3	91
1959	249.6	127	3.5	80.8	33.1	42.8	93
1960	224.0	114	-10.3	81.3	26.0	46.2	100
1961	213.2	108	-4.8	66.5	28.0	45.8	102
1962	233.8	119	9.7	77.6	35.9	42.8	100
1963	243.0	123	3.9	78.5	33.6	49.2	99
1964	246.7	125	1.5	72.5	40.0	51.0	99
1965	258.8	131	4.9	69.8	54.0	58.6	103
1966	268.4	136	3.7	72.1	63.4	59.2	105
1967	280.6	142	4.5	69.3	67.8	67.2	105

* Excludes perquisites.

Source: Statistical Reporting Service, U.S.D.A., Portland, Oregon.

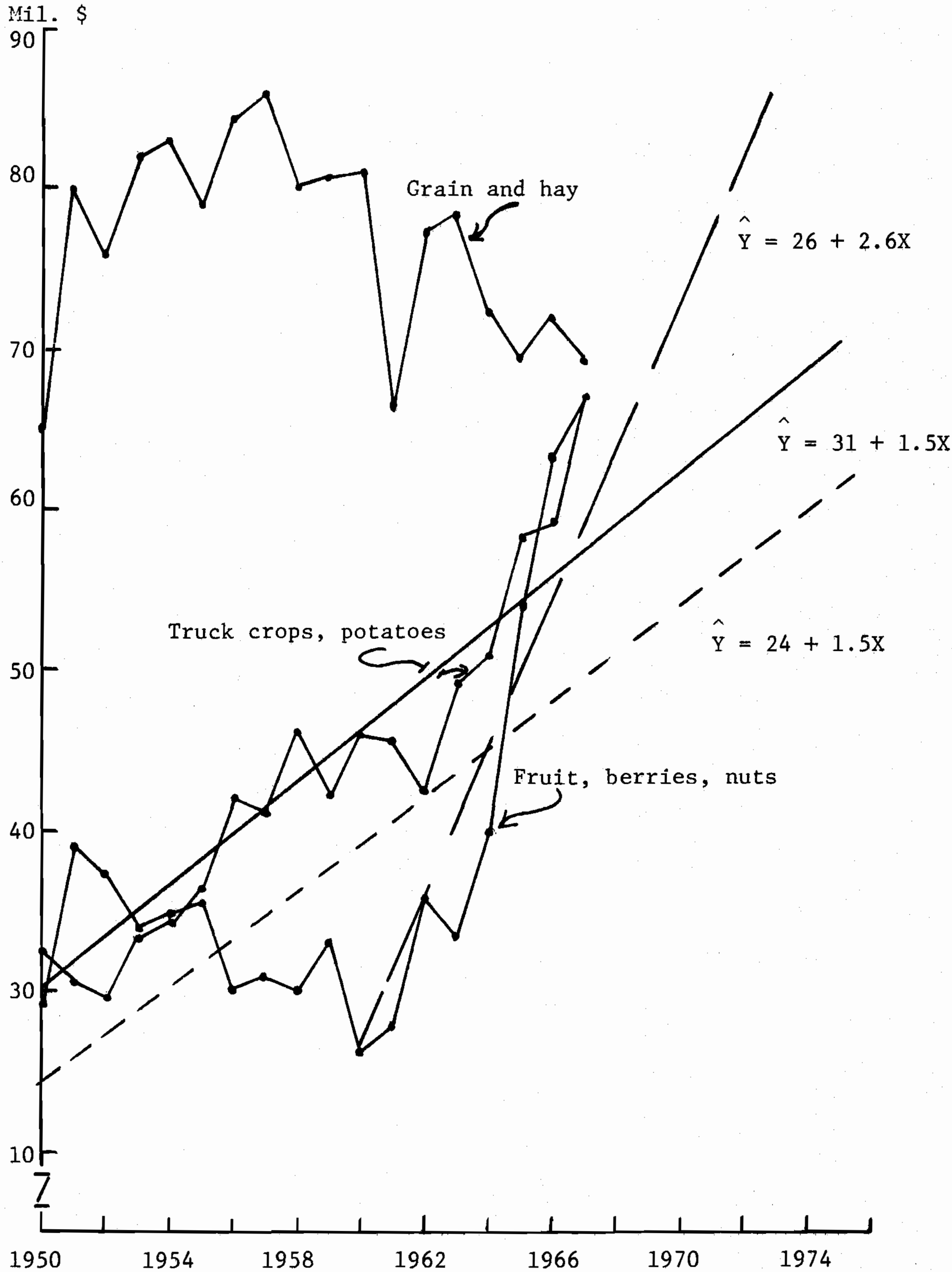

Figure 3. Trend in All Crops Cash Receipts, Oregon, 1950-1966 at 1950 Prices.

increase in output per year and the trend is consistently upward. If this continues, 68 million dollars cash receipts is projected for 1975 in 1950 dollars or an output index of 234 with 1950=100.

Theoretical Implications

The price elasticity of demand, which relates to the slope of the demand curve, has been estimated for the nation as a whole to be between .15 and .25. (5) The income elasticity of demand, which relates to the position of the demand curve to changes in disposable income, has been estimated to be about .16 for the nation as a whole. Based on these estimates, the total cash receipts is expected to be declining as physical output is increasing[1/] in Oregon. This, however, is not the case. Total revenue has increased because:

(1) The decrease in indexes of total agricultural product prices is less than the increase in livestock product physical output. The index of prices received for Oregon agricultural products never declined less than 9 percent in any year, yet physical output increased by 18 percent from 1950-1966.

1/ There were 5.3 million tons of agricultural products in 1950 and 6.4 million tons in 1966; 4.4 million tons and 5.6 million tons for crop products in 1950 and 1966, respectively; 893,000 tons and 863,000 tons for livestock products in 1950 and 1966, respectively.

2. The crop price indexes have been relatively constant, except for 1957-1959 with significant declines, and 1952 with significant increase. However, the physical volume of crop products increased by about 23 percent.
3. Although the price indexes of livestock products declined by 11 percent and the physical volume of livestock products declined by 4 percent, these are not enough to outweigh the two above.

This demonstrates that most of Oregon agricultural products probably have higher income elasticities than the estimates above. As per capita income increases in Oregon (and the nation) the demand for products with high income elasticities, such as meat animals, fruits and vegetables, increases relative to those of less expensive energy foods, such as grains and potatoes. Consequently, Oregon farmers find themselves adjusting to economic laws as related to these products.

Other technical and institutional factors affecting demand for high income elasticity products are: (a) recent increase in size of retail stores, (b) self-service displays, (c) federal grading of agricultural products, and (d) advertising and promotion.

Addendum

The 1967 output figures recently published by the Statistical Reporting Service, U.S.D.A., have not significantly changed the analysis in this chapter. Total value of farm production in 1967 was 523.1 million dollars in 1950 prices or an output index of 131 if 1950=100. This is about 1.6 percent increase over 1966.

Cash receipts at 1950 prices for livestock and livestock products decreased 9.4 percent over 1966; the output index for 1966 was 128 and 115 for 1967. There were decreases in all three categories: meat animal by 7.3 percent, dairy products by 4.5 percent, and poultry products by 18.2 percent.

Cash receipts at 1950 prices from crops increased by 4.5 percent over 1966. "Grains and Hay" decreased 4 percent, while "Fruits, Berries and Nuts" had a 7 percent increase. "Truck Crops and Potatoes" increased 13.5 percent over 1966.

Finally, income from sale of crops was 55 percent of total income, while livestock and livestock products was 45 percent, a percentage distribution consistent with earlier analysis.

CHAPTER III

INPUTS

Increased output can be the result of changes in the quantity of inputs used, improved technology or both. That part of the increment of output attributable to increased input use is the "explained output"; the unattributable residual is the "unexplained output", that is, unexplained by conventional quantity changes in land, labor and capital. (22)

In order to help identify the increase due to unexplained output, Table 4 is constructed. It shows the computed indexes of output (gross cash receipts at 1950 prices), conventional inputs (total production expenses at 1950 prices), aggregate productivity indexes and value of unexplained output.

