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The main objective of the study was an attempt to obtain a general explanation for the geographical pattern of agricultural income. This was undertaken in the belief that certain possible determinants of agricultural income, specifically those related to natural resource characteristics, have not been satisfactorily considered in investigations up to the present time. Consequently, various determinants which other researchers have found important, e.g., location, education, age, etc., were combined in one model, together with a number of variables designed to measure various characteristics of natural resources.

As far as the natural resource characteristics were concerned, considerable emphasis in this study was placed upon an empirical investigation of the range of choice hypothesis. This hypothesizes that the narrower the range of choice permitted by the natural resource complex, the greater will be the incentive toward specialization and

hence higher incomes. Conversely, it was believed that the wider range of choice of enterprises permitted, the greater will be the tendency toward highly diversified, self-sufficient and low income farming units. One of the complications involved in testing the range of choice hypothesis was the desirability of measuring the opportunity for pursuing a number of enterprises rather than the result of producing them. It was believed, however, that one of the more important determinants of the range of choice was the long-run climatic conditions. In order to arrive at climatic measures suitable for the purposes of this study, various modifications were made on those developed by Thornthwaite and Mather.

Regression techniques were used extensively for the ensuing empirical investigation, which relied heavily on data from secondary sources. County data for Kansas and Oregon in 1959 and 1960 provided the basis for the bulk of the empirical analysis although some consideration was also directed towards these states for the years 1939 and 1949.

Three models, differing only with respect to the climatic measures employed, were constructed consisting basically of two equations. The first equation utilized the median earnings of male farmers and farm managers as the dependent variable together with measures of age, education, race, land capability, irrigation, range of choice and off-farm employment as independent variables. The second equation reflecting earnings from off-farm employment consisted of the percentage of commercial farm operators who work off the farm as the dependent variable and measures of location, time available for off-farm employment, age, race and education as independent variables.

The empirical results which were obtained for Kansas and Oregon in 1959 differed in many respects. Most notable was the fact that the range of choice hypothesis was far more significant in Kansas than in Oregon. In addition, the expected decrease in importance of this hypothesis through time did not materialize in either Oregon or Kansas. Possible reasons for this are due to the shortness of the time period studied and that there has been a differential impact of technology. In the first equation, age and education also proved to be significant in both Oregon and Kansas, while in addition in the former state off-farm employment was important, as was irrigation in the latter state. The latter two were also found to have increased in importance over the last 30 years.

Empirical results obtained from the second equation revealed that time availability and location were the most important determinants in Kansas and Oregon in 1959. In Oregon, however, evidence was obtained concerning the desirability of modifying the conventional location matrix theory because the unique employment opportunities offered by the lumber industry mean that off-farm employment opportunities are not synonomous with the presence of urban concentrations.

NATURAL RESOURCE CHARACTERISTICS AS RELATED TO THE PATTERN OF AGRICULTURAL INCOME IN CERTAIN SPECIFIED AREAS OF THE UNITED STATES

by

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NATURAL RESOURCE CHARACTERISTICS AS RELATED TO THE PATTERN OF AGRICULTURAL INCOME IN CERTAIN SPECIFIED AREAS OF THE UNITED STATES

I. INTRODUCTION

Traditionally agriculture has been considered to have played an important role in the initial development of any economy. However, as Table 1 indicates, the quantitative significance of agriculture in the national economy progressively decreases as a result of the attainment of an industrialized developed country.

Nevertheless, in spite of the continuing obvious importance of agriculture in the over-all economy, economists have failed to explain in a convincing manner the geographic pattern of agricultural income which has evolved in the United States (see Table 2). The research that has been carried out on the determinants of agricultural income has invariably been of a disconnected nature with little or no attempt to integrate these determinants in one model. In addition it is believed certain possible determinants of agricultural income, particularly in the case of those related to natural resource characteristics, have not been satisfactorily considered in investigations up to the present time.

Theoretical Significance of Natural Resources

Ciriacy-Wantrup (15, p. 29) has reclassified the so called

Table 2. Geographic distribution of counties by median earnings of farmers and farm managers who were rural farm residents for the United States, Divisions, Kansas and Oregon, 1959.[a]

	Mean of medians ($)	Percentage of counties whose earnings occur in the i to (i +999) $ range where i = 0, 1,000,----, 9,000.									
		<$1,000	$1,000 to $1,999	$2,000 to $2,999	$3,000 to $3,999	$4,000 to $4,999	$5,000 to $5,999	$6,000 to $6,999	$7,000 to $7,999	$8,000 to $8,999	$9,000 or more
Conterminous U.S.	2,038	11.65	31.96	34.14	14.26	4.69	1.72	0.76	0.36	0.16	0.30
Division:											
New England	2,316	0	20.00	58.46	20.00	1.54	0	0	0	0	0
Middle Atlantic	2,422	0.71	9.29	72.86	14.29	1.43	0	0	0	0.83	0.83
East North Central	2,191	0.46	23.96	58.76	16.13	0.46	0.23	0	0	0	0
West North Central	2,278	0.32	23.18	54.46	17.18	3.40	1.13	0.16	0.16	0	0
South Atlantic	1,315	26.93	53.69	13.09	3.51	0.92	1.11	0.18	0.18	0.37	0
East South Central	1,048	41.32	49.31	8.54	0.55	0.28	0	0	0	0	0
West South Central	2,155	9.38	44.14	19.40	11.51	7.04	3.84	1.71	1.71	0	1.28
Mountain	3,012	2.89	3.62	27.17	37.68	17.03	5.80	2.54	2.54	0	0.72
Pacific	3,231	0	5.93	25.93	32.59	22.22	2.96	4.44	4.44	1.48	0
State:											
Kansas[b]	2,973	0	10.78	50.98	21.57	9.80	4.90	1.96	0	0	0
Oregon[b]	3,268	0	6.67	40.00	33.33	16.67	0	0	3.33	0	0

a The basic data used in compiling these statistics were obtained from the following sources: (11, p. 12; 91, p. 266-274; 92, p. 151-153).

b These included in addition those farmers and farm managers who were non-farm residents but excluded those of the female sex.

"trinity" of factors of production, i.e., land, capital and labor in terms of three broad classes of resources, namely natural, cultural and human. Natural resources[1] can crudely be defined as wealth supplied by nature or more explicitly as "the sum total of the natural and man-made[2] resources over which possession of the earth's surface gives control" (4, p. 7). Thus natural resources include such phenomena as mineral deposits, forests, soil fertility, water resources and others such as access to sunlight, rain, wind and changing temperatures, and location with respect to markets and other areas.

Natural resources per se cannot be manufactured by the human agent, although when present, man can mould and modify them to fulfill his objectives. Consequently, it is not unreasonable to state that the presence of natural resources is a necessary condition for man's livelihood, but are not by themselves a sufficient condition for the continued existence of man. Effort on the part of the human agent is

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[1] To economists, the term "land" is considered synonymous with natural resources. However, land carries with it the misleading implication of a definite limit in a physical sense, which is not entirely valid since the quantities of natural resources depend to a great extent on the level of technology. In addition land also bears the connotation that a reward can be appropriated for its services, whereas certain natural resources although scarce and valuable, cannot command such a remuneration (e.g., climate). For these reasons in this study the term natural resources is used in preference to land.

[2] Barlowe (4, p. 7) in his definition of land or natural resources includes those man-made improvements which are attached to the surface of the land and cannot be easily separated from it.

required to reap a livelihood or income from the natural resources provided by nature. If it is assumed that the factor markets are not completely efficient, then no model, constructed to determine agricultural income, would be complete unless it contained independent variables depicting both natural resource and human agent characteristics.

However, in spite of this there has been no unified thinking as to the exact value of natural resources as a factor of production. Opinions have varied from attributing a dominant role to natural resources as in the case of the classicists such as Ricardo (6, p. 15) to others such as Harrod (25, p. 20) who disregard them altogether. Still others such as Kindleberger are less dogmatic and content themselves with remarking that "other things being equal, more resources are better than fewer" (33, p. 46).

Nevertheless, as Schultz (50, p. 2) points out the two extreme opinions mentioned above when viewed with reference to the time when they were formulated, may not be inconsistent. Indeed there is some evidence advanced by several investigators, e.g., Schultz (52, p. 134-139) and Denison (17, p. 88), that the economic importance of natural resources decreases with economic growth.

It is probably reasonable to state that natural resources have generally been considered passive at all stages of economic growth. Castle (14, p. 22) has noted that if one assumes mobility of cultural (i.e., capital) and human resources, then it may be concluded that, according to micro-economic theory concepts, returns to these factors would be equal at the margin if adjustment is made to the natural resource base. However, if this model is made more dynamic in nature, by the introduction of technological change, location considerations, price and yield variabilities, etc., then the results may be quite different from those derived from the traditional static model.

Evolving from this framework, Castle (13, p. 2) has advanced a range of choice hypothesis which will be described in greater detail later in the study. Very briefly, however, the range of choice in production is determined by the natural resource base. Variations in the range of choice may have a considerable influence on the farming organization that evolves and hence on the geographical pattern of income that results. More explicitly, where the natural resource base permits a number of enterprises to be pursued, the opportunity cost of not specializing is low, therefore allowing a highly diversified low income agriculture to persist for a longer time period than would be the case where the range of choice is limited. The latter situation would arise where the natural resource base is less favorable from an agricultural point of view, thus giving a greater incentive to adopt new technology and specialize, thereby resulting in higher agricultural incomes.[1]

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[1] This hypothesis is based on assumptions discussed on pages 25-28 of this study.

Objectives of the Study

The general purpose of the study was an attempt to obtain a more general system for explaining the geographical pattern of agricultural income than is currently in existence. In order to fulfill this objective it was proposed to integrate into one model the various determinants of agricultural income which other investigators have found important, e.g., location, education, age, etc., together with a number of variables designed to measure various characteristics of natural resources, which have been largely neglected in investigations to this time.

A sub-objective was to obtain a rational evaluation of the overall importance of natural resources in determining the geographical pattern of agricultural income together with the more specific aim of testing the validity of the range of choice hypothesis.

Finally, it was hoped to ascertain whether or not the determinants of agricultural income had changed in significance over time.

Methodology and Underlying Assumptions

Oregon and Kansas were selected for testing the aforementioned hypotheses. The sampling unit used was the county, the frame being the number of counties in the state under consideration. Where possible all counties in the frame were used in the analysis. Census data were used extensively, the main sources being the 1959 Census of Agriculture and the 1960 Census of Population. This discrepancy in years necessitates the assumption that the values of the statistics used from the Census of Population for 1960 do not differ from what they would be in 1959, which was the year selected for the ensuing empirical investigation. This did not prove to be a serious limitation because the variables for which statistics were obtained for 1960 do not appear to change significantly from year to year, e.g., education and age.

Regression Analysis

A generalized linear multiple regression equation of the type used in the study can be expressed as follows:

$$Y_i = b_0 + b_1 X_{i1} + b_2 X_{i2} + \ldots + b_p X_{ip} + u_i$$

where:

$i = 1, 2 \ldots n.$

$j = 1, 2 \ldots p.$

and: Y_i is the observed value of the dependent variable, i.e., the endogenous variable.

X_{ij} is the ith value of the jth independent variable, i.e., one of the p exogenous variables.

b_j is the coefficient of the jth independent variable.

u_i is the $\underline{ith}$ random disturbance term.[1]

The use of regression analysis arises as a result of the Gauss-Markoff theorem which can be briefly stated as follows.