The gross output and aggregate productivity indexes increased by about 29 percent and 36 percent, respectively. The conventional input index is relatively stable except for slight declines in 1953, 1957 and 1959. It can be inferred that 29 percent of the output is unexplained in 1966; this is about 136 million dollars at 1950 prices. The year 1952 was the only one in which the "unexplained output" fell by about 28 million dollars at 1950 prices. The appearance of this negative "unexplained output" indicates either or all of the following:

(1) Deterioration in quality of conventional inputs and expansion

Table 4. Indexes of Changes in Value of Output, Aggregate Input, Aggregate Productivity and Unexplained Output: 1950=100. Oregon

Year	Index of value of output*	Index of aggregate input	Aggregate productivity	Unexplained output	Value of unexplained output** (Mil. Dol.)
1950	100	100	100	0	0
1951	102	100	102	2	8
1952	97	103	94	-7	-28
1953	103	102	101	1	4
1954	107	101	106	6	24
1955	116	101	115	15	60
1956	118	101	117	17	68
1957	112	99	113	13	52
1958	112	98	114	14	56
1959	119	97	123	22	88
1960	112	98	114	14	56
1961	112	98	114	14	56
1962	117	97	121	20	80
1963	118	96	123	22	88
1964	120	96	125	24	96
1965	126	95	133	31	124
1966	129	95	136	34	136

* Includes perquisites.

** "Unexplained output" is obtained by multiplying 399.7 million dollars (value of gross output in 1950) by the differences between the output and input indexes.

of production into marginal inputs.

(2) Decrease intensity in utilization of inputs.

(3) Over-investment in 1952 which will not increase production immediately but will increase it in subsequent years.

(4) Imperfect measurement of variables.

The positive "unexplained output" in other years could result from: (26)

(1) Aggregate production function is not linearly homogeneous, yet the derivation of the aggregate input index assumes this. How this and scale of farm operation affect output are other empirical questions. However, the relationship between economic efficiency and size is important only if production techniques are specified because larger farms are not necessarily more efficient than smaller farms.

(2) If factor markets are not competitive, the price of the factors will not be competitive either. In any case, it cannot be rigorously tested which part of the positive unexplained output results from deviation of factor prices from their respective marginal products. The author, however, had derived factor prices according to some clearly defined criteria of the U.S.D.A. estimated from 1950 prices.

(3) Better transportation facilities, good health and general economic and institutional framework can also be responsible for the positive unexplained output. Like the above, they do not lend themselves to rigorous statistical analysis.

(4) Results of changes in technology, quality of labor and degree of resource utilization.

Land

The total value of farm real estate in current dollars was 1,216 million dollars in 1950 and 2,472 million dollars in 1966, a 103 percent increase. When reduced to constant dollars, as in Table 5, the value is relatively constant.

The high current price could result from either value of real estate improvements or land inflation or both. Using constant prices indicates that the inflationary effect is of major importance in Oregon. If net capital additions were involved, value would not be constant at constant prices.

Column 2 of Table 5 also shows that land in farms remained at about 21 million acres from 1950-1966. The reasons are probably:

(1) The nonmobility of land input. Pressure is strong for land to remain in agriculture. As small farmers leave agriculture, their land is bought up by neighbors using previous labor and machine capital inputs to achieve economies of scale.

(2) The zero reservation price of land, given the quantity of land supply relative to demand for nonfarm uses in Oregon. Consequently, within this short period, agricultural land remains in agricultural production since value of products

Table 5. Real Estate Use and Value at 1950 Prices, Oregon, 1950-1966

Year	Land in farms	Average size of farm	Number* of farms	Real estate value** Total	Per acre
	(Mil. Ac.)	(Acres)	(Thous.)	(Mil. Dol.)	(Dol.)
1950	20.0	335	62.6	1,216	60
1951	20.3	339	60.0	1,214	61
1952	21.2	372	57.0	1,213	62
1953	21.2	389	54.5	1,217	65
1954	21.2	408	52.0	1,218	63
1955	21.2	416	51.0	1,218	63
1956	21.2	420	50.5	1,214	62
1957	21.2	428	49.5	1,220	61
1958	21.2	433	49.0	1,214	61
1959	21.2	442	48.0	1,218	61
1960	21.2	451	47.0	1,214	60
1961	21.2	456	46.5	1,219	60
1962	21.1	464	45.5	1,213	60
1963	21.1	469	45.0	1,213	62
1964	21.0	472	44.5	1,214	62
1965	21.0	483	43.5	1,213	63
1966	20.9	486	43.5	1,218	62

Sources: * U.S.D.A., E.R.S., Crop Reporting Board, Washington, D.C.
** Farm Real Estate, Market Development (as of March 1 of each year). Includes land and buildings.

forthcoming covers the short-run reservation prices of labor and capital which are technical complements.

Oregon farmers have also adjusted to economic conditions during this period by shifting land from crops which have low income and price elasticities to those with high income and price elasticities. For example, the acreage harvested for rye, wheat and oats declined by 32 percent, 19 percent and 65 percent, respectively, while acreage harvested for commercial truck crops such as snap beans, beets, cabbage and tomatoes increased by 44 percent.

Irrigation

In 1950, about 1.3 million acres of land were under irrigation in Oregon and 1.6 million acres in 1964. Two-thirds of the increase was for cropland and the rest for pasture. Also half of the increase was in the Willamette Valley, while the rest occurred in other parts of the state (32).

The extent land will be irrigated in Oregon in the future was studied by Professor Youmans (32). He assumes that development of irrigated land will depend on the national population and crop yield increases. With a 1 percent compounded annual yield increase, he predicted 4.3 million acres for 2020 and with 1.2 percent, he predicted 2.7 million acres.

Whichever of these limits is approached depends on the degree to which new irrigation districts are formed in Oregon.

Size and Number of Farms

Table 5 shows the number and size of farms in Oregon between 1950 and 1966. The number of acres in farms has been constant at about 21 million; and there is no reason to believe that any significant change will occur between now and 1975.

The average size of farm in 1950 was 335 acres and 486 acres in 1966. This is a 45 percent increase. If this trend continues, the average farm size would be about 614 acres in 1975.

The number of farms was 62, 600 in 1950 and 43, 500 in 1966. This is an average decline of about 2.5 percent yearly. At this rate, the number of farms is expected to be about 35, 600 in 1975.

Since the rate at which the number of farms declines is approximately the same as the rate at which the average size of farms increases, the average size of farms may, therefore, depend on the rate at which the number of farms declines.

Fertilizer

Table 6 and Figure 4 show total fertilizer usage in Oregon by kinds and nutrients. Fertilizer use has increased more rapidly than any other class of input. In 1950, 97, 000 tons were used in Oregon as against 363, 000 tons in 1966, a 375 percent increase. The change is more significant if 1945 is used as the base year--about 725 percent increase. For comparison, total fertilizer use increased 88 percent between 1950 and 1966 in the nation.

Nitrogen use in Oregon was 12, 000 tons in 1950 and 57, 000 tons in 1966, a 475 percent increase. Phosphorus and potassium

Table 6. Fertilizer Consumption by Kinds and Nutrients in Oregon, 1950-1966.

Year	Nutrient consumption				Fertilizer price index
	Total	N	P_2O	K_2O	
	(Thousand ton)				
1950	97	12	12	3	100
1951	125	17	14	3	106
1952	121	17	11	3	108
1953	148	24	11	2	109
1954	147	26	12	3	110
1955	172	32	13	3	108
1956	170	31	13	4	106
1957	218	42	15	4	107
1958	192	40	13	4	106
1959	200	42	14	4	106
1960	199	38	17	4	106
1961	241	45	20	7	107
1962	250	47	20	7	107
1963	268	54	21	7	106
1964	285	55	23	8	106
1965	329	55	23	7	107
1966	363	57	24	8	107

Source: Office of Economic Information, Oregon Cooperative Extension Service, 1967.

use were 12, 000 and 3, 000 tons, respectively, in 1950, and 24, 000 and 8, 000 tons, respectively, in 1966. Yet, the fertilizer price index has been relatively stable. This indicates rapid productivity increases in the fertilizer industry.

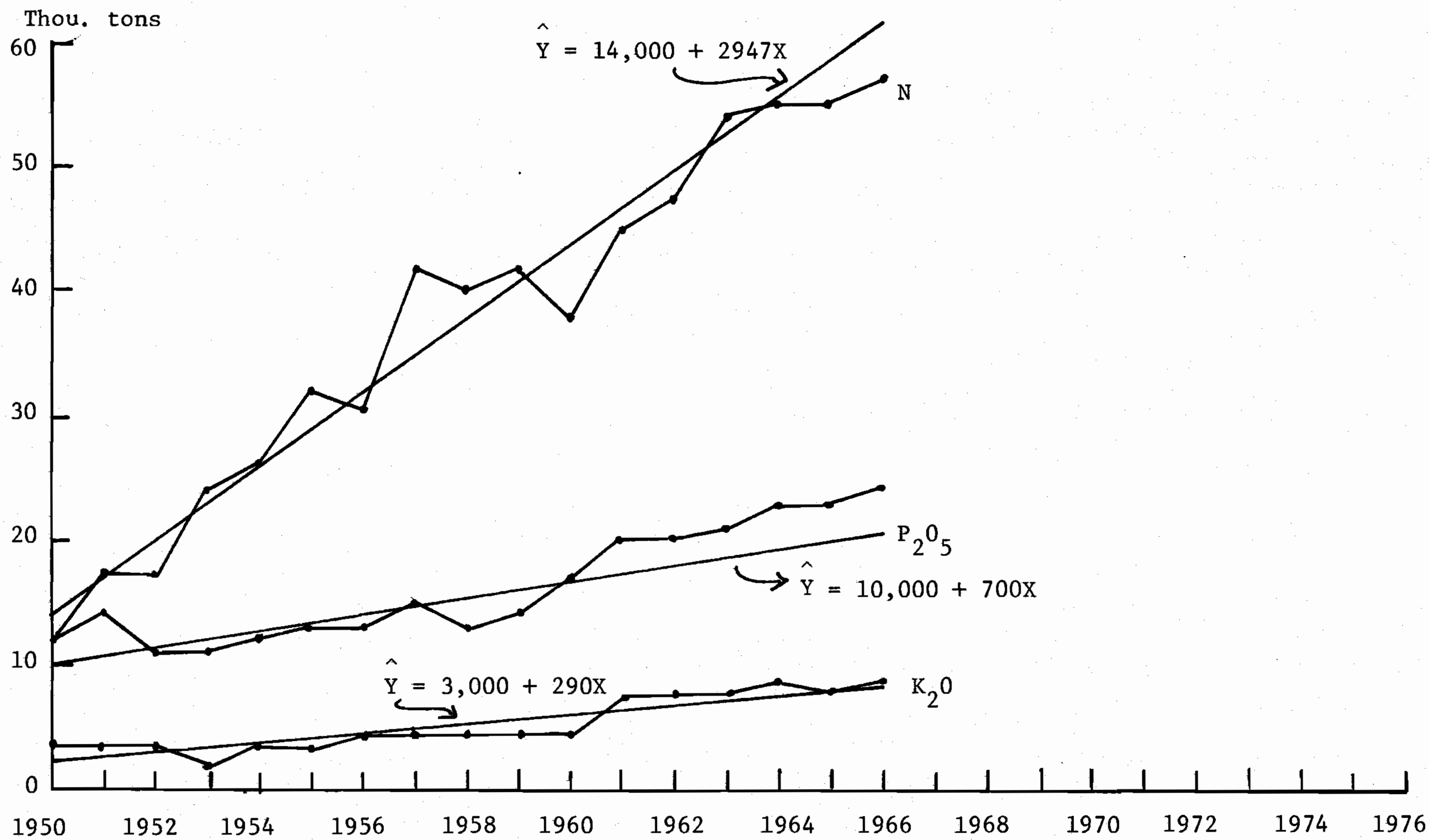

Figure 4. Fertilizer Consumption in Oregon

Labor

Table 7 shows the labor input in Oregon agriculture. Fifty-nine million man-hours of hired labor was employed in 1950 and 39.8 million man-hours in 1966. This is a decrease of 33 percent. If this trend continues, hired labor is projected to be about half of the quantity used in 1950 by 1975.

Operator and family labor was 13.1 million man-hours in 1950 and 8.0 million man-hours in 1966, a 39 percent decline. The projected operator and family labor input by 1975 is about 40 percent of the quantity used in 1950.

Both the number of family workers and farms show a decrease. However, family workers per farm are relatively constant at a level of 1.4. This suggests that each farm ceasing to operate also had an average of approximately 1.4 family workers per farm unit.

Consequently, hard pressed as Oregon farmers are by the cost-price squeeze, they must use their labor input, both hired and family labor, more efficiently in the future.

On-farm and Off-farm Inputs

Table 8 is constructed to separate the impact of technological change in the form of off-farm inputs from on-farm inputs.

Off-farm inputs are intermediate products purchased annually by farmers from nonagricultural industries, such as gasoline,

Table 7. Labor Used on Oregon Farms, 1950-1966.

Year	Family workers on farms: Family workers	No. of farms*	Family workers per farm	Hired labor	Operator and family labor	Wage rates per month
	(Thou.)	(Thou.)		(Mil. man-hr.)	(Mil. man-hr.)	(Dol.)
1950	82	63	1.3	59.0	13.1	142
1951	79	60	1.3	55.8	12.6	160
1952	79	57	1.4	55.1	12.6	174
1953	77	55	1.4	51.9	12.3	171
1954	75	52	1.4	51.8	12.0	167
1955	73	51	1.4	50.8	11.7	170
1956	71	51	1.4	49.2	11.4	179
1957	67	50	1.3	49.8	10.7	182
1958	67	49	1.4	48.5	10.7	181
1959	66	48	1.4	49.7	10.6	181
1960	66	47	1.4	48.4	10.6	184
1961	67	47	1.4	46.7	10.7	194
1962	67	46	1.5	50.1	10.7	193
1963	64	45	1.4	48.1	10.2	193
1964	63	45	1.4	49.5	10.1	202
1965	57	44	1.3	45.1	9.1	209
1966	50	43	1.2	39.8	8.0	233

*Census enumerations were 59,827 in 1950; 54,441 in 1954; 42,573 in 1959; and 39,757 in 1964. The census definition of farm changed between 1954 and 1959. In 1959, a unit of 10 acres or more with sales of $50 or more, and less than 10 acres with sales of $250 or more, was counted as a farm. For 1954, a unit of 3 acres or more with value of output of $150 or more, and less than 3 acres with sales of $150 or more, was counted as a farm. Hence, the difference in the figures on this table and census figures.

Source: Office of Economic Information, Oregon Cooperative Extension Service.

Table 8. Indexes of Off-farm Input, On-farm Input and Aggregate Productivity Index, Oregon, 1950-1966.

Year	Index of off-farm input	Index of on-farm input	Ratio
1950	100	100	100
1951	119	101	118
1952	111	105	106
1953	104	104	100
1954	103	103	100
1955	105	102	103
1956	106	103	103
1957	110	100	110
1958	113	101	112
1959	117	104	113
1960	117	103	114
1961	122	108	112
1962	132	102	129
1963	135	107	126
1964	133	112	119
1965	134	107	125
1966	139	107	130

processed feeds, hired labor, fertilizer, seeds, etc. On-farm inputs are durable items such as tractors and other machinery, real estate and family labor used within the year and calculated on rent or opportunity cost basis.

In Table 8, it is found that indexes of increases in off-farm inputs are greater than on-farm inputs. Consequently, changes in off-farm inputs affect aggregate productivity more than on-farm inputs in Oregon. As aggregate productivity increases, the ratio of index of off-farm and on-farm input rises. The off-farm input index increases steadily while on-farm input index is relatively constant. This suggests that, at least, a portion of the increase in aggregate productivity is attributable to increases in off-farm input and that changes in off-farm input affects aggregate productivity. With this relationship, if off-farm inputs are small, aggregate productivity will be small and vice versa. (13)

Intensity of Operation

Intensity of Oregon agriculture will be discussed in three areas: income, capital and labor intensity (Table 9). This will help analyze the main contributing factors to increased output.

Income Intensity: Income intensity is measured by the gross income per tillable acre. It indicates, in a summary sense, the value of gross output with respect to other inputs used to produce it.

Despite the relatively fixed and sometimes declining total farm price index from 1950 to 1966, the index of income intensity increased as much as did gross income. This indicates a 29 percent gain in dollar output per tillable acre from 1950 to 1966.

A primary reason for this increased output per acre ratio has been technology. This calls for separation of acreage and yield effect for selected crops.

Since total production depends on both yield and acreage, any change in output is directly attributable to both and the interaction of both factors. The recognition and quantification of these factors

Table 9. Indexes of Intensity of Farm Operations in Oregon from 1950-1966.