Consider a number of uncorrelated observations Y, which are distributed with common variance σ^2 about a mean $\sum_{i=j}^{n} Y_i/n$ and the b_j's are unknown parameters while the X_{ij}'s are known constants. The best linear unbiased estimates of $b_1, b_2 \ldots b_p$ are solutions of a system of linear equations obtained by minimizing the residual sum of squares $\sum_{i=1}^{n} (Y_i - b_1X_{i1} - b_2X_{i2} - \ldots - b_pX_{ip})^2$ with respect to the unknown parameters.[2]

Therefore, for this theorem and regression analysis to be valid, certain conditions or specifications have to be fulfilled. Stated more explicitly those relating to the residual or error terms (u) are, according to Johnston (32, p. 7) and Valavanis (101, p. 9):

1. u is a random real variable.

2. The expected value of u_t for every t is zero.

$$E(u_t) = 0$$

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[1] The error term is present due to errors of omission, the fundamental randomness of human behavior, measurement errors, and due to fitting the wrong form of function (32, p. 6).

[2] A more detailed discussion is given by Graybill (24, p. 114).

3. The variance of u_t is constant and finite for all t, i.e., homoskedastic.

$$E(u_t, u_t) = u^2$$

4. The random terms of different time periods are independent, i.e., there is no autocorrelation.

$$E(u_t, u_{t-\theta}) = 0 \text{ where } \theta \neq 0$$

5. The random term is not correlated with any predetermined variable, i.e., there is no multicollinearity.

$$E(u_t, X_t) = 0$$

If the above assumptions are fulfilled, then the estimators will have the following important properties:

1. They are unbiased estimators, i.e., if all possible samples of size n are considered and if $\hat{b}$ estimates the parameter b; then if $E(\hat{b}) = b$, one can conclude that $\hat{b}$ is an unbiased estimate of b.
2. They are consistent estimators, i.e., as sample size n increases, $\hat{b}$ gives a progressively better estimate of a parameter b, i.e., $\lim_{n \to \infty} \Pr(|\hat{b}_n - b| < \epsilon) = 1$.
3. They are efficient or minimum variance estimators, i.e., if $\hat{b}$ and $\breve{b}$ are two estimators from a sample of n observations, the more efficient estimate is the one with the lower

variance.[1]

Bearing in mind these assumptions and the contingent properties, it is now possible to describe the estimating technique utilized in stepwise regression. Very briefly, stepwise regression, which is most conveniently carried out on a computer, commences with the calculation of the simple correlation coefficients between the dependent variable Y, and each of the independent variables, $X_1 \ldots X_p$. The first regression run is between Y and the X variable (e.g., X_i) having the highest correlation with Y. The residuals $(\hat{Y}-Y)$ from this regression are then computed, after which simple correlation coefficients are calculated between the residuals and the remaining independent variables which have not yet been included in the regression equation (i.e., $X_1 \ldots X_{i-1}, X_{i+1} \ldots X_p$). The second regression run includes Y as the dependent variable, and X_i and X variable (e.g., X_j) having the highest correlation coefficient with the residuals from the first step, as the independent variables.[2] An

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[1]Various other properties underlying the estimators can be delineated, but the three mentioned here are generally considered most critical. Valavanis (101, p. 47) gives a brief discussion concerning the properties not mentioned above.

[2]It should be noted that an alternative estimation procedure is also sometimes termed stepwise regression. Briefly, this involves regressing the residuals from the previous step against the next independent variable to be added. This is in contrast to the procedure described above in which the dependent variable remains the same for each step. In other words step k of the stepwise regression described above would give identical estimates for the k parameters

identical procedure is carried out until all the variables have been included in the estimating equation.

From a statistical viewpoint, two factors are important in determining which step should be adopted as an estimate of the dependent variable Y. The factors to consider are the correlation coefficient and the standard error of estimate. As more variables are added the multiple correlation coefficient increases monotonically, while at the same time the standard errors of estimate decrease and then may eventually increase. The equation accepted is the one where the multiple correlation coefficient is significant and the standard error of estimate is near its minimum value.

Beta Coefficients

One of the main purposes of this study was to determine the relative strength of the relation between Y and the p independent variables. If the sample standard deviations of X_1, X_2, . . . X_p were the same, then one could simply compare the various partial regression coefficients.

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as would a straightforward linear multiple regression containing the same k independent variables. Thus the properties of the estimators would be the same in both cases. In contrast where the alternative stepwise procedure is followed, Freund, Vail and Clunies-Ross (20, p. 100) and Goldberger and Jochems (22, p. 106 and 23, p. 1000) have shown there is a bias introduced, in that the estimates of the parameters of the added independent variables are less in absolute terms than if straightforward linear multiple regression techniques are used.

Since the sample standard deviations are not usually the same, Ezekiel and Fox (19, p. 148 and 196) and Snedecor (58, p. 416) propose an alternative procedure which involves the calculation of beta coefficients or standard partial regression coefficients, as they are sometimes called.

Such coefficients take into account the variation in the independent variables relative to the variation in the dependent variable, while at the same time their absolute values give an indication of the relative importance of the effect of each of the independent variables on the dependent variable.[1] The sign of the beta coefficient indicates the direction of this effect.

The computation of the beta coefficient is achieved in the following manner:

Suppose that the linear multiple regression equation

$$\hat{Y}_i = \hat{b}_0 + b_1 X_{i1} + \hat{b}_2 X_{i2} + \ . \ . \ . + \hat{b}_p X_{ip}$$

has been estimated.

Thus $$\hat{\beta}_j = \hat{b}_j \sqrt{\frac{SS_{X_j}}{SS_Y}}$$

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[1]Another possible measure suggested by Ezekiel and Fox (19, p. 192) is the calculation of coefficients of partial correlation. Ranking of the independent variables in order of importance as determined by the coefficients of partial correlation and the beta coefficients is usually the same although occasionally the ranking may differ due to mathematical differences in the meaning of the two sets of measures.

where:

$j = 0 \ldots p$

$\hat{\beta}_j$ = the estimated beta coefficient of X_j

$\hat{b}_j$ = the estimated partial regression coefficient of X_j

SS_{X_j} = the sum of squares of X_j

SS_Y = the sum of squares of Y

Other Methodological Considerations

Other techniques which were utilized to a lesser extent and pertain to specific parts of the study are embodied in the text itself.

Limitations of the Study

The limitations to this study can be divided into two main parts, one of a theoretical and one of a practical nature.

Unfulfilled Assumptions[1]

When working with economic data the assumptions underlying regression analysis[2] are usually assumed to be fulfilled.

[1]According to Friedman (21, p. 39-43) this should not be considered a limitation, since the test of the validity of a theory should be based purely on its predictive ability. Baumol (5, p. 6), however, is a little less dogmatic, in noting that the satisfaction or not of the underlying assumptions can give some indication of the theory's relevance. Since the present study is concerned more with structure rather than prediction, it seems reasonable to argue that a violation of the assumptions would detract from the value of the results.

[2]See pages 9-10.

Unfortunately, it is rarely that these are met completely satisfactorily with the result that the estimators tend to be biased, inefficient and inconsistent.

More specifically autocorrelation and multicollinearity result in inefficient but unbiased estimates, while heteroskedascity gives rise to inefficient but unbiased and consistent estimates. Tests of the severity of these assumption violations have been devised.

The Durbin and Watson test (32, p. 192) is commonly used in order to test for autocorrelation. However, serial correlation is unlikely to be important unless time series data are being utilized, and thus was not considered to be relevant in the present study, where cross sectional data were utilized.

Such was not the case with multicollinearity which was considered to be of some significance in this study. Unfortunately no simple test of the severity of multicollinearity has yet been devised although Klein (34, p. 64) has noted:

> The warning light to the statistician that multicollinearity is serious, is that the sampling errors in the individual coefficients become large. The coefficients of each variable . . . will not be very precisely estimated even though the over-all correlation for the entire equation is high. Intercorrelation of the explanatory variables is a relative matter. It is not possible to say whether a separate influence can be singled out if the intercorrelation is at least .6, .7, .8, .9 or even higher. The sampling error of an individual coefficient depends on both the intercorrelation with other explanatory factors and over-all correlations of the whole equation. If the former is high relative to the latter, indeterminacy appears.

In addition, Johnston (32, p. 206) implies that if the estimated variance of the coefficient increases as more variables are brought into the equation, the presence of multicollinearity is to be suspected. Stepwise regression provides an ideal method of investigating this phenomenon.

When multicollinearity was found to be serious, an attempt, as suggested by Johnston (32, p. 207), was made to acquire new data which would be free of multicollinearity data, or in some cases one of the variables concerned was simply eliminated from the model.

Limitations Pertaining to the Data

Two main limitations pertaining to the data can be discerned as:

1. The heavy reliance placed on proxy variables. Due to the lack of data, it was often necessary to use proxy variables, which may or may not measure the theoretical construct that they are supposed to represent. A related problem was the choice of weights to be used in setting up index numbers. The ranking of the counties could be radically altered by the choice of different weights.
2. Another problem which applies to most studies of a similar nature is that in linear multiple regression analysis the independent variables are assumed to be measured without error. This is not likely to be the case, since much of the

II. VARIABLES INFLUENCING THE MEDIAN EARNINGS OF MALE FARMERS AND FARM MANAGERS

Before turning to a discussion on the possible determinants of agricultural income, the basic model underlying the subsequent empirical analysis is presented.

The Basic Model

The basic theoretical model fundamentally consists of the following identity in which the total income of farmers reflects income derived from both agricultural pursuits and from part time jobs of a non-agricultural nature.[1]

(1) $I = I_A + I_{NA}$

where:

I = total income of the farmer.

I_A = agricultural income of the farmer.

I_{NA} = income of the farmer derived from non-agricultural sources.

The factors considered to be important in determining income from agricultural sources were:

(2) $I_A = g_1(I_R, Q, A, E, R, C)$

[1] Since the sampling unit is a county the variables depicted would represent an average per county, but in the interest of conciseness and non-repetition the words "average per county" have been omitted.

where:

I_R = amount of irrigation.

Q = land quality.

A = age of farmer.

E = education of farmer.

R = race of farmer.

C = range of choice index.

The range of choice index is itself dependent upon certain natural resource characteristics.

(3) $C = h(W, Q, O_1 \ldots O_n)$

where:

W = a measure of weather.

$O_1 \ldots O_n$ = other variables.

Weather itself is in turn made up of a number of characteristics.

(4) $W = j(W_A, S, G, I_N)$

where:

W_A = water availability.