		Income intensity		Capital intensity				Labor intensity	
		Gross		Capital input *					
Year	Land	income	Intensity	A	B	Intensity		Labor input	Intensity
1950	100	100	100	100	100	100	100	100	100
1951	97	102	105	101	99	104	102	98	101
1952	101	97	96	102	105	101	104	104	103
1953	101	103	102	103	112	102	111	99	98
1954	101	107	106	103	115	102	114	96	95
1955	101	116	115	103	115	102	114	92	91
1956	101	118	117	105	113	104	112	92	91
1957	101	112	110	103	113	102	112	89	88
1958	101	112	110	105	113	104	112	85	84
1959	101	119	118	103	113	102	112	83	82
1960	101	112	110	105	110	104	109	83	82
1961	101	112	110	105	105	104	104	87	86
1962	100	117	117	103	106	103	105	85	85
1963	100	118	118	105	103	105	102	79	79
1964	100	120	120	105	110	105	109	79	79
1965	100	126	126	106	113	106	112	72	72
1966	100	129	129	108	114	108	113	68	68

*Capital is divided into "A" and "B". "A" is production expenses less cost of hired labor, and "B" is fixed capital items on opportunity cost basis.

are necessary for prediction of the consequences of various programs of agricultural policy and as an index of the response of changes for various kinds of economic expectations.

The relative effects of changes in yield and acreage on year-to-year changes in wheat production was investigated by Meinkein for the nation as a whole. He determined the "direct effect of yield" by multiplying the change in yield from one year to the next by the previous year's acreage. The "direct effect of acreage" was determined by multiplying the change in acreage from one year to the next by the previous year's yield. Meinkein's study showed that the yield component was more important in 1920-1938 and acreage influence was almost equal to yield influence in 1939-1954.

Sackrin (21) said Meinkein's method is limited by the fact that the "direct effects of yield and acreage" do not exactly equal actual changes in production. He proposed

$$\frac{P_t}{P_{t-1}} = \left(\frac{A_t}{A_{t-1}}\right) \left(\frac{r_t}{r_{t-1}}\right)$$

where P_t = present year's production

P_{t-1} = immediate past year's production

A_t = present year's acreage

A_{t-1} = immediate past year's acreage

r_t = present year's yield

r_{t-1} = immediate past year's yield.

When expressed in first difference of logarithm, the relationship is:

$$\Delta \log \text{production} = \Delta \log \text{acreage} + \Delta \log \text{yield}.$$

Sackrin's method allows us to change a multiplicative relationship to an additive one. But when the two methods were compared, the results were not significantly different. Consequently, Meinkein's method is used for Oregon analysis and results are reported in Table 10.

Acreage and yield effects are relatively equal for wheat and barley. Snap beans show more acreage effect than yield effect. In all the years, except 1952, acreage effect is positive for snap beans and its yield effect fluctuates from -26 to 8 thousand tons.

Although strawberries show more impact of yield effect than acreage effect, the variations in both are great, indicating the strong influence of weather on this crop.

Two conclusions can be drawn from this analysis. First, acreage planted is as important, if not more important, for total agricultural output in Oregon than yield. Second, there is as much variation in acreage as in yield effect for each crop category. This is probably the result of a composite of reactions to weather, government programs and regulations which result in sharp acreage

Table 10. Acreage and Yield Effects for Selected Crops

	Wheat (Mil. bu.)		Field corn (Thou. bu.)		Snap beans (Thou. ton)		Strawberry (Mil. lbs.)		Barley (Mil. bu.)		All hay (Thou. ton)	
Year	Acr.	Yield	Acr.	Yield	Acr.	Yield	Acr.	Yield	Acr.	Yield	Acr.	Yield
1951	3.0	3.0	88	-60	6.0	-0.7	-2.0	-12.0	0	-0.3	-49	-51
1952	3.0	-0.8	-100	60	-7.0	-0.7	2.0	20.0	-2.0	2.0	25	208
1953	1.0	0.8	0	0	9.0	-5.0	0.7	6.0	1.0	0	41	70
1954	-9.0	2.0	155	105	13.0	3.0	-1.0	-2.0	5.0	-0.3	-48	-113
1955	-2.0	-3.0	424	58.5	8.0	2.0	9.0	13.0	1.0	-3.0	56	-90
1956	-0.2	4.0	-195	0	0.8	-5.0	-3.0	-10.0	0.4	3.0	14	207
1957	-2.0	4.0	130	179	0	8.0	6.0	13.0	2.0	-1.0	-54	20
1958	0.3	-1.0	453	-86	0.8	2.0	-14.0	-11.0	-1.0	-1.0	-118	-30
1959	-0.7	1.0	355	113	3.0	-9.5	0	20.0	-2.0	1.0	-29	0
1960	-0.2	-2.0	197	120	5.0	-4.0	-6.0	-11.0	-3.0	-0.3	174	0
1961	0.1	-6.0	-414	-33	33.0	1.0	-8.0	3.0	1.0	-1.0	-73	72
1962	-3.0	9.0	-272	120	0	-5.0	5.0	12.0	-3.0	4.0	57	-50
1963	4.0	-0.9	-146	-40	7.0	7.0	0	-16.0	0.9	-2.0	44	82
1964	0.07	-0.7	-426	-54	14.0	-26.0	0	32.0	-1.0	0.6	143	-63
1965	0.5	0.5	68	12	16.0	-4.0	-15.0	38.0	-1.0	2.0	-39	123
1966	-1.0	-1.0	-138	39	16.0	-7.0	5.0	28.0	2.0	-2.0	58	-153

Calculation: Acreage effect = (Δ acreage) (Previous year's yield)
Yield effect = (Δ yield) (previous year's acreage)

Proof: $Q_t - Q_o = C_o Y^1 + Y_o C^1 + C^1 Y^1$

where Y^1 and C^1 = increment in yield and crop area, respectively.
Y_o and Y_t = yield per acre in base year and year t, respectively.
C_o and C_t = crop area in base year and year t, respectively.
$Q_t = Y_t (C_t)$ $\quad$ $Q_o = Y_o (C_o)$.

reductions for crops harvested.

Capital Intensity: Two concepts of capital have been used in this analysis. The first is all inputs other than labor. This includes consumption of durable means of production (depreciation), other intermediate products and interest on total capital. The second is only that service of capital that finds its compensation in interest.

Table 9 shows that both concepts indicate increasing capital intensity in Oregon agriculture. However, capital intensity increases for the first concept of capital is less than the second concept of capital. This is because fixed capital serves in complementary capacity with land; and over a large range, helps hold land to its current uses.

Possible explanations of increasing capital intensity are:

(1) The relatively increasing importance of off-farm input over on-farm input in Oregon.

(2) The more rapidly increasing productivity of off-farm inputs than on-farm inputs, composed mainly of real estate.

(3) As labor grows in price relative to capital, it becomes more economical to substitute capital for labor. And, with capital becoming relatively abundant and labor becoming relatively scarce, the relative prices of capital and labor tend to favor substitution of machines for labor.

(4) With mechanization and high fixed cost inputs, cost economies are greater for increased farm size.

In short, factor prices in Oregon are such that continued substitution of capital for labor will continue. Since capital for machines is required in large quantity with per unit costs decreasing over greater acreage, Oregon farms will continue to be larger in the future and capital requirements will grow because potential scale economies are possible only if the operator has the required acreage.

Labor Intensity: Index of labor intensity decreased by 32 percent while capital and income intensity increased (Table 9). This labor intensity decrease is in direct relationship with labor input decrease since land input has been constant.

Possible explanations of this decrease are essentially those responsible for increased capital intensity discussed previously since the transition is from labor technology to machine technology.

CHAPTER IV

TRENDS IN PRODUCTIVITIES

Productivity is usually defined as the ratio of output to an input category. But productivity is not this limited for it includes efficient organization of production. This allows for consideration of relative levels of productivity measured in comparison to a level achieved in the past. It also implies that greater efficiency of a given factor of production means greater productivity over a given period of time.

Changes in aggregate productivity provide a precise measure of resources saved as a result of technological change only under four conditions. (19) First, product and resource combinations must be the same as those which would be employed in competitive equilibrium. Second, the production function must be homogeneous of degree one so that there will be constant returns to scale. Third, technical progress must be neutral so that the marginal rates of substitution between resources will be the same in all periods. Four, factors and product prices relative to each other must be the same.

If these conditions are satisfied, labor and/or aggregate productivities are good indicators of technical change. Since it is implicit that these conditions do not generally hold simultaneously, aggregate and partial productivity ratios and correlation coefficients will be used in this chapter. (19)

All inputs are calculated on an opportunity cost basis at 1950 prices (Table 11). Land rent is calculated as seven percent of the value of real estate and buildings.

Cost of labor is total man-hours of hired, operator and family labor times the weighted-period value of composite hourly wage rates.

Capital input is divided into fixed and variable inputs. Variable capital input is current operating expenses minus cost of hired labor. Fixed capital input includes such items as interest and depreciation.

Aggregate input is the summation of the four categories of inputs as listed.