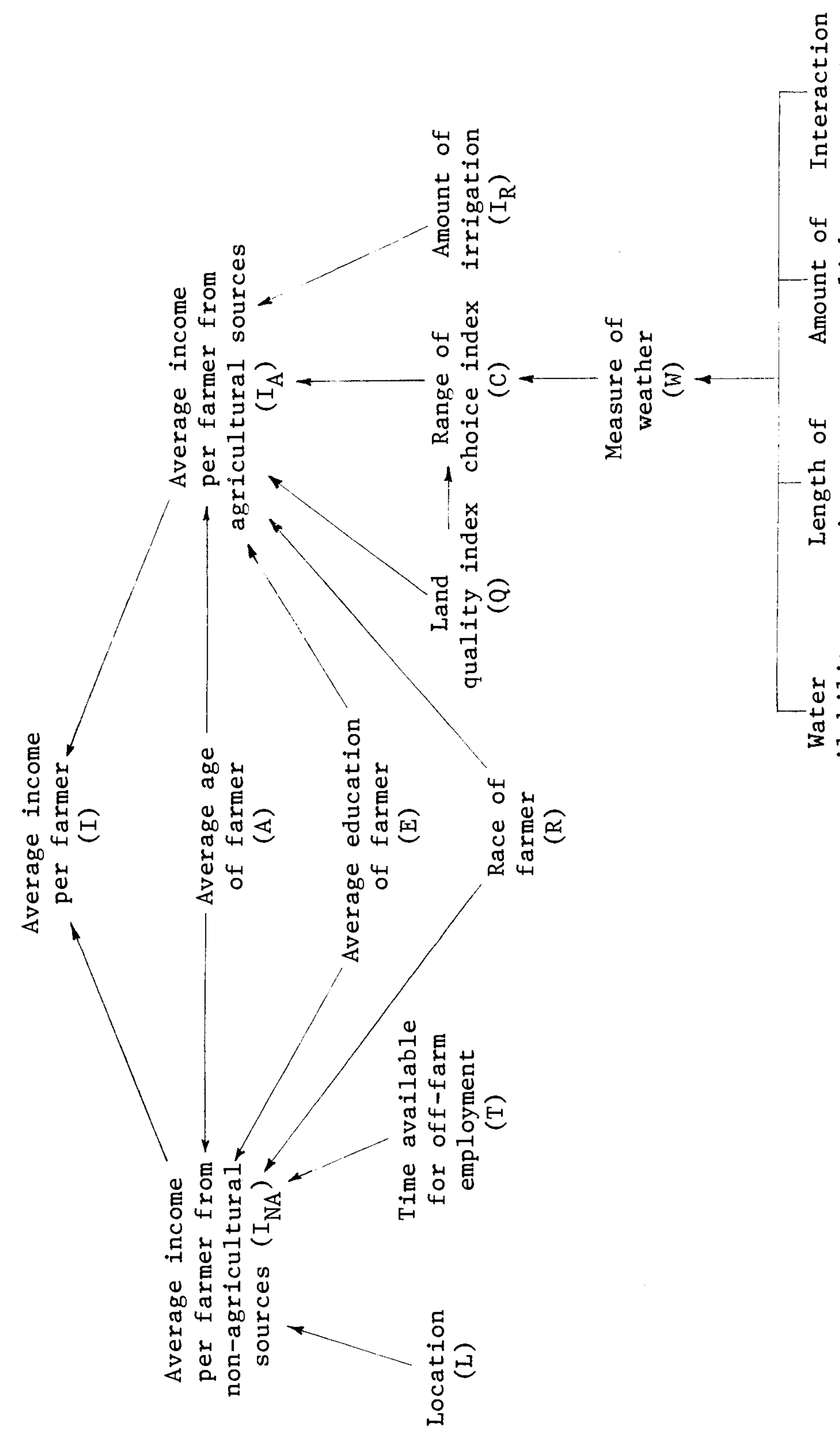
S = amount of sunlight.

G = length of growing season.

I_N = an interaction term.

Since weather (W) is determined solely by exogenous variables it can also be considered exogenous. Thus the range of choice index

Figure 1. Diagram showing the relationships of the factors included in the basic model.



(C) is also completely determined by exogenous variables and therefore can also be regarded as an exogenous variable. Consequently, the equation depicting average income per farmer from agricultural sources (I_A) can be rewritten as:

(5) $I_A = g_z(I_R, Q, A, E, R, W_A, S, G, I_N, O_1 \ldots O_n)$

On turning to the factors underlying the determination of the average income per farmer from non-agricultural sources (I_{NA}), the following were considered to be of relevance:

(6) $I_{NA} = k(L, T, A, E, R)$

where:

L = location.

T = time available for off-farm employment.

Thus the basic model consisted essentially of the two following equations.

(7) $I = g_3(I_A, I_{NA})$

$= g_4(I_R, Q, A, E, R, W_A, S, G, I_N, O_1 \ldots O_n, I_{NA})$

(8) $I_{NA} = k(L, T, A, E, R)$

The remainder of the chapter is devoted to a theoretical justification for the variables included as possible determinants of the equation depicting the total income of the farmer. In addition consideration is also directed towards possible measures of these variables, although it is recognized that some modifications may be desirable in the light of subsequent empirical results.

Selection of a Dependent Variable

The choice of a suitable dependent variable designed to measure the incomes of farmers derived from both farm and off-farm sources proved to be a difficult task. The income derived from off-farm sources was considered to be a necessary ingredient of the model, because most effects of the location-matrix theory are hypothesized to act through the labor market.

After much deliberation, earnings of male farmers and farm managers were selected as best fitting the above specifications.[1]

According to the U. S. Census of Population (90, p. LXXIX) "earnings" include both wages and salaries plus self-employment income.[2] Earnings represent the amount of income received before deductions for personal income taxes, social security contributions, bond purchases, union dues, etc. Thus earnings of male farmers and farm managers reflect remuneration for time spent in employment on and off the farm.[3]

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[1] Other variables considered and the reasons for their rejection are discussed in Appendix A.

[2] "Earnings" plus other income, e.g., rent, royalties, veteran and social security payments, interest, dividends, unemployment insurance, etc., result in total income. These additional items of remuneration require very little time allocated to them for their materialization.

[3] This fact was confirmed as a result of correspondence in February 1964 between Mrs. E. Horrell, Extension Agricultural Economist at Oregon State University, and H. S. Shryock, Jr., Acting Chief of the Population Division of the Bureau of the Census.

The definition of farmers and farm managers as given by the General Economic and Social Characteristics section of the U. S. Census of Population (91, p. XXI) includes owner operators, tenant farmers and share croppers. This is comparable to that of the operator in the U. S. Census of Agriculture (81, p. XXXII), which designates a person who operates a farm,[1] either doing the work himself or directly supervising it. Thus an operator may be the owner, hired manager, tenant, renter, or sharecropper. However, empirically the values of these two series differ by the number of non-commercial farms in the counties,[2] which are mainly farms selling products of value less than $2, 500 per year (81, p. XXXV).

Thus it is possible to conclude that when allowance is made for statistical discrepancies and year to year variations, the number of farmers and farm managers is the same as the number of commercial farm operators. On the basis of this reasoning it is reasonable to consider the median earnings of farmers and farm managers as an approximation of the median earnings of commercial farm

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[1]In the Census of Agriculture the number of operators is synonymous with the number of farms.

[2]For example in Oregon in 1959 and 1960, the following results were obtained for the state as a whole.

Number of farm operators (1959).	42,573
Estimated number of commercial farm operators (1959)	22,802
Number of farmers and farm managers (1960).	24,452

The small difference in the series can be attributed to statistical discrepancies, and the fact that the statistics were taken from different years.

operators. Therefore, whenever data were available, variable measures depicting commercial farm operators were used in preference to data representing both commercial and non-commercial farm operators.

The Range of Choice Hypothesis

The Theoretical Concept

A characteristic which may be important in explaining the existing pattern of agricultural income is the versatility or range of choice in production which is permitted by the natural resource complex. Variations in the range of choice may have a profound effect on the resulting type of farm organization and therefore income.

It is hypothesized that the narrower the range of choice the natural resource complex presents, the greater will be the tendency towards specialization and therefore higher incomes. In such cases the opportunity cost of not specializing would be high in terms of income foregone. Conversely, a wider range of choice would permit highly diversified, self-sufficient and therefore low income farming units to exist. Here the opportunity cost of not specializing would be lower and a diversified pattern of agriculture would persist for a longer period of time. Consequently, both the natural resource complex and economic forces may be factors in promoting specialization rather than diversification. To summarize: a narrow range of choice will have a positive influence on farm incomes; a natural resource complex which permits a wide range of choice will have a depressing influence on the level of farm incomes.

The range of choice hypothesis as stated above assumes a particular view of the adjustment process in agriculture. More explicitly, Castle (13, p. 4) has specified four assumptions.

1. In general higher incomes result from specialization rather than diversification or in other words specialization and market dependence are positively related to agricultural income. As early as 1776 Adam Smith (57, p. 1-21) observed that economic development was possible as a result of specialization of labor, i.e., division of labor, although its extent would be limited by the size of the market. Later Ricardo (44, p. 73-75) advanced the theory of comparative cost which once again emphasized the economic advantages of specialization. More recently, conventional micro-economic theory with its emphasis on a more rigorous mathematical approach has shown that up to a certain output level, lower costs per unit of output are possible, due to internal and external economies of scale. Such a phenomenon has been recognized in many empirical studies. For example, Stippler and Castle (60, p. 8) have verified that economies of scale exist on specialized wheat-summer-fallow farms in the Columbia Basin of Oregon. In addition, Table 3 provides some

Table 3. Median earnings of male farmers and farm managers in specialized counties compared with those in diversified counties. Oregon, 1959.[a]

Specialized counties[b]		Diversified counties[c]	
County	Median earnings of male farmers and farm managers	County	Median earnings of male farmers and farm managers
Baker	3,281	Clackamas	2,051
Crook	3,567	Clatsop	d
Gilliam	d	Columbia	1,889
Grant	3,713	Douglas	2,212
Harney	d	Lane	2,835
Hood River	3,718	Marion	2,871
Lake	3,938	Washington	2,798
Sherman	7,148	Yamhill	2,510
Tillamook	3,256		
Average	4,089	Average	2,437

[a] Source: U.S. Census of Population (92, p. 151-153) and unpublished data provided by the Oregon State University Extension Service.

[b] Defined as those counties which derived more than 60% of their total sales value in 1959 from one enterprise.

[c] Defined as those counties in which no enterprise accounted for more than 25% of the total sales value in 1959.

[d] No data on earnings were available for these counties.

evidence that higher incomes result from specialization compared with diversification. This is consistent with the notion that specialization permits advantage to be taken of economies of scale.

2. A change or disruption of the traditional pattern of agriculture constitutes a disutility to most farmers. This does not necessarily mean that a more self-sufficient type of agriculture is preferred to greater specialization if all other things were equal. Nevertheless it can be argued that farmers have surrendered their self-sufficiency reluctantly because:

(a) The physical and economic risk and uncertainty attached to confining entrepreneurial endeavor to one enterprise has outweighed the possible pecuniary benefits resulting from such specialization. Castle (12, p. 284) has found empirically that this skepticism is justified to some extent in that reduced variability of gross income results from some diversification.

(b) Transportation facilities which are vital to the success of a specialized enterprise were deficient in times past thereby encouraging diversified farming to arise where the natural resource complex would permit it.

Because of these and other reasons, which may have caused the traditional agricultural pattern to be diversified, there will be reluctance on the part of most farmers to becoming specialized and in so doing placing greater reliance on market forces.

3. There is some level of income which is necessary to overcome this resistance. The opportunity cost of not specializing, in terms of income foregone, will at some point become sufficiently great to overcome this resistance to change. In other words the risk and uncertainty attached to specializing may still be present but the possible pecuniary benefits may progressively increase. The influence of economic forces and technological developments which can only be used in large scale enterprises could conceivably be factors contributing to an increase in the potential pecuniary benefits. Eventually when these reach a certain value, resistance will diminish and a change in the farm organization will result.

4. Due to variations in natural resource characteristics, the penalty associated with clinging to the traditional pattern of agriculture differs among areas. If the range of choice is great, the traditional pattern of agriculture with greater emphasis on self-sufficiency and diversification, comes at a lower cost in terms of income foregone, than if the range of choice is quite narrow. In the latter case the relative comparative advantage of specialization and market orientation is greater.

It should be noted, however, that a narrow range of choice is neither a necessary nor sufficient condition for specialization and market orientation. On the other hand a wide range of choice is a necessary condition for diversification and self-sufficiency. Thus as Castle (13, p. 4) notes, one would expect to find some specialization in areas which permit a wide range of choice, although one would also expect to find much more self-sufficiency in such areas than where the choice range, permitted by the natural resource complex, is quite narrow.