Aggregate Productivity

Table 12 shows the indexes of productivity for each category of input and aggregate input from 1950-1966. Aggregate input index declined by five percent while output increased 29 percent. Also, the aggregate productivity index, which provides a measure of efficiency in use of resources showed a 36 percent increase. These changes in output and aggregate productivity depend on the following technological and economic influences including dynamic

Table 11. Distribution of Input at 1950 Prices, Oregon, 1950-1966.

						Percent distribution				
Year	Land* rent	Labor	Variable capital input	Fixed capital input	Total	Land	Labor	Variable input	Fixed input	Per cent agr.
	(Mil. $)	(Mil. $)	(Mil. $)	(Mil. $)	(Mil. $)					
1950	85.6	137.4	145.0	36.4	404.4	21.2	34.0	35.8	9.0	100.0
1951	85.0	134.4	148.3	36.1	403.8	21.1	33.3	36.7	8.9	100.0
1952	84.9	142.7	149.3	38.2	415.1	20.5	34.4	36.0	9.2	100.0
1953	85.2	135.8	152.2	40.9	414.1	20.6	32.8	36.8	9.9	100.0
1954	85.3	131.3	150.8	41.9	409.3	20.8	32.1	36.8	10.2	100.0
1955	85.3	126.8	152.8	42.0	406.9	21.0	31.2	37.6	10.3	100.0
1956	85.0	126.6	155.2	41.3	408.1	20.8	31.0	38.0	10.1	100.0
1957	85.0	122.0	153.5	41.3	401.8	21.2	30.4	38.2	10.3	100.0
1958	85.0	117.0	154.3	41.3	397.6	21.4	29.4	38.8	10.4	100.0
1959	85.3	114.4	153.4	41.0	394.1	21.6	29.0	38.9	10.4	100.0
1960	85.0	114.3	154.8	40.2	394.3	21.6	29.0	39.3	10.2	100.0
1961	85.3	119.3	153.9	38.3	396.8	21.5	30.1	38.8	9.7	100.0
1962	84.9	116.6	153.3	38.5	393.3	21.6	29.6	40.0	9.8	100.0
1963	84.9	108.5	155.4	37.5	386.3	22.0	28.1	40.2	9.7	100.0
1964	85.0	108.4	154.6	40.3	388.3	21.9	27.9	39.8	10.4	100.0
1965	84.9	99.4	157.7	41.4	383.4	22.1	25.9	41.1	10.8	100.0
1966	85.3	92.9	163.4	41.6	383.2	22.3	24.2	42.6	10.9	100.0

* Calculated on 7% of value of farm real estate.

Table 12. Indexes of Aggregate and Partial Productivity Ratios in Oregon, 1950-1966.

Year	Aggregate analysis: Aggregate input	Aggregate analysis: Aggregate output	Aggregate analysis: Aggregate variability	Partial analysis: Land	Partial analysis: Labor	Partial analysis: Variable input	Partial analysis: Fixed input
1950	100	100	100	100	100	100	100
1951	100	102	102	105	107	100	103
1952	103	97	94	96	103	94	92
1953	102	103	101	102	116	98	92
1954	101	107	106	106	122	103	93
1955	101	116	115	115	133	110	101
1956	101	118	117	117	140	110	104
1957	99	112	113	111	133	106	99
1958	98	112	114	111	137	106	99
1959	97	119	123	118	142	112	105
1960	98	112	114	111	137	105	102
1961	98	112	114	111	140	106	107
1962	97	117	121	117	139	110	110
1963	96	118	123	118	146	110	115
1964	96	120	125	120	145	112	109
1965	95	126	133	126	168	116	112
1966	95	129	136	129	195	114	113

Calculated from Table 1 and Table 11.

interactions between them:

(1) Improved performance of individual farm managers resulting from more and higher quality education.

(2) Expanded technical production possibilities provided by agricultural research.

(3) Variation in the scale of production, that is, the net outcome of tendencies towards increasing or decreasing returns because some inputs are not expanded proportionally with output.

(4) Changes in relative prices of factors and products.

(5) Increased intensity in use of resources.

(6) Random phenomena such as weather, diseases and insects.

(7) Shifts to higher value crops which were profitable in 1950 but, due to limited demand expressed through processor contracts, were not produced.

(8) General economic forces such as:

(a) Factors influencing increase in demand for farm products.

(b) Availability of nonfarm employment opportunities which is a major determinant of change in size of farm labor force.

(9) Technological progress in:

(a) The nonfarm sector which leads to quality improvements and variety of nonfarm inputs available and to a relative decrease in their supply price.

(b) In agriculture due to development and diffusion of improved practices and other innovations among farmers.

Capital Intensity and Productivity

Capital intensity significantly explains the reason for the increase in aggregate productivity or increase in technology in Oregon agriculture. This statement is proved by the model:

$$A_p = B_o + B_1 \frac{K}{L} + e$$

where A_p = aggregate productivity index.

$\frac{K}{L}$ = capital intensity index $\left(\frac{\text{capital}}{\text{land}}\right)$ ratio

The result was:

$$\hat{A}_p = -398.59 + 4.97 \frac{K}{L} \quad \text{2/}$$

$r^2 = .76$ $\qquad$ $r = .81$

2/ Another model tested was: $L_p = B_o + B_1 \frac{K}{L} + e$, where L_p = labor productivity. The result was: $\hat{L}_p = -964.6 + 10.7 \frac{K}{L}$ with $r^2 = .86$ and $r = .87$. Therefore, $\frac{K}{L}$ has more impact on L_p than it does on A_p.

The coefficient of multiple determination, r^2, indicates that 76 percent of the variation in aggregate productivity is explained by capital intensity.

This model shows that for each one percent increase in capital intensity, aggregate productivity increases 4.97 percent.

This model makes two assumptions (24) First, all new technologies are labor-saving and lead to increase $\frac{K}{L}$ ratio. The only requirement for this assumption is a positive correlation coefficient between the dependent and independent variable. This is .81 in Oregon.

Second, it assumes constant returns to scale to guarantee that any increase in aggregate and labor productivity results from technological change.

The main problem with this function is that it permits only movement along any production function, whereas technological change generally means a shift in a production function. The distinction is, however, statistically obscured by

> "... the fact that while a production function represents a range of hypothetical alternative factor combinations, in fact, at any one time, only one combination can be observed and the effect of technology and $\frac{K}{L}$ ratio on labor productivity (aggregate productivity) are confounded if the function shifts due to technology over time." (11)

On the other hand, the function is acceptable since it permits substitution between factors as long as $\frac{K}{L}$ ratio is increased.

Second, it reflects the quantity and quality of technology available and the capitalization of existing productivity advantages in form of management of inputs. (11)

Partial Ratios

The four partial ratios to be discussed are land, labor, fixed capital and variable capital productivities. The term "productivity measure" usually has the implication that productivity can be measured in partial ratios. This is usually not the case because there is no guarantee that input categories are based completely on either the perfect substitutability or perfect complementarity of inputs. Real input combination problems exist among categories of inputs which are neither perfect substitutes nor perfect complements. Hence, the term "ratios" will be used.

Land Ratios

This index is included for completeness because quantitatively it excludes more inputs than it includes. An increase in output per acre is usually a result of more input, such as fertilizer, new varieties of seeds, management, technology, or changes in the average soil quality. In effect, the ratio measures actual production level or "technical productivity" and not productivity in an economic sense.

Table 12 shows that land ratios increase as aggregate output indexes increase. This phenomenon is explainable by the fact that total acreage in farm has been relatively constant.

Capital Ratios

This concept aims at denoting the relationship between output and input of capital, in terms of purchasing power used in order to obtain the factors of production. This shows some similarity with determination of profitability which shows returns on the unit of capital employed.

However, there are two differences between this ratio and profitability. First, profitability calculations are based on current prices. Second, all costs in computing profitability, except interest and unpaid management, are deducted from total revenue so as to be able to express net revenue accruing to the capital factor as a percentage of total capital employed.

In this study, capital has been categorized into two parts: fixed and variable capital. Ratios of both categories have been moving relatively together since 1950. Second, the impact of each on total output has been less than for land in all years (Table 12).

Labor Ratios

A meaningful analysis of changes in agricultural productivity either in partial ratios or in aggregate, requires a reasonable estimate of labor productivity. This measure of productivity is less likely to be misleading than the other three described above. But, because of the substitution between labor and machine, the ceteris paribus clause is far from being applicable.

The method used to calculate labor input allows description of facts, not possibilities, as may be the case if working-day is used or with cost-return calculations as basis for price policy.

Table 13 shows the distribution of labor force between agricultural and nonagricultural sectors in Oregon and the United States for census years. First, the percent of agricultural employment in Oregon is greater than that for the nation. Oregon had 20 percent of the labor force in agriculture in 1950 and 11 percent in 1965, while the nation had 16 percent and 7.5 percent in respective years. However, the decline within the period was relatively equal.