One of the complications involved in testing the range of choice hypothesis is the desirability of measuring the opportunity for pursuing a number of enterprises rather than the result of producing them. For example, Table 3, which shows the results of specialization and diversification, gives no indication of what caused the specified counties to become orientated in this way. Because of the desirability of measuring the opportunity for pursuing a number of enterprises, it is difficult to construct a range of choice index in an explicit sense, although it can be expressed in terms of a number of physical factors such as rainfall, temperature, length of growing season, etc. In addition, certain other variables may have some influence on the range of choice, but their over-all importance in this regard is difficult to determine. Such variables are location, age, education, irrigation, land quality, etc., although their inclusion in the basic model is justified for reasons other than their influence on the range of choice hypothesis. Also, all these additional variables contain elements which are a function of the human agent thereby implying that the range of choice index may not be solely dependent on the natural resource complex. However, for the purpose of this study, the most important determinants of the range of choice were considered to be the climatic variables, which are now to be considered.

The Weather Variables (W)

In recent decades many attempts have been made by geographers, soil scientists and ecologists to derive universal measures of climate. Foremost among these have been Koppen, Lang, De Martonne[1] and Thornthwaite. In contrast, apart from Oury (45, p. 270-283), little work has been carried out by agricultural economists on the weather factor except in its effect on particular crops in specified areas, e.g., Stallings (59, p. 180-186), Thompson (63, p. 182-185) and Shaw (54, p. 218-231). Edwards (18) provides a typical example of the complexities involved in this type of approach in utilizing a production function model to relate yield and weather data for the Northern Great Plains spring wheat region.

However, for the purposes of this study, it was deemed necessary to utilize more general measures such as those developed by the geographers. As a result heavy reliance was placed on those

[1] Thornthwaite (65, p. 633-634 and 64, p. 73-75) and Oury (45, p. 271-274) give short summaries of the work of these investigators.

suggested by Thornthwaite, which Oury (45, p. 282) credits as being among the best in existence at the present time.

Thornthwaite (65, p. 634) observes that the degree of temperature, the amount of precipitation and the seasonal variations of each are the most important climatic elements, although he quite rightly cautions that crude measurements of these variables are not satisfactory.

Three alternative measures of weather variables were utilized in the study, in order to test whether the empirical verification of the range of choice hypothesis was determined by the variable measures used. If all the variable measures give consistent results to the range of choice hypothesis, then conclusions concerning its validity can be drawn with some degree of certainty. This approach was considered necessary due to the difficulties involved in attaining completely accurate measures of climate.

The various measures employed and their underlying assumptions are described below while the computational aspects are discussed in Appendix B.

A. The so-called "primitive measures of climate" were based on those developed by Thornthwaite in 1931 (65, p. 636-649). It was recognized that moisture availability, as far as the plant is concerned, depends not only on the amount of precipitation but also on the amount of evaporation. However, as very few weather stations maintain records on evaporation, Thornthwaite argued that evaporation is mainly a function of temperature,[1] and on the strength of this, together with the help of empirical evidence, constructed a precipitation effectiveness index. For the reason that, as far as the present study is concerned, only the moisture availability during the growing season was of interest, the size of the precipitation effectiveness index during the months when the monthly average temperature is $43^{o}F$[2] or above, was chosen as the relevant variable.

Insufficient heat is a limiting factor for plant growth just as is deficient moisture. The thermal efficiency index which Thornthwaite computed assumes that the most favorable thermal conditions will stimulate plant growth to the same extent and in the same amount as the most favorable moisture conditions. Only that part of the thermal efficiency index occurring during months when the mean temperature is more than $43^{o}F$ was considered to be of relevance in the present study.

The length of the growing season was also included although it was expected to have a high degree of correlation with the size of the

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[1]In actual fact, other factors such as vapor tension, wind and atmospheric pressure also have some influence, but Thornthwaite (65, p. 636) claimed that the exclusion of these from consideration makes no significant difference in the results.

[2]This is the temperature at which Martin and Leonard (39, p. 21) maintain that appreciable growth of most temperate crops can be detected.

thermal efficiency index as defined above.

Finally an interaction term was included in the belief that this would perhaps most accurately reflect the range of choice index.

It is hypothesized that larger values for these four variables will permit a wider range of choice and hence lower farm incomes to persist for longer periods of time than would be the case where the values are lower.

Very briefly, the disadvantages of these measures are that water losses through drainage, run-off and transpiration are not taken into account. In addition, another factor neglected is the water retention capacity of the soil. However, these measures have the advantage of simplicity in calculation and the avoidance of making suspect assumptions.

B. A second set of climatic measures utilized were those based on methodology developed later by Thornthwaite (64, p. 63-94) and Mather (66, p. 185-311). The reason for Thornthwaite's dissatisfaction with his previous measures was their failure to take account of water loss by transpiration. He notes (64, p. 56) that as water supply increases, the combined evaporation from the soil surface and transpiration from plants (i.e., commonly called evapotranspiration) rises to a maximum in a way that depends solely on the climate. This maximum which represents water need, is called potential evapotranspiration as distinct from actual evapotranspiration.[1] Since potential evapotranspiration does not represent actual transfer of water to the atmosphere but rather the transfer that would be possible under ideal conditions of soil moisture and vegetation, it usually cannot be measured directly but must be determined experimentally. One can obtain a rational definition of the moisture factor by comparing potential evapotranspiration with precipitation.

As a result of empirical investigations, Thornthwaite and Mather (66, p. 185-311) have developed an ingenious method for computing potential evapotranspiration. Consequently the following were used as measures of climate:

1. The moisture index during the growing season.[2] This is very easily calculated once the potential evapotranspiration is known.
2. The potential evapotranspiration during the growing season was used as a measure of thermal efficiency. It has the virtue of being an expression of day length as well as of temperature.

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[1] Thornthwaite (64, p. 59) has found that the rate of evapotranspiration depends on four factors, i.e., climate, soil moisture supply, plant cover and land management. Of these, the first two prove to be by far the most important.

[2] The growing season was defined slightly differently in Kansas and Oregon. See Appendix B.

3. The length of the growing season.

4. An interaction term.

It is obvious that the main advantage of these climatic measures compared with those discussed under A lies in their relative sophistication in taking into account transpiration, drainage and surface run-off. However, in order to accomplish this, it was necessary to make an assumption. This was obligatory due to the lack of more detailed information. Specifically it involved an assumption about the water availability capacity of the soil. This was assumed to be four inches, although in practice it is, of course, dependent on the depth, type and structure of the soil. However, Thornthwaite and Mather (67, p. 24) have concluded that results obtained using this assumption are comparable to those obtained when the actual water retention capacity is known.

In terms of the range of choice hypothesis, it is believed that higher values for these variables would indicate a wider range of choice, and thus lower farm earnings.

C. These climatic measures were similar to those discussed under B, with the exception that a different measure of moisture was employed. The total detention of water during the growing season was used in place of the moisture index. In order to achieve this, an additional assumption was employed, namely that only about 50% of the surplus water which is available for run-off in any month actually does run off.[1] The rest of the water is detained on the watershed and made available for run-off during the next month.

It should be noted that all the climatic measures mentioned above have been modified somewhat from those developed by Thornthwaite and Mather in that growing season measures were taken rather than including values for the whole year. In addition, it may not be amiss to mention that a possible disadvantage of all these measures of climate is that man-induced modifications of weather are not taken into account. The importance of such a factor may increase in significance in the future.

It is believed that the average weather conditions rather than those prevailing in any particular year are important in determining the range of choice. Consequently long term normal monthly temperature and precipitation data were collected for the weather stations selected as being representative of the agricultural region of each county. A list of the weather stations which were considered representative of the climatic conditions prevailing in the agricultural areas of each county in Oregon and Kansas are included in Appendix B.[2]

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[1] Thornthwaite and Mather (66, p. 193) note that this is true for large watersheds. However, for watersheds only a few square miles in area, the detention of surplus water may differ from 50%, but due to a lack of detailed information it was not possible to make an allowance for this.

[2] Together with the stations are recorded the years for which the long term monthly averages were computed.

Irrigation Variable (I_R)

The presence of the natural resource, water, is one of the necessary conditions for the support of life. Precipitation by itself is not necessarily a limiting factor in plant growth, if an alternative source of water supply exists in the form of irrigation potential. However, irrigation requires effort on the part of the human agent, if it is to have a beneficial effect on commercial plant growth and farm incomes.[1]

A suitable measure for this variable was considered to be the percentage of farm land that is irrigated. A positive correlation is expected to exist between this variable and the earnings of male farmers and farm managers.

One possible criticism of this variable is that although water itself is a natural resource, the utilization of it in irrigation necessarily implies the use of some capital. However, as mentioned previously, water by itself is of little value, and therefore if capital is a necessary prerequisite for it to be used for the benefit of mankind, then it is reasonable to argue that the variable measured should imply both elements, i.e., water and capital. The availability of

[1] A beneficial effect on farm incomes assumes that initially the marginal revenue from irrigation exceeds the marginal cost of irrigation, which is not unreasonable especially where moisture is a severely limiting factor.

water, however, is the dominant or necessary element while capital may or may not be a sufficient condition.

The capital used may come from public or private sources. Nevertheless, whatever the source, its appropriation for harnessing water for irrigation purposes must be justified to some extent in terms of the increased incomes expected to accrue to the beneficiaries of the increased water supply. It may be argued that this variable should be included in the range of choice index, but one of the assumptions underlying the range of choice hypothesis is that farmers tend to maintain traditional farming techniques, e.g., diversification, thereby making them resist change and as a result contributing to the persistence of low incomes. However, irrigation as it is practiced today is a comparatively new technique and hence if farmers are prepared to accept this, then they are also prepared to accept various other modern farming practices, which contribute to their increased welfare. In addition, there may be an element of subsidy connected with irrigation which will also have a beneficial effect on incomes. Thus, on balance it is believed that increased irrigation can be expected to have a positive effect on the earnings of male farmers and farm managers.

Land Quality Variable (Q)

Theoretical Conceptualization

The influence of land quality on agricultural income has been questioned on both theoretical and empirical grounds.

Schultz (49, p. 214) and Tang (62, p. 8-11) for example have argued in theoretical terms that it is variations in the efficiency of the factor markets rather than differences in the natural resource endowment that will determine the disparities in the levels of farm incomes among communities. For example, if the factor market is efficient (inefficient) then high (low) farm incomes will be derived from poor quality land. Consequently, Tang (62, p. 11) reasons that the relevant approach is to try to explain why factor markets persistently function with various degrees of efficiency in different communities, rather than to consider the differences in the natural endowment base. In order to seek an answer to this problem, Tang hypothesizes that the rate of economic development exerts positive influences upon the performances of the factor markets. This, of course, is one facet of the location matrix theory to be discussed in Chapter III of this study. However, in order to determine the influence of land quality on agricultural incomes, the effects of other possible determinants, e.g., efficiency of the factor markets, education, etc., must be standardized. It is believed that Tang and

Schultz have not adequately examined the influence of land quality from this angle. This does not mean that their conclusions are invalid but rather disagreement arises with respect to the introduction of differing exogenous influences which are not a direct result of varying land qualities.[1] In fact it can be shown mathematically (28, p. 98-101) that under ceteris paribus conditions varying land qualities can result in different income levels if rents are not capitalized into land.

Empirical work to determine the influence of varying land qualities has been inconclusive. Black (8, p. 348 and 351-352) has found some evidence that a higher level of fertility will have a positive influence on farm incomes, although the lower returns per acre from lower quality land appear to be compensated to some extent by a tendency towards larger sized farms. However, caution should be exercised in drawing too many implications from these results since education levels differed markedly between the counties, while the measure of farm income utilized is primitive in nature. Nevertheless, there may be some validity in these results since a more recent study by Bachmura (1, p. 351) indicates that regional farm

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[1] In fairness to Tang, it should be noted that he is concerned more with an increasing disparity of farm incomes over time, rather than the disparity existing at a certain point in time, in which the natural endowment argument could be one of the explanatory factors.

income disparities in Iowa cannot be explained to any great extent as a result of various adjustments for regional differences.[1] As a result, he advances the hypothesis (1, p. 349) that because of the lack of knowledge the capitalized value of land may not accurately reflect changes in investment (e.g., erosion control practices) or disinvestment (e.g., soil exhaustion) in the land. Due to this, regional differences in returns to farmers may arise. Unlike Black, who considered land quality in terms of fertility levels, Back (3, p. 4) has used dollar value per acre which reflects both physical productivity and locational aspects. Results presented by him (3, p. 7) indicate that gross farm income per acre increases with increases in land quality when rural farm population densities are standardized.

The above discussion implies that although the over-all significance of the land quality is not altogether clear, it is believed that a more systematic approach to ascertaining its importance is to consider it in combination with the other possible determinants of agricultural income.

Land Capability Index

For the purposes of empirical testing, land quality was defined

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[1] These included reporting on a gross rather than a net income basis and adjustments for differences in age-sex distribution and non-farm work.

solely in a natural resource sense. In other words, land quality was interpreted in terms of physical productivity (i.e., output or yield per unit of input applied to a fixed area of land), while considerations of location were ignored.[1]

For the purposes of measuring the land capability of a particular county, a weighted index was computed consisting of the number of acres in each land capability class. Broadly speaking, the land capability classes are designed to make possible "broad generalizations based on soil potentialities, limitations in use and management problems" (95, p. 73). The Soil Conservation Service (7, p. 15-16) delineates eight land capability classes, in which the risks of soil damage or limitations in use become progressively greater as one moves from class one to class eight. Classes one to three are suited for cultivation and other uses, class four is satisfactory for limited cultivation while the remainder are not generally suited for cultivation. Indeed class eight land use is restricted to recreation, wildlife, water supply or aesthetic purposes. Thus, the last capability class was not included in the following index, since farms are not likely to be situated on soil of such quality.

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[1] Denison (17, p. 91) has concluded locational aspects are far more important in determining land quality than are physical differences. The influence of location as a possible determinant of farm earnings will be considered separately.

The land capability index[1] was computed as follows:

$$Q_j = \frac{100 \sum_{i=1}^{7} C_i A_{ij}}{28 \sum_{i=1}^{7} A_{ij}}$$

where:

Q_j = land capability index in county j.

C_i = capability class i.

A_{ij} = number of 1,000 acre units of capability class i land in county j.

The way in which the land capability index was constructed means that the lower the value of the index is, the higher will be the land capability for the county as a whole. Thus, it is hypothesized that a negative relationship can be expected to exist between the land capability index and agricultural income. As suggested previously, land quality may be one of the less important determinants of the range of choice in which case a positive relationship would be expected to result. The reason for this is that land of high capability (i.e., a low capability index value) will mean a wide range of choice of enterprises is possible, therefore encouraging diversification and low incomes to persist. This, of course, assumes ceteris paribus

[1] The index was computed from land that was not owned by the Federal government.

conditions. Therefore, it is also hypothesized that under certain circumstances where the influence of the latter relationship outweighs the former, a positive sign could result on the coefficient of the land capability index.

Education Variable (E)

It is generally recognized that the amount of education and the income level are positively correlated. If this were not so, then apart for a few exceptions (e.g., where education is pursued purely for aesthetic purposes), there would be little support for educational institutions. This is obvious due to the comparatively high opportunity cost in addition to real cost involved in obtaining a formal education particularly at the higher levels.[1] The process of education can be considered as investment in the human agent, and theoretically at least, a person will pursue it until his prospective returns no longer exceed the costs of obtaining his education. It is not difficult to perceive that a higher formal education should have a beneficial effect on agricultural income, due to improving the quality of the human agent.[2]

[1] Empirical evidence presented by Schultz (53, p. 21) supports this statement.

[2] Although the treatment given here deals with education as a production good, it may be pertinent to note that the aspect of education as a consumption good has generally been ignored. It may well be, for example, that an increase in educational levels at the lower income levels will have a beneficial effect on the latter, whereas at the higher income levels the cause-effect relationship may be reversed and higher incomes instead give rise to higher educational achievement levels.

Many economists have considered in some detail the ramifications of investment in the human agent, but perhaps among the most informative have been contributions by Schultz (53), Houthakker (29, p. 24-29) and Wolfle (104). In addition, among others Denison (17, p. 67-79) and Bryant (11, p. 207-208) have shown empirically that formal education and income levels are positively correlated.

In this study two main measures of education were utilized in the empirical testing. They were as follows:

1. An index was constructed that assumed formal education is a linear function of the number of years spent in school. The validity of this assumption is supported by empirical evidence obtained by Houthakker (29, p. 25) and Denison (17, p. 68). The Census of Population for 1960 gives data on the number of persons 25 years old and over in the rural farm population who have completed a specific number of years of school. The Census divides the number of years of school completed into nine classes. Therefore, bearing the above in mind, the following weights were assigned:

Weight	Class	
0	No school years completed.	
2-1/2	Elementary:	one to four years.
5-1/2		five and six years.
7		seven years.
8		eight years.

10	High school:	one to three years
12		four years.
14	College:	one to three years.
16		four years or more.

The resulting education index was:

$$E_{xj} = \frac{100 \sum_{i=1}^{9} W_i N_{ij}}{75 \sum_{i=1}^{9} N_{ij}}$$

where:

E_{xj} = education index for county j.

W_i = weight for the i'th category, e.g., $W_6 = 10$.

N_{ij} = number of persons in the rural farm population who were 25 years old and over, in county j, who completed the number of years of school specified in category i.

2. In certain cases another measure of education was used. Specifically this was the median number of years of school completed, by persons of age 25 years and over, who were members of the rural-farm population.

Both of these measures have three possible disadvantages. First, the measures refer to the educational achievement of the rural-farm population, rather than specifically to farmers and farm managers, concerning which data were not available. Such measures necessitate the assumption that the educational attainments for farmers and farm managers are identical to those for the rural-farm population as a whole. Secondly, the measures disregard quality differentials in the formal education received while thirdly, vocational training is also excluded from these measures.

It is hypothesized that both these measures are positively correlated with income.

Age Variable (A)

Age has been considered in the literature as one of the more important determinants of income. The reasons for its significance are not difficult to discern, in that physical and mental abilities, which are closely correlated with age, are presumably of influence in determining the marginal physical product of labor. Both physical and mental abilities exhibit an increase up to middle age after which a decline sets in. Thus, if labor is remunerated according to its value of marginal productivity, one can hypothesize that the wage level will increase up to a certain age after which it will slowly decline. This hypothesis is substantiated by empirical results presented by Houthakker (29, p. 25) and by the U. S. Bureau of Census which shows that in 1959 the highest median income of men was obtained in the 35 to 44 age group (90, p. LXXXII). Bryant (11, p. 46) makes a very pertinent point concerning the fact that, while the education variables only measure formal education, age includes elements gleaned from informal education and experience.

Two measures were used in determining the impact of age on the earnings of male farmers and farm managers. They were:

1. This measure consisted of two variables, i.e., percent of operators less than 25 years old and the percent of operators 25 to 44 years old. It is hypothesized that a negative relationship exists between the first age variable and agricultural earnings and hence earnings from all sources, while a positive relationship is expected to result between the second age variable and earnings.

2. In certain cases the average age of operator was used as an alternative measure of age. In this case the direction of the relationship is in some doubt since up to a certain point an increase in average age will have a stimulating effect on earnings while the effect of a high average age may be depressing in nature.[1]

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[1]It should be noted that it was considered highly probable that a significant degree of multicollinearity would prove to exist between the education and age variables. For example, the proportion of the population which is formally educated will vary with the age distribution, due to the vastly improved educational facilities and opportunities existing at the present time compared with 30 years ago. If subsequent empirical investigation lent support to the above conjecture, then the model was accordingly modified.

Race Variable (R)

The inclusion of race as a variable is justified on the basis that Negroes, in particular, have tended to receive an inferior education compared with Caucasians. In addition to differentiation in the field of education, discrimination may also exist in the non-farm labor market. As a result the opportunity cost for Negroes in farming tends to be low, thereby encouraging them to stay in agriculture even when farm incomes are low.

A negative relationship can be expected to exist between the percentage of male farmers and farm managers who are non-white and agricultural income. Unlike areas in the South, race is not likely to be a significant variable in Oregon and Kansas where the numbers of Negroes are very low.

Variable Depicting Income From Off-Farm Employment (I_{NA})

Data were not available that directly reflected earnings of male farmers and farm managers from off-farm employment. However, an alternative measure is available which should be highly positively correlated with such earnings. This is the percentage of commercial operators who work off the farm.

An assumption was utilized in order to hypothesize what sign can be expected on the variable measuring earnings of male farmers and farm managers from off-farm employment. It was assumed, ceteris paribus, that earnings, as defined by the Census of Population (90, p. LXXIX),[1] are a function of the amount of time spent working. Since there is a definite limit that can be devoted to work in any given time period, a decision has to be made by the farmers and farm managers, concerning the allocation of time between agricultural and non-agricultural employment. However, earnings of farmers and farm managers are defined to include only those persons who derive most of their remuneration from agricultural sources. Figure 2 suggests a very high positive correlation probably exists between the total earnings of male farmers and farm managers and those derived from agricultural sources. Since most earnings are derived from agricultural sources, higher total earnings will imply higher earnings from agricultural sources and relatively lower earnings from off-farm sources. When time availability is brought into consideration, it may be hypothesized that as earnings increase from agricultural sources, those from off-farm sources will actually decrease. The reasoning behind this hypothesis will be discussed in detail later[2] but it can be mentioned at this point that this hypothesis is substantiated by empirical results for Oregon in 1959, in which a

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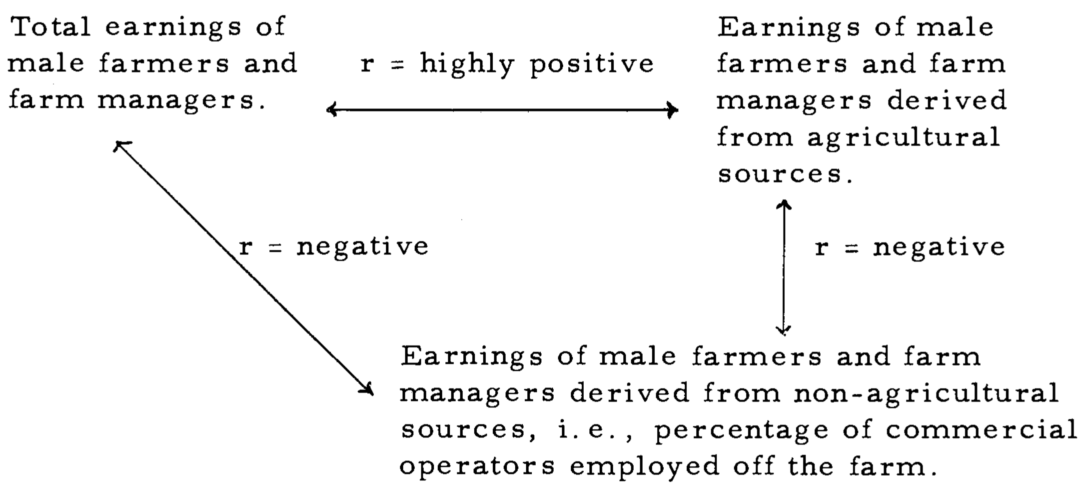
[1]See page 22 of this study.

[2]See pages 63-66.

correlation coefficient of -0.9077 existed between the real average value of products sold per operator per county and the percentage of operators working off the farm per county. This interpretation necessitates the assumption that the real average value of products sold per operator per county and earnings from agricultural sources are positively correlated.

Figure 2. Hypothesized relationships between the variables depicting earnings of male farmers and farm managers.



Thus, it is possible to hypothesize that a negative relationship will exist between total earnings of farmers and farm managers and the percentage of commercial operators working off the farm.