Second, Oregon farmers depend more on hired labor than the average for U.S. farmers. Hired labor in Oregon was 31 percent (23.5 for U.S.) in 1950 and 32 percent (26.4 for U.S.) in 1965. This is because of the seasonal nature of most of Oregon's crop output.

Since labor is different from capital (as intermediate goods) or land (as natural resources), we must analyze changes in labor productivity in relation to the supplies and productivities of land

Table 13. Estimates of Employment for Oregon and the United States for Selected Years.

	Man-years			
	1950	1955	1960	1965
Total employment				
Oregon	607,500	644,900	682,300	771,500
United States	62,208,000	65,208,000	69,628,000	74,455,000
Agricultural employment				
Oregon	119,000	103,000	92,000	84,000
United States	9,926,000	8,379,000	7,057,000	5,610,000
Percent of agricultural employment				
Oregon	19.6	16.0	13.5	10.9
United States	16.0	12.9	10.1	7.5
Percent of hired labor				
Oregon	31.1	29.1	28.3	32.1
United States	23.5	24.3	26.7	26.4

Source: Oregon State Department of Employment; Agricultural Statistics, U. S. D. A.; and Employment and Earnings, Bureau of Labor Statistics, U.S. Dept. of Labor.

and capital.

If land, labor and capital ratios are $\frac{Y}{N}$, $\frac{Y}{L}$, and $\frac{Y}{K}$, respectively; then, labor productivity, $\frac{Y}{N}$, can be transformed as:

$$\frac{Y}{N} = \frac{Y}{K} \cdot \frac{K}{Y} \text{ ------------------------ } (1)$$

$$\frac{Y}{N} = \frac{Y}{L} \cdot \frac{L}{N} \text{ ------------------------ } (2)$$

where Y = output, N = labor, L = land, K = capital.

$\frac{K}{N}$ in (1) is the capital structure since it shows capital invested per man-hour and $\frac{L}{N}$ in (2) is land input per man-hour of labor. Consequently, labor productivity is

(capital productivity) (capital structure)

or

(land productivity)(land input per man-hour)

If we transform (1), we have:

$$Y = N \cdot \frac{Y}{K} \cdot \frac{K}{N} \text{ ------------------------ } (3)$$

If (3) is substituted in (2), we have

$$\frac{Y}{N} = \frac{K}{L} \cdot \frac{Y}{K} \cdot \frac{L}{N} \text{ ------------------------ } (4)$$

That is, labor productivity can be written as:

(capital intensity) (capital productivity) (land input/man-hour)

These three factors which influence changes in labor productivity are presented in Table 14. First, the impact of the index of per

Table 14. Changes in Factors Influencing Labor Productivity in Oregon, 1950-1966*

Year	Index of labor productivity $\frac{Y}{N}$	Index of capital intensity $\frac{K}{L}$	Index of per capita land area of man-hour of labor $\frac{L}{N}$	Index of capital productivity $\frac{Y}{K}$
1950	100	100	100	100
1951	107	104	102	101
1952	103	101	107	95
1953	116	102	113	100
1954	122	102	115	104
1955	133	102	116	113
1956	140	104	120	112
1957	133	102	120	109
1958	137	104	123	107
1959	142	103	120	114
1960	137	103	123	108
1961	140	103	126	108
1962	139	103	119	114
1963	146	105	123	112
1964	145	104	120	115
1965	168	106	133	119
1966	195	108	152	119

*Calculated from Table 1 and Table 11.

capita land area of man-hour of labor was almost three and seven times as great as that of capital productivity and capital intensity, respectively. Second, when the index of labor productivity, $\frac{Y}{N}$, decreases with respect to the previous year (as in 1952, 1957 and 1960) capital intensity, $\frac{K}{L}$, and capital productivity, $\frac{K}{K}$, decreases while per capita land area of man-hour of labor, $\frac{L}{N}$, increases.

Labor productivity almost doubled during the 16-year period (Table 12). At this rate, the index is predicted to be about 247 in 1975.

Possible reasons for the acceleration of labor productivity are:

(1) The exodus of people from agriculture. This exodus is not an explanation of the process, rather, it is a main part of the process itself. (3)

(2) The increased efficiency of mechanical, chemical and biological means of production, all of which are grouped under technology.

(3) The rate of adoption and the extent of usage of technology, both of which are determined economic factors and not an automatic process. (5) In other words, acceleration of labor productivity in Oregon agriculture reflects the accelerating tendencies in Oregon and national economic system, since Oregon is a supplier for the nation and local production is "related to local market only to the extent that local market is a part of the national market." (32)

(4) The proportional changes in quantities of the economic trilogy: land, labor and capital. Table 11 shows that with relatively constant supply of land and fixed capital, there is a significant increase in variable or working capital and

a significant decrease in labor. It can be said that expansion of Oregon agricultural output is due to substitution of capital, labor and land is mutually supplementary, that is, calls for less labor output. Second, the relative price of labor is increasing while that of fertilizer is relatively constant.

(5) There is increase in the degree of utilization of family labor or labor in general, that is, operators and their families and hired laborers are working hard.

Contribution of Lp to Unexplained Output (11)

Hypothesizing that unexplained output is a function of time, the function fitted by least squares was:

$$A(t) = \lambda + \lambda t (1.02) + e$$

where $A(t)$ = value of unexplained output, λ is rate of improvement in productive efficiency. The result was:

$$\hat{A}(t) = -11.25 + 8.15t (1.02)$$

$$r^2 = .84 \qquad r = .92$$

Equation $\pi = \frac{b1}{\lambda}$ was used to measure the contribution of technology to increase in labor productivity. The b_1 is estimated by hypothesizing that labor productivity is also a function of time, that is:

$$L_p = B_o + B_1 t (1.02) + e$$

The result of this function was:

$$\hat{L}_p = 98.41 + 4.06\ t\ (1.02)$$

$$r^2 = .81 \qquad r = .90$$

Substituting for $\frac{b_1}{\lambda}$, the contribution of technology to increase labor productivity is about 50 percent $\left(\frac{4.06}{8.15}\right)$.

Complementarity and Substitutability of Inputs

The third method used to clarify factors responsible for changes in output and productivity is that of correlation coefficients. These are calculated by the formula:

$$r = \frac{\sum xy}{\sqrt{\left(\sum x^2\right)\left(\sum y^2\right)}}$$

The result is shown in Table 15. These coefficients measure the degree variables vary together and indicate the direction (complementarity or substitutability) of variables.

In general, land is not highly correlated with any of the variables. The coefficients between labor and other input categories are negative and close to one, indicating strong substitutability relationship. On the other hand, variable capital input is highly positively correlated with technology[3/] and output indicating high complementarity relationships.

3/ Technology is indexed as on p. 53.

Table 15. Correlation Coefficients Between Inputs and Between Inputs and Output.

Labor vs. variable capital input	-.88
Labor vs. fixed capital input	-.34
Labor vs. technology	-.94
Hired labor vs. technology	-.85
Family labor vs. technology	-.90
Variable capital input vs. technology	.95
Variable input vs. output	.87
Land vs. labor	.20
Land vs. variable input	.26
Land vs. fixed input	.0084
Land vs. technology	-.32
Output vs. technology	.88
Output vs. fixed input	.52
Output vs. labor	-.91

In short, expansion of production in Oregon depends more on technology and variable inputs than fixed input and land. It has been more favorable, therefore, for Oregon farmers to adopt technical improvements which require more intensive use of capital and less intensive use of labor for increasing land productivity and labor efficiency. However, increasing land productivity and labor efficiency might require more fixed capital.

Input and Productivity Effect

Just as was done in Chapter III for "yield and acreage effects" "input and productivity effects" from year to year will be separated. "The interaction effect" is significant here; consequently, assuming "linearity" (16) half of the interaction effect will be added to input effect and the other half to productivity effect.

The input effect for two periods, therefore, is the change in output that would have resulted from the given change in input, holding productivity or technology or productive efficiency constant. Similarly, the productivity effect for two periods is the change in output that would have resulted from the given change in productivity or technology or productive efficiency, holding the quantity of inputs constant.

The results of these calculations are shown in Table 16. It is found that not all the yearly changes in output can be attributed to

Table 16. Input and Productivity Effect in Explaining Changes in Output of Farms in Oregon, 1950-1966.