III. VARIABLES INFLUENCING OFF-FARM WORK BY COMMERCIAL FARM OPERATORS

The dependent variable reflecting earnings of male farmers and farm managers from off-farm sources was the same as that used as an independent variable in the equation depicting total earnings, i.e., percentage of commercial farm operators who work off the farm. This chapter is concerned with a discussion on the factors considered to be important in determining values of this variable.

Location Variable (L)

Historically the classicists almost completely ignored the problems of location,[1] as implicit in their economic theory was the assumption that all factors of production, commodities and consumers are concentrated at a single spot and therefore problems of transportation can be ignored (41, p. 319).

It is not surprising, therefore, that the area of locational theory did not develop significantly until comparatively recently. The main contributors to its evolution have been von Thünen (41, p. 320-331), Weber (41, p. 331-337), Losch (38), Roscher, Chamberlin, Predohl, Manur, etc. While von Thünen's theory concentrated on agriculture alone, the theories of Weber and Losch are

[1] Adam Smith (1723-1790) can be cited as one of the few classicists who considered location explicitly (57, p. 379-383).

more generalized in nature. In this respect the locational matrix hypothesis[1] of Schultz (49, p. 205-206) is similar to that of von Thünen's, although the similarity disappears when one considers the fact that von Thünen concentrated almost solely on the product side of the market, while the Schultzian approach emphasizes both the factor and product markets.[2]

The Location Matrix Hypothesis

Schultz (52, p. 146) and others, e.g., Tang (62, p. 11-15) have argued that the main reason for the existence of an uneven pattern of economic development within a specified area can be attributed to the influence of location on the efficiency of the factor and product markets.

Schultz (49, p. 205), who formulated the original locational matrix hypothesis,[3] has stated it as follows:

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[1]In much literature, hypothesis and theory are often used interchangeably. However, semantically these two words differ. A hypothesis refers to a tentative statement setting forth an apparent relationship among observed facts while a theory refers to such a relationship which has been repeatedly verified by independent investigators.

[2]It could be argued that von Thünen was justified in ignoring the factor side of the market in that if one assumes perfect competition in the product and factor markets, this therefore implies that variable resources are mobile among different employments. However, since the assumption of perfect competition is relaxed in the locational matrix hypothesis, the possibility of inefficiency in resource use is no longer excluded.

[3] This hypothesis has also been known as the urban-industrial hypothesis and the retardation hypothesis.

1. Economic development occurs in a specific locational matrix; there may be one or more such matrices in a particular economy. The process of economic development does not necessarily occur in the same way, at the same time, or at the same rate in different locations.
2. These locational matrices are primarily industrial-urban in composition; as centers in which economic development occurs, they are not mainly out in rural or farming areas although some farming areas are situated more favorably than are others in relation to such centers.
3. The existing economic organization works best at or near the center of a particular matrix; and it works less satisfactorily in those parts of agriculture which are situated at the periphery of such a matrix.

Schultz (52, p. 147) has commented that the major disagreement would be with respect to the third part of his hypothesis and consequently research should be directed towards determining whether this part is empirically valid.

Much literature has been published on the theoretical reasoning behind the validity of the location matrix hypothesis.[1] Consequently, it is not proposed to cover this aspect in detail. Briefly, however, variations in the efficiency of the factor markets are usually considered to be one of the most important determinants of income differentials. As a starting point, it is assumed that agriculture is poorly organized and therefore is out of adjustment in that there is

[1] Bryant (11, p. 39-45), for example, has presented a very informative discussion on the sub-hypotheses underlying the basic hypothesis that agricultural incomes are higher near the center of the matrix than on the periphery.

too much labor and too little capital engaged in agriculture.[1] Proximity to an urban industrial complex and potential non-farm job market will tend to result in an opportunity cost for farm labor which is relatively high, thereby giving rise to a higher premium (i.e., wage rate) being placed on farm labor. Thus, farmers near such matrix centers are forced to become more efficient in their use of labor and capital thereby encouraging labor to move out of agriculture and capital investment to move in. Consequently, optimum input conditions are more nearly approached, although the rapid increases in technology have contributed to making factor adjustments continuously necessary over time, if this optimum state is to be maintained. Near matrix centers, surplus labor resulting from improved technology is soon absorbed into the non-farm labor force, but in peripheral areas where off-farm employment opportunities are small, the opportunity cost of farm labor is very low. This means that the surplus remains in agriculture thereby giving rise to lower farm incomes as the optimum combination of resources is no longer attained. This situation results eventually in an increasing pressure to migrate on the part of the agricultural workers as their economic position continues to degenerate. Many investigators, however, have noted that there appear to be numerous inhibiting influences to migration. For

[1] This assumption does not appear to be unrealistic since Hathaway (26, p. 83) and others have recognized the same phenomenon.

example, some of the reasons advanced by Bachmura (2, p. 1024-1042), Brewster (10, p. 1177-1178) and Johnson (31, p. 87) are lack of financial resources, uncertainty of the unknown, distances, lack of the skills and education required in industrial jobs, closed union shops, etc. Thus, it is not surprising that farm labor tends to be immobile until their economic position reaches a certain low threshold value. Other reasons that have been advanced for the presence of income differentials are that agricultural incomes tend to be higher close to matrix centers due to lower transportation costs, better knowledge, higher education levels of the farmers and the possibility of specializing in one enterprise because of the proximity of a large consumer market.

With reference to the empirical verification of the location matrix hypothesis, many different proxy variables have been utilized resulting in some cases in conflicting conclusions. The different measures of location can perhaps be divided into three groups as those emphasizing the urban, industrial and spatial facets of the location matrix theory. Ruttan (47, p. 41), Sisler (56, p. 1105) and Bryant (11, p. 202) have all concluded that location is an important determinant of agricultural income differentials for the United States. Regionally, support for the locational matrix theory has been found in the South Piedmont by Nicholls (42, p. 339-340) and Tang (62, p. 218), in the lower Mississippi Valley by Bachmura

(2, p. 1041-1042) and in the South as a whole by Sinclair (55, p. 510-516). However, in the West, Sisler (56, p. 1105) found that in general location is not a significant factor although this conflicts with the results of Bryant (11, p. 202-203) who in using a different location measure found that even in some parts of this region, e.g., Pacific division, location still appears to be of some significance in determining median incomes of white rural farm families but not of earnings of male farmers and farm managers.

Before turning to a consideration of the measures of location utilized in this study, it may not be amiss to mention briefly four criticisms that can be advanced concerning the locational matrix hypothesis. They are:

1. Disagreement with the notion that different rates of urban-industrial development are necessary for income differentials to exist between two communities. There have, in fact, been other hypotheses advanced concerning how these income differentials may arise. Vining (102, p. 922-942) and North (43, p. 943-951), for example, have proposed such hypotheses. The range of choice hypothesis considered in this study would also fall in this category.

2. Another criticism accepts the major hypothesis that income differentials among communities are caused by the presence of locational matrices, but argues with the emphasis placed on impediments to factor mobility and market efficiency rationale. Bryant (11, p. 25)

cites Ruttan as being one of these dissenters.

3. A great deal of criticism has occurred concerning the meaning in economic terminology of various words used in the original hypothesis, e.g., "locational matrix," "urban-industrial growth," "works better," etc.

4. Another criticism which has not appeared in the literature and which is submitted to empirical verification in this study is that under certain circumstances it might be better to generalize the location matrix hypothesis. It is believed that it is the relative magnitudes of off-farm employment opportunities that determine to a large extent income differentials among agricultural communities. Usually urban-industrial centers and abundant off-farm opportunities will coincide. However, under certain special circumstances, situations may arise where abundant off-farm opportunities exist even in the absence of matrix centers. For example, the lumber industry is largely independent of urban-industrial concentrations while at the same time it can create considerable off-farm opportunities, thereby creating a market for agricultural products, encouraging efficiency in the factor markets, etc. Thus, it is hypothesized that under these circumstances it may be necessary to operationalize the location matrix hypothesis into a more generalized form, and consider the prospect that a specific matrix center may not be a necessary condition for its application, but rather the presence of off-farm

employment opportunities.

Location Measures Employed

Since most of the empirical work carried out has emphasized that the influence of location operates primarily through the labor market, e.g., Ruttan (47, p. 56), it was considered advisable to include the location measures in the equation depicting earnings from off-farm employment.

Three measures of location were utilized in the present study, all of which have been developed by other investigators. Bryant (11, p. 71-75) propounded the computational aspects of the distance and size-distance measures while Ruttan (47, p. 39) and Sisler (56, p. 1104) deserve credit for the third measure. The computational procedure underlying these variables is as follows:

A. Size-distance variable.

Each county was assigned a number determined by a combination of the size of the influencing SMSA[1] and the distance of the farthermost border of each county from the SMSA in question. Bryant (11, p. 38) notes the following hypotheses underlying this variable:

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[1]A standard Metropolitan Statistical Area (SMSA) is defined crudely as a county or a group of counties which contains at least one city of 50,000 inhabitants or more or twin cities with a combined population of at least 50,000 (90, p. XXXI).

(a) The influence of any SMSA on incomes of nearby communities is a joint linear function of the distance between the community and SMSA and of the population size of the city.

(b) SMSA's with populations of two million or more have similar influences on neighboring counties.

(c) An SMSA of two million or more extends its influence up to a maximum of 450 miles.

Numbers to assign to SMSA counties were calculated as follows:

SMSA population	Number assigned
50,000 - 99,999	0.5
100,000 - 199,999	1.0
200,000 - 299,999	2.0
|	|
2,000,000 or more	20.0

The number assigned to a county between X and (X + 50) miles from an SMSA was two less than the number assigned to a county between (X - 50) and X miles from the SMSA. Thus, every county was assigned a number from zero to twenty.

The same procedure was followed as Bryant (11, p. 73), in that where one county could be assigned two values, the one actually assigned was the higher of the two. Also where one SMSA was in the influence of another SMSA, the value of the SMSA county plus the value derived from the influencing SMSA was assigned to the county, subject to the constraint that the value assigned could not be greater than the value assigned to the influencing county.

A positive relationship can be expected to exist between this variable and the percentage of operators working off the farm.

B. The distance variable.

Each county was assigned a number corresponding to the distance it was from the SMSA. Bryant (11, p. 37-38) lists the following hypotheses underlying the use of this variable:

(a) A linear function exists between incomes of nearby counties and the distance of the county from the SMSA.

(b) Size of the SMSA has no influence on the incomes of nearby counties.

Thus, each county was assigned a number determined by the distance of the SMSA from the farthermost border of the county, i.e.

Distance of county from the SMSA county (miles)	Number assigned
0	0
1 - 50	1
51 - 100	2
⋮	⋮
350 - 400	8

Owing to the method of computing this measure, a negative relationship can be expected to exist between this location variable and the percentage of commercial operators working off the farm.

These two measures of location were utilized primarily because it is believed that they most accurately reflect the original hypothesis advanced by Schultz. However, one possible disadvantage concerning these variables as constructed is that urban areas with populations of less than 50,000 are ignored which may not be too realistic in sparsely populated areas, such as exist in the West. Bryant (11, p. 37) appears to justify his use of the variables on the basis that for the U. S. in 1960, 70% of the population were urban residents, and of these, 76% resided in urbanized areas.[1] However, in Oregon in 1960, only 62% were urban residents and of these only 64% resided in urbanized areas thus tending to imply a limitation on the use of the variables in the West where relatively few cities attain SMSA status.

C. Percentage of the population that is non-farm.

Ruttan (47, p. 40) has noted that the main advantage of this measure is that it is a relative measure and is well adapted to handling different sized areas. In addition, it is believed that this measure provides a crude means for testing in an empirical manner the validity of the criticism mentioned earlier in this chapter.[2] A

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[1] An urbanized area contains at least one city of 50,000 inhabitants or more, as well as the surrounding densely populated areas which meet certain specified conditions (90, p. XXVI).

[2] See page 58.

positive relationship can be expected to exist between this variable and the percentage of commercial farm operators working off the farm.

It is hoped that from the empirical results some idea will be gleaned as to what facet of location is important as far as agriculture is concerned in Oregon and Kansas, e.g., is distance, or a combination of size of city and distance important or is it simply the presence of off-farm employment possibilities, therefore necessitating a generalization of the conventional locational matrix theory. There is no reason to suppose that identical conclusions will be reached for Oregon and Kansas.

Time Availability Variable (T)

As was mentioned earlier, two factors are considered to be important in determining earnings from off-farm sources,[1] if one assumes ceteris paribus conditions, e.g., similar age, educational achievements, job opportunities, etc. These are earnings from agricultural sources and time availability for off-farm employment. It is hypothesized that the higher are the earnings of farmers and managers from agricultural sources, the lower will be the amount of

[1]See pages 49-51.

time available for off-farm employment,[1] therefore lower will be the percentage of commercial farm operators who work off the farm and consequently lower will be the earnings from such sources.

This hypothesis can be visualized conceptually in the following simplified model:

Assume (a) Two farmers (A and B) who behave rationally.

(b) They fulfill optimum resource allocation criteria.

(c) They produce a homogenous product under perfectly competitive conditions.

(d) The off-farm wage rate offered both farmers is the same, due to the ceteris paribus conditions mentioned above.

(e) The labor productivities of the farmers on their own farms differ due to differing capital intensities, land quality, etc.

(f) They are each prepared to work a maximum of x hours per day.

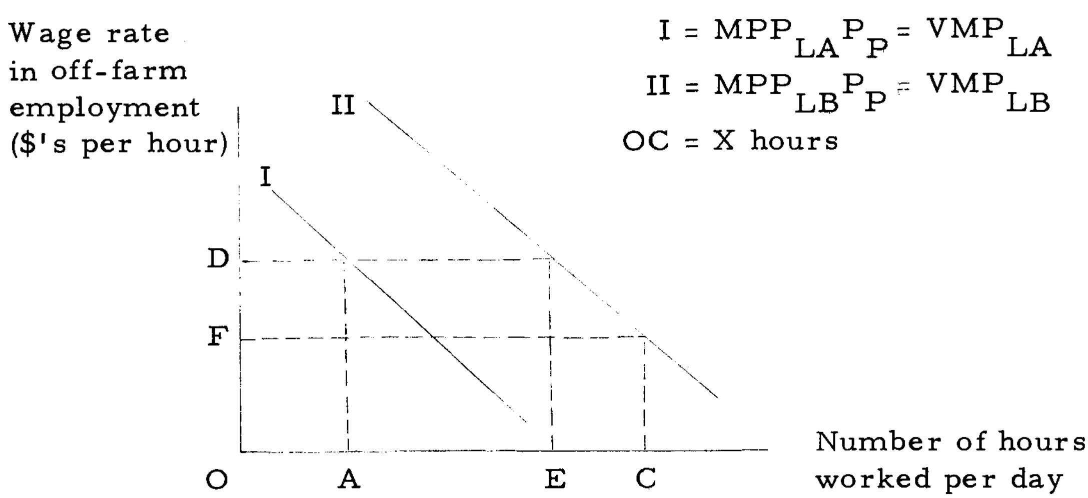
Figure 3 shows diagrammatically that when the off-farm wage rate is OD dollars per hour,[2] farmer A, due to the lower

[1]In addition, a person receiving satisfactory earnings from agriculture will probably decrease the total number of hours he is willing to work, thereby cutting down even further his time availability for off-farm employment.

[2]One of the factors affecting off-farm wage rates will be the demand for non-farm labor which is determined to some extent by location.

productivity of his on-farm labor works only OA hours on his farm and AC hours in off-farm employment, while farmer B only works EC hours off the farm and the remainder on the farm. In fact, if the off-farm wage rate falls below OF farmer B will cease to work off the farm.[1]

Figure 3. Time available for off-farm employment.



This serves to illustrate the fact that the higher the productivity of a farmer's on-farm labor is, the higher will be his earnings from agricultural sources and therefore lower will be the amount of time he is willing or able to devote to off-farm employment and hence

[1] A relaxation of assumptions (c), (d) and (f) will not alter the basic hypothesis in any way.

lower will be the earnings from such sources.

Two measures designed to reflect the amount of time availability for off-farm employment were used in the empirical investigation. These were:

1. Average value of land and buildings per commercial farm per county.
2. Average specified expenditures per commercial farm per county.

Unfortunately, both measures have disadvantages. In the case of the expenditure measure by no means all the expenditures committed by the farmer are included[1] while the value measure is determined by so many factors outside of the control of the farmer,[2] that the resulting interpretation may be somewhat suspect.

Higher values for these measures indicate less time available for off-farm employment, and therefore a negative relationship can be expected to exist between these measures and the percentage of commercial operators working off the farm.

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[1]Specified expenditures include livestock and poultry feed and purchases, machine hire, hired labor, gas and oil, and seeds, bulbs, plants and trees. In Iowa, Bachmura (1, p. 345) has found such expenses amount to 46% of total expenses.

[2]Scharlach and Schuh (48, p. 49) found in Indiana that value of land and buildings per acre is determined by population density, specified farm expenditures per acre, distance from Chicago, weighted index of land capability, farm wage rate and property tax rate.

Age (A), Education (E) and Race (R) Variables

The reasons for their inclusion and the expected signs on the coefficients are identical to those discussed with respect to their presence in the equation depicting the median earnings of male farmers and farm managers.[1]

Specific Models Used in the Empirical Investigation

From the foregoing theoretical development, three models were constructed to explain the earnings of male farmers and farm managers. The models differ with respect to the measures of climatic variables used.

Since the equations representing earnings from off-farm sources are identical in all three models, these are presented first.

Equation 2A

$$O_{PC} = g_1(L_{SD}, T_E, A_P^1, A_P^2, E_X, R_A)$$

where:

O_{PC} = percentage of commercial operators who work off the farm per county.

L_{SD} = size-distance measure of location of county.

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[1]See pages 44-49 of this study.

Table 4. Summary of the hypothesized signs on the variables to be included in the empirical analysis.

Variable	Model I Equation 1	Model II Equation 1	Model III Equation 1	Equation 2A	2B	2C
I_R	+	+	+			
Q	+ or -	+ or -	+ or -			
P_{EG}	-					
M_{XG}		-				
T_{DG}			-			
T_{HG}	-					
P_{EVG}		-	-			
G_S	-	-	-			
I_N^1	-					
I_N^2		-				
I_N^3			-			
R_A	-	-	-	-	-	-
E_X	+	+	+	+	+	+
A_P^1	-	-	-	-	-	-
A_P^2	+	+	+	+	+	+
O_{PC}	-	-	-			
L_{SD}				+		
L_D					-	
L_{NF}						+
T_E				-	-	-

T_E = average specified expenditures per commercial farm per county.

A_P^1 = percentage of farm operators in the county who are less than 25 years old.

A_P^2 = percentage of farm operators in the county who are 25-44 years of age.

E_X = education index of the rural farm population (age 25 years or more) of the county.

R_A = percentage of male farmers and farm managers in the county who are non-white.

Equation 2B

$$O_{PC} = g_2(L_D, T_E, A_P^1, A_P^2, E_X, R_A)$$

where:

L_D = distance measure of location of county.

Equation 2C

$$O_{PC} = g_3(L_{NF}, T_E, A_P^1, A_P^2, E_X, R_A)$$

where:

L_{NF} = percentage of the population of the county who are non-farm residents.

Model I

Equation 1

$$E_T = f(I_R, Q, P_{EG}, T_{HG}, G_S, I_N^1, R_A, E_X, A_P^1, A_P^2, O_{PC})$$

where:

E_T = median earnings of male farmers and farm managers in the county.

Q = land capability index of the county.

P_{EG} = precipitation effectiveness of the county during the months when the mean temperature is 43°F or more.

T_{HG} = thermal efficiency of the county during the months when the mean temperature is 43°F or more.

G_S = length of the growing season of the county.

I_N^1 = interaction term.

Model II

Equation 1

$$E_T = h(I_R, Q, M_{XG}, P_{EVG}, G_S, I_N^2, R_A, E_X, A_P^1, A_P^2, O_{PC})$$

where:

M_{XG} = moisture index of the county during the growing season.

P_{EVG} = potential evapotranspiration of the county during the growing season.

I_N^2 = interaction term.

Model III

Equation 1

$$E_T = k(I_R, Q, T_{DG}, P_{EVG}, G_S, I_N^3, R_A, E_X, A_P^1, A_P^2, O_{PC})$$

where:

T_{DG} = total detention of water of the county during the growing season.

I_N^3 = interaction term.

IV. RESULTS OF EMPIRICAL ANALYSIS FOR OREGON

The equations in the models presented at the end of the preceding chapter were estimated using stepwise regression. The majority of the computations underlying the estimation procedure were performed on an IBM 1410 Computer.

Since this study is concerned with structural rather than predictive aspects, both the step where the standard error of estimate is at a minimum and the final estimating step are presented for each model. For purposes of conciseness, the step at which the standard error of estimate is at a minimum is denoted as the minimum step equation.

Due to the lack of data on earnings of male farmers and farm managers, six counties were excluded from the analysis. These were Clatsop, Curry, Gilliam, Harney, Lincoln and Wheeler. Since these are widely distributed throughout the state, it was believed that no significant bias resulted from their exclusion. The omission of these counties resulted in the empirical analysis being performed with a sample of 30 counties.

Equation 1 for each of the models is considered first, followed by a discussion on equation 2, which is identical for the three models.

Median Earnings of Male Farmers and Farm Managers Equation

Model I

Preliminary analysis indicated that a high degree of multicollinearity (r=0.7246) existed between the thermal efficiency during the growing season and the length of growing season. This was to be expected since the value of the former variable will become progressively larger as the growing season lengthens. Consequently, the length of the growing season was eliminated from the model, because it was believed that it would be reflected in the value computed for the thermal efficiency index during the growing season. In addition, as expected, a high degree of multicollinearity (r=0.9924) proved to exist between the precipitation effectiveness during the growing season and the climatic interaction term. This was due to the method of computation of values of the latter variable, i.e., precipitation effectiveness index during the growing season times the thermal efficiency during the growing season. As a result, two variants of model I (equations 1a and 1b) were estimated, one with the inclusion of the precipitation effectiveness during the growing season and one with the climate interaction term.

Therefore, the stepwise regressions that were actually estimated were as follows:

Equation 1a

$$Y_1 = b_0 + b_1 Y_2 + b_2 X_1 + . . . + b_9 X_8 + U$$

where:

Y_1 = median earnings of male farmers and farm managers in the county.

Y_2 = percentage of commercial farm operators in the county who work off the farm.

X_1 = percentage of farm operators in the county who are less than 25 years old.

X_2 = percentage of farm operators in the county who are 25-44 years old.

X_3 = education index of members of the rural farm population in the county who are 25 years old or more.

X_4 = percentage of the male farmers and farm managers in the county who are non-white.

X_5 = percentage of the farm land in the county which is irrigated.

X_6 = weighted index of the land capability in the county.

X_7 = thermal efficiency of the county during the months when the mean temperature is 43°F or more.

X_8 = precipitation effectiveness of the county during the months when the mean temperature is 43°F or more.

Equation 1b

$$Y_1 = b_0 + b_1 Y_2 + b_2 X_1 + \ldots + b_8 X_7 + b_{10} X_9 + U$$

where:

Y_1, Y_2, X_1 . . . X_7 are the same as above.

X_9 = climate interaction term (i.e., X_7 times X_8).

The results for these equations are shown in Tables 5 and 6. The signs on all the coefficients in the two equations are consistent with those hypothesized in the theoretical development of Chapters II and III. Off-farm employment, education and the percentage of commercial operators between the ages of 25 and 44 proved to be most significant.

The negative signs of the land capability index indicated that the range of choice element contained in this variable was not dominant. In fact, the over-all significance of the variables depicting the range of choice hypothesis appeared to be negligible, since none of them were present in the minimum step model of equation 1a, while only the climate interaction term, with a non-significant T value, appeared in the minimum step part of equation 1b. These conclusions were confirmed by the following results of an F test:

Equation 1b

Ho: $b_8 = b_{10} = 0$

Table 5. Median earnings of male farmers and farm managers equation. Model I. Equation 1a. Oregon, 1959.

Variable	Minimum step equation			Full equation		
	Partial regression coefficients	T values	Beta coefficients	Partial regression coefficients	T values	Beta coefficients
Constant	-5113.9900			-4070.7900		
Y_2	-39.8181	-2.8640**	-0.3711	-42.0376	-2.3485*	-0.3918
X_1				-289.8680	-0.7578	-0.1068
X_2	103.6910	2.7211**	0.3729	108.9570	2.1568*	0.3918
X_3	56.2093	2.7130**	0.3589	500.2710	2.1708*	0.3194
X_4				-54.8101	-0.9366	-0.1354
X_5				8.0216	0.4704	0.0720
X_6	-58.8527	-1.1449	-0.1488	-43.5796	-0.7657	-0.1102
X_7				-3.0891	-0.1237	-0.0246
X_8				-2.9432	-0.7248	-0.1301
		R = 0.7854** R^2 = 0.6168 S_{yx} = 128.9720			R = 0.8107** R^2 = 0.6573 S_{yx} = 136.3750	

* Significantly different from zero at the 5% level.

** Significantly different from zero at the 2% level.

Table 6. Median earnings of male farmers and farm managers equation. Model I. Equation 1b. Oregon, 1959.

Variable	Minimum step equation			Full equation		
	Partial regression coefficients	T values	Beta coefficients	Partial regression coefficients	T values	Beta coefficients
Constant	-5438.7500			-4104.6900		
Y_2	-40.4562	-2.9304**	-0.3771	-42.8324	-2.4510	-0.3986
X_1				-296.4350	-0.7745	-0.1091
X_2	87.9136	2.3801*	0.3161	106.9130	2.1610*	0.3838
X_3	556.9510	2.6806**	0.3556	503.2420	2.1983*	0.3211
X_4				-53.3333	-0.9205	-0.1316
X_5				8.3140	0.4894	0.0746
X_6				-41.6946	-0.7269	-0.1053
X_7				-1.9057	-0.0745	-0.0152
X_9	-0.0584	-1.1519	-0.1488	-0.0537	-0.7519	-0.0137
	$R = 0.7855$**			$R = 0.8111$**		
	$R^2 = 0.6171$			$R^2 = 0.6579$		
	$S_{yx} = 128.9320$			$S_{yx} = 136.2430$		

* Significantly different from zero at the 5% level.

** Significantly different from zero at the 2% level.

Results:

Analysis of Variance

Source of Variation	Degrees of freedom	Sums of squares (SS)	Mean squares (MS)
Regression SS of complete model ($\hat{b}_0 \ldots \hat{b}_8, \hat{b}_{10}$)	9	20, 709, 300	
Regression SS of reduced model ($\hat{b}_0 \ldots \hat{b}_7$)	7	20, 153, 700	
Added SS due to $\hat{b}_8, \hat{b}_{10}$	2	555, 600	277, 800
Residual SS of complete model	20	10, 766, 000	538, 300
Total	29	31, 475, 400	

F = 0.5161 is not significant at the 5% level.

Conclusion: Accept the hypothesis.

A similar F test to test that b_8 and b_9 in equation 1a were equal to zero, yielded a value of 0.4956 which is also not significant at the 5% level. However, although the range of choice hypothesis does not appear to be quantitatively significant in this model for Oregon, the signs on the coefficients depicting this hypothesis are consistent with the underlying theory.

Model II

Similar intercorrelation relationships to those in model I were detected between the climatic variables. More specifically and for the same reasons as in model I, a correlation coefficient of 0.9944 proved to exist between the moisture index during the growing season and the climatic interaction term, while a correlation coefficient of 0.8736 existed between the length of the growing season and the potential evapotranspiration during the growing season. Consequently, an analogous reasoning was used in estimating two variants of model II. They were as follows:

Equation 1a

$$Y_1 = b_0 + b_1 Y_2 + b_2 X_1 + \ldots + b_7 X_6 + b_{11} X_{10} + b_{12} X_{11} + U$$

where:

Y_1, Y_2, X_1 . . . X_6 are defined the same as in model I.

X_{10} = potential evapotranspiration of the county during the period when the temperature last reaches 28°F in the spring and the first time it is attained in the fall.

X_{11} = moisture index of the county during the period when the temperature last reaches 28°F in the spring and the first time it is attained in the fall.

Equation 1b

$$Y_1 = b_0 + b_1 Y_2 + b_2 X_1 + \ldots + b_7 X_6 + b_{11} X_{10} + b_{13} X_{12} + U$$

where:

Y_1, Y_2, X_1 . . . X_{10} are the same as in equation 1a.

X_{12} = climate interaction term (i.e., X_{10} times the sum of X_{11} and 50).[1]

The results obtained for these equations (see Table 7)[2] proved to be very similar to those derived for model I. Once again off-farm employment, the percentage of commercial farm operators between 25 and 44 years of age and educational achievement proved to be the most significant determinants of earnings of male farmers and farm managers.

An F test to determine the significance of the range of choice variables, neither of which appeared in the minimum step equation, gave rise to the following results:

Equation 1b

Ho: $b_{11} = b_{13} = 0$

---

[1] The reason for the addition of 50 is explained in Appendix B.

[2] Since the minimum step equations were exactly the same as those obtained for the minimum step equation of equation 1a in model I (see Table 5), these were omitted from Table 7.

Table 7. Median earnings of male farmers and farm managers equation. Model II. Equations 1a and 1b. Oregon, 1959.

Variable	Final step of equation 1a			Final step of equation 1b		
	Partial regression coefficients	T values	Beta coefficients	Partial regression coefficients	T values	Beta coefficients
Constant	-3059.0700			-2995.9100		
Y_2	-45.1444	-2.6399**	-0.4207	-45.2083	-2.6661**	-0.4213
X_1	-243.5520	-0.6480	-0.0898	-243.4570	-0.6489	-0.0897
X_2	94.6229	1.9796	0.3403	93.8314	1.9811	0.3374
X_3	530.6280	2.2641*	0.3387	528.5480	2.2268*	0.3374
X_4	-53.1240	-0.9388	-0.1312	-52.0884	-0.9197	-0.1287
X_5	10.2586	0.5934	0.0921	10.0735	0.5846	0.0905
X_6	-67.0224	-1.0132	-0.1695	-66.2530	-1.0107	-0.1676
X_{10}	-35.5216	-0.6133	-0.1271	-33.5392	-0.5745	-0.1200
X_{11}	-1.1057	-0.2912	-0.0501			
X_{12}				-0.0549	-0.3445	-0.0598
	$R = 0.8101$** $R^2 = 0.6562$ $S_{yx} = 136.5880$			$R = 0.8104$** $R^2 = 0.6568$ $S_{yx} = 136.4730$		

* Significantly different from zero at the 5% level.

** Significantly different from zero at the 2% level.

Results:

Analysis of Variance

Source of variation	Degrees of freedom	SS	MS
Regression SS of complete model ($\hat{b}_0 \ldots \hat{b}_7, \hat{b}_{11}, \hat{b}_{13}$)	9	20,672,800	
Regression SS of reduced model ($\hat{b}_0 \ldots \hat{b}_7$)	7	20,153,700	
Added SS due to $\hat{b}_{11}, \hat{b}_{13}$	2	519,100	259,500
Residual SS of complete model	20	10,802,600	540,130
Total	29	31,475,400	

F = 0.4795 is not significant at the 5% level.

Conclusion: Accept the hypothesis.

A similar F test to test the hypothesis that b_{11} and b_{12} in equation 1a were equal to zero yielded a value of 0.4629 which is also not significant at the 5% level.

From these results it is permissible to conclude that in Oregon in 1960, the range of choice had no significant influence on the earnings of male farmers and farm managers.

Model III

As a result of preliminary investigations the climatic variables were once again found to exhibit a high degree of multicollinearity. For example, a correlation coefficient value of 0.9952 proved to exist between the total detention of water during the growing season and the climatic interaction term.

Consequently, for reasons identical to those presented in model I, two variants of model III were estimated. They were:

Equation 1a

$$Y_1 = b_0 + b_1 Y_2 + b_2 X_1 + \ldots + b_7 X_6 + b_{11} X_{10} + b_{14} X_{13} + U$$

where:

Y_1, Y_2, X_1 . . . X_6, X_{10} are the same as in models I and II.

X_{13} = total detention of water during the period when the temperature last reaches 28^{o}F in the spring and the first time it is attained in the fall.

Equation 1b

$$Y_1 = b_0 + b_1 Y_2 + b_2 X_1 + \ldots b_7 X_6 + b_{11} X_{10} + b_{15} X_{14} + U$$

where:

Y_1, Y_2, X_1 . . . X_6, X_{10} are the same as in equation 1a.

X_{14} = climate interaction term (i.e., X_{13} times X_{10}).

Once again the results were comparable to those obtained in models I and II, in that off-farm employment, education and percentage of commercial farm operators of age 25 to 44 were still most significant (see Tables 8 and 9). The remaining variables making up the equation, in which the standard error of estimate was at a minimum, were the land capability index and the measure of moisture.

Nevertheless, as the following results indicate, the significance of the range of choice hypothesis in Oregon is questionable.

Equation 1b

Ho: $b_{11} = b_{15} = 0$

Results:

Analysis of Variance

Source of variation	Degrees of freedom	SS	MS
Regression SS of completed model ($\hat{b}_0 \ldots \hat{b}_7, \hat{b}_{11}, \hat{b}_{15}$)	9	20,880,800	
Regression SS of reduced model ($\hat{b}_0 \ldots \hat{b}_7$)	7	20,153,700	
Added SS due to $\hat{b}_{11}, \hat{b}_{15}$	2	727,100	363,550
Residual SS of complete model	20	10,594,500	529,729
Total	29	31,475,540	

F = 0.6863 is not significant at the 5% level.

Conclusion: Accept the hypothesis.

A similar F test in equation 1a that b_{11} and b_{14} equal zero,

Table 8. Median earnings of male farmers and farm managers equation. Model III. Equation 1a. Oregon, 1959.

Variable	Minimum step equation			Full equation		
	Partial regression coefficients	T values	Beta coefficients	Partial regression coefficients	T values	Beta coefficients
Constant	-3930.2400			-3057.4200		
Y_2	-38.4864	-2.7834**	-0.3587	-43.6159	-2.5478**	-0.4065
X_1				-244.2540	-0.6561	-0.0900
X_2	93.4324	2.4121*	0.3360	95.8877	2.0310*	0.3448
X_3	508.1800	2.4169*	0.3244	507.4970	2.1752*	0.3240
X_4				-51.6499	-0.9186	-0.1276
X_5				8.5919	0.4983	0.0772
X_6	-59.0055	-1.1579	-0.1492	-62.9572	-0.9893	-0.1592
X_{10}				-22.9052	-0.3837	-0.0820
X_{13}	-8.5014	-1.1990	-0.1596	-5.9343	-0.6209	-0.1114
		R = 0.7991**			R = 0.8132**	
		R^2 = 0.6385			R^2 = 0.6613	
		S_{yx