Year	Input effect	Productivity effect	Percent change in output attributable to change in: Inputs	Productivity
	(Mil. dol.)	(Mil. dol.)		
1950				
1951	0	8.0	0	100
1952	7.4	-36.8	-55	155
1953	-5.2	27.4	-12	112
1954	-5.0	19.4	-42	142
1955	0	36.3	0	100
1956	0	8.1	0	100
1957	-5.5	-16.9	26	74
1958	-4.7	3.8	-91	191
1959	-6.4	33.5	-10	110
1960	3.1	-36.7	-25	125
1961	0	0	0	0
1962	-6.0	26.0	-31	131
1963	-0.8	3.4	-62	162
1964	0	7.7	0	100
1965	-6.6	29.1	-21	121
1966	0	14.4	-11	111

productivity or technology. However, much of the increase in output is due to productivity increases. Second, the years in which the productivity effect is negative (1952, 1957 and 1960) are also the years in which rate of output declined. Possible reasons for this are those given in Chapter III for the existence of negative "unexplained output" in 1952.

CHAPTER V

RATES OF RETURN

A farm production function of the Cobb-Douglas type is chosen for this analysis since it is concerned with the distribution of returns from the total farm business in Oregon to factor inputs in a power type of function. In general the function is:

$$Y = A X_1^{B_1} X_2^{B_2} e^u \text{ --------------------- (1)}$$

where Y = value of output (Table 1), X_1 = labor input (Table 11, col. 3), X_2 = capital input (Table 11, col. 4 plus 5), e = base for natural logarithm, u = error term with standard statistical properties assumed, B_1 and B_2 are elasticities of production with respect to labor and capital, respectively. This model can be transformed to

$$l_n Y = l_n A + B_1 l_n X_1 + B_2 l_n X_2 + u \text{ -------- (2)}$$

Equation (2) was fitted to the time series data by the least squares method in a multiple regression equation.

An implicit assumptions is that changes in prices or quality of intermediate products "do not affect the optimal combination of labor and capital to be used" (10). For each production process, there is a unique labor requirement since each process has a specific kind of capital cost associated with it.

Land input was insignificant because it was relatively constant during the period. Second, the influence of the time factor was minimized by the short period of analysis.

The result of the model was

$$l_n \hat{Y} = l_n 2.97 - .43\, l_n X_1 + .99\, l_n X_2$$

Std. dev. (.0307) (.1038) (.4371)

$$r^2 = .87 \qquad \sum b's = .5577$$

The multiple correlation coefficient is statistically significant below the one percent level. The r^2 indicates that 87 percent of the variation in output is explained by the two factors--labor and capital.

Elasticities of value of output with respect to labor and capital are -.4305 and .9882, respectively. That is, if labor or capital is increased by one percent, on the average, with the other factor held constant, output will decrease by .43 percent and increase by .99 percent, respectively. The high production elasticity for capital indicates that the shortage of capital on many farms was perhaps the single most limiting factor with respect to gross farm income.

The standard errors of estimated coefficients show the reliability of the estimates. It can be said, with a confidence of about 67 percent, that parameters estimated in this way will be between -.53 and -.43 for labor and 1.43 and .45 for capital.

Σ b's > 1, about .56, indicating decreasing returns to scale. Marginal productivity is expected to decrease as more of all resources is used with proportion held constant; that is, if all inputs increase one percent, income is expected to increase only by .56 percent.

Labor has a negative coefficient. Although Tintner pointed out that this is "meaningless," (27) it is conceivable that marginal labor has a negative productivity in certain sectors of Oregon agriculture. Nonetheless, one should recognize the possibility that negative labor coefficient was caused by one or both of the following:

(a) Incorrect theoretical specification of the production function that leads to biased estimates.

(b) Sampling errors or other statistical problems that resulted in estimates that deviated from their true values.

<u>Marginal Value Product</u>

The amount by which gross income will be increased for each one unit increase in input was calculated by:

$$MVP_{x_i} = b_i \frac{\overline{Y}}{\overline{x}_i} \qquad (2)$$

where $\overline{Y}$ and $\overline{x}_i$ are averages of gross income and each category of input for the period respectively; b_i are coefficients associated with each category of input.

This method attributes all farm income to each input without regard to the other input. The results are:

$$MVP_{Labor} = -.4305 \; \frac{450.8235}{120.4588} = -1.61$$

$$MVP_{Capital} = .9882 \; \frac{450.8235}{193.3} = 2.30$$

The policy implications of these estimates is in farm organization. It is logical that capital, which earns more at the margin than the cost of using it, can be profitably increased and labor profitably reduced. The high $MVP_{Capital}$ may also be considered as an evidence of either internal or external capital rationing.

Practically, the proposed adjustment involves long-time planning because farmers individually determine their own marginal factor costs of labor. This cost depends on the degree of risk the farmer and his family is willing to assume. Any loss, therefore, comes out of the returns to family labor.

Note that the marginal productivity estimates are at the means. In examining allocation efficiency, it is important to look at the MVP_{x_i} at the means and also the dispersion of MVP_{x_i} for each farmer around this mean. Consequently, further research is needed to explain the dispersion of farms about the mean.

Possible Reasons for Negative MVP_{Labor}

The evidence of negative MVP_{Labor} can never be entirely satisfactory to western economists who might ask:

(1) Why would labor be employed in farming with zero or negative MVP?

(2) How do the marginal farmers live?

Several possible explanations will be offered here. The first pertains to the employment of family labor. In answer to question (1) a wage-labor system, taken as given, probably does not exist for family labor which has a zero supply price.[4/] Marginal productivity of family labor (and for that matter hired labor) could be below the farm wage rate. A variety of evidence on cross-sectional agricultural production function studies on individual farm data estimates the marginal productivity of labor to be substantially below the comparable hired wage rate in the locality. In answer to question (2), marginal workers could be supported because average product is still positive. For instance, if the size of farm is such that production can be maximised with only the operator's labor, and there are three other members of the family, this could lead to decreasing

4/ A cobb-Douglas function, with labor input divided into hired and family labor showed a positive coefficient for hired labor and negative coefficient for family labor.

total returns. However, the other three may still remain on the farm, especially if there are few nonfarm occupations available to them. In this situation, the marginal product of labor may well be zero or perhaps even negative. Stated somewhat differently, if no wages need to be paid to family labor as such, and if families place a zero value on the opportunity cost of family labor, then it would be profitable to maximize the output from the fixed factor (land and capital) and this would entail employing the abundant factor (labor) until its marginal product was zero.

The second possible reason concerns structural changes in farm operations; namely, the consolidation of smaller farm units into larger units. During the 1950-1966 period, average farm size has increased from 335 acres to 486 acres. To illustrate how this phenomena could lead to a negative coefficient for labor input, consider two farms of 400 acres and 200 acres, each employing equivalent of two full-time workers. If the 400 acre farm absorbs the 200 acre farm, due to greater efficiency of the farmer, the larger farm may be operated by employing only three workers rather than four previously on the two farms. In addition, the superior efficiency of the larger unit when applied to the additional 200 acres, could result in a larger total output than was previously produced. This might require more variable capital input, which is consistent with the trend reported in Chapter Three. In this hypothetical example, an increase in output is associated with a decrease in labor.

Although hypothetical, this situation agrees with the observed changes in farm size. When expanded to aggregate output and input, such structural changes could account for the negative coefficients. Even though the fundamental influence is the structural change, the statistical estimation has attributed the increase in output, in part, to a decline in labor input.

The third reason pertains to the fact that the production function was assumed constant over the period. This study, however, had shown that technology has contributed most of the increase in output and that this technology is associated with variable capital inputs that are labor-saving. Such technological developments imply that the aggregate production function has not been stable but dynamic. The MVP_{Labor} would have become steeper, higher for the first labor inputs but falling to zero at a smaller quantity of labor each time period. Under this circumstance, the agricultural industry has been in a continuous state of adjustment. The movement of labor out of farming requires time and some workers may have few off-farm alternatives. This leads to excess labor in farming at a given time. In other words, a stable production function was used to represent a situation in which there was a continuous disequilibrium caused by dynamic changes in agricultural production.

As a fourth explanation, it is probable that the quality of labor has increased over the period and this improvement was not reflected in the measurement of labor adopted in the analysis.

In conclusion, the four explanations above are not mutually exclusive. When they are combined, a rationale for negative labor coefficient is provided which is both plausible conceptually and consistent with observed events in Oregon agriculture. In 1950 prices, 3.8 million dollars was spent on institutions serving as adjustment base in Oregon (research and extension) while 9.7 million dollars in 1950 prices was spent in 1966. With this constantly increasing expenditure, it is probable that adjustment process will be faster in the next decade in order to find an equilibrium.

Capital-Labor Substitution

A family of production functions can be derived from labor productivity and real wages so as to contain the elasticity of substitution between labor and capital as a parameter. (1) This is because the process of technological change involves capital and labor inputs plus intermediate inputs. The relevant consideration should include the elasticity of substitution between labor and intermediate inputs.

Consequently, the relationship between labor productivity and wage rate can be expressed in a regression equation. Two models were considered:

$$L_p = A\ W^B\ u \text{ ----------------------------------Model 1}$$

$$L_p = B_o + B_1 W + u \text{ ------------------------Model 2}$$

where L_p is labor productivity (Table 13), W is index of money wage rate (Table 7) and u is the error term.

These models assume that product and factor markets are competitive, and the function is homogeneous of degree one with B_1 parameter as elasticity of substitution between labor and other inputs. The second assumption is that productivities of hired and family labor are the same.

The models are justifiable because agricultural wage rate is fairly highly <u>structured</u>. Wage agreement is not based on coercion but on some comparability of bargaining power between farmers and workers resulting in some degree of equity. Second, labor productivity is highly correlated with wage rate and technology in Oregon (.88 and .80, respectively). This shows that the ratio of income and wages generally follow the growth of labor productivity.

The results are:

(a) $\ln L_p = -11.59 + 1.34 \ln W.$

$R^2 = .81$

(b) $L_p = -51.05 + 1.44\ W.$

$R^2 = 91$

Since $b_1 > 1$, the MRS_{KL} is relatively high. A change in the marginal rate of technical substitution between the two factors is expected to induce a proportionately greater change in capital-labor ratio. Second, since the time effect is excluded in the model, any increase in wages relative to cost of capital will (a) induce input shifts that can increase marginal productivity of labor relative to marginal revenue of capital, (4) and (b) decrease the relative share of labor.

In conclusion, as capital is substituted for labor in Oregon, the value and quality of labor is likely to change less than the man-hours of labor and different wage rates will develop for different grades of labor. Workers with higher skill will be substituted for those with lower skill as farmers use more capital relative to labor.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Output-input relationships pertaining to the problem of adjustment and income in Oregon agriculture have been analyzed in this study. The causes, nature and magnitude of change have been developed.

Changes in input productivity were discussed in terms of resource combinations and relative contributions of nonagricultural sectors to aggregate and partial productivity ratios.

The percentage difference of indexes of aggregate productivity between two periods helps to indicate the improvement of economic efficiency. This implies that:

(a) The production function in any two periods is a linear equation of the form:

$$Y = A(t) \; X_1 \, X_2$$

where Y = value of output, A = a constant, t = time effect and X_1 and X_2 are labor and capital inputs, respectively.

(b) The technological process in the first period is replaced by another process in the second period.

First, the study found that the value of agricultural output increased in terms of constant dollars by 29 percent from 1950-1966. If this growth rate continues, the index of total value of agricultural products is projected to be 140 if 1950=100 in 1975.

The percentage distribution of the value of "all crops" and "livestock and livestock products" remained at about 55 and 45 percent, respectively, each year. The value of "all crops" cash receipts at constant prices increased by 36 percent while cash receipts for "livestock and livestock products" increased by 28 percent. The categories of agricultural products that have the greatest increases in cash receipts are those with relatively high income and price elasticities of demand.

Even though the index of aggregate input decreased by only five percent, there have been some major changes in the input mix. The percent share of labor input decreased by about ten percent while the variable capital input share increased by about seven percent. The share of land and fixed capital input increased by about one percent each. This means that the increase in output has been achieved without proportional increase in the use of total conventional inputs. The competitive nature of agriculture made Oregon farmers adopt new output-increasing technology. Hence, changes in off-farm inputs are directly and positively related to changes in aggregate productivity changes.

The number of farms has declined by about 40 percent while the average farm size increased by 45 percent from 1950-1966. This suggests that Oregon agricultural economy may be under the influence of long-run secular changes, although they are not enough to bring it to adjustment.

The study also documents increasing aggregate productivity and shows that this has been associated with capital intensity; supporting the proposition that technological change has been important. Correlation analysis also supports the idea that technological change is associated with capital input.

However, it is important to separate new technology from capital input or current inputs because new technology usually is embodied in some off-farm inputs. Since the index of fixed input is relatively constant, it can be said that most of the increased output was due to current inputs which are flow inputs purchased largely as needed. Their use is consequently dependent upon their marginal value product exceeding their acquisition cost.

The fixed capital inputs, on the other hand, are not replaced since their marginal value product is greater than their acquisition cost. So, low returns to these fixed inputs in Oregon will not persist unless a high degree of price uncertainty persists because prices are guides to resource allocation either within farms, between farms, or between sectors in the economy.

There are various ways by which this price or income uncertainty can be decreased. Some of these are:

(1) Adoption of enterprise subject to less income variation,

e.g., dairy.

(2) Adoption of multiple enterprise which are complementary and can lead to efficient labor utilization.

(3) Getting part-time job off the farm by the operator and his family.

(4) Increase contractual arrangements.

Partial productivity ratios have also changed during this period. These ratios have many limitations. For example, land ratio has increased but this has been due to increased intensity of land use and the technology associated with increased intensity of capital. Also, a large part of labor productivity increases has been induced by changes outside agriculture. Technological development in nonfarm sectors has made on-farm input relatively expensive and off-farm input relatively cheap. Oregon farmers, therefore, have responded by substituting capital for labor. The apparent changes in farm labor productivity are, to a large extent, simply a reflection or a by-product of changes in productivity in nonfarm industries.

The savings in resources, or value of unexplained output, was eight million dollars at 1950 prices in 1951 and 136 million dollars at 1950 prices in 1966. The total savings for the entire study period was about 968 million dollars at 1950 prices. These approximations are based on the premise that the resources saved received the same <u>per</u> unit return as was received by the resources actually used.

Farm Labor Exodus

Labor migration from agriculture in Oregon will continue because:

(1) The rate at which resources are transformed into products has increased more rapidly than demand.

(2) The production function is changing to increase the rate of substitution of capital for labor.

(3) The price of labor has increased relative to capital, following substitution.

These three forces will have two effects: (a) they will continue to pull Oregon agriculture in the direction of larger and more specialized farms, relying more on machines and less on labor; and more on biological capital and less on land. The change will not be discrete or revolutionary, but gradual and continuous as it has been in the study period. (b) These forces put against low supply elasticity of labor in agriculture--relative to the demand for labor in farming--will cause price and resource incomes to be depressed below long-run equilibrium levels.

This apparent need for decrease in labor input in agriculture raises the following problems:

(1) Identifying those agricultural workers who can take advantage of nonfarm employment through re-training. An unselective reallocation could decrease output.

(2) The extent that closed shop rules in nonfarm sectors serve as effective device in restricting entry, thus decreasing opportunity for farm migration.

These problems, however, will be aggravated by inelastic supply of labor mentioned above. Some of the reasons for this, especially to those who really need to move out of agriculture are:

(1) The rising cost of education.

(2) Opportunity cost of not working after the age of 15 or so is higher on farms than in cities and specifically high for low income farm families.

(3) Cultural values in rural communities may also put less value on education than do many other groups in society.

(4) Greater social adjustments usually involved in leaving rural areas to attend college.

In short, in order to reduce the inefficiency in Oregon agriculture, research efforts need to be directed towards:

(1) Reduction of uncertainty.

(2) Education directed to increasing productivity on small low income farms.

(3) Credit for acquisition of capital and expansion of farm size.

(4) Provision of employment outlook services.

(5) Job training and transfer assistance.

Implication for Future Research

Too much weight should not be placed on the results of this analysis because of conceptual and statistical problems and data limitations. The conclusions are not concrete answers to policy questions but a set of hypothesis for further research. The conceptual problems are mainly in specification of the production function. It will be useful to consider alternative ways of specifying labor in the production function. For instance, labor could be specified by weighing hours worked by men, women, children and hired labor.

Second, statistical estimation of production function parameters has been extensively criticized in economic literature. It is, however, believed that reasonably good estimates have been obtained in this analysis.

Third, the data was taken as given. This data was collected for other purposes and have been used effectively in this study. If one were collecting raw data expressly to estimate the productive function parameters for Oregon agriculture, one would proceed differently.

All these notwithstanding, many of the conclusions in this analysis are interesting and have important intellectual interest and policy implications. While it is unwise to base policy recommendations solely on these results, they shed some light on Oregon agricultural economy and serve as guides for further research in production relation, economic efficiency and returns to factor inputs. In this light, this study is another input in the policymakers' decision function.

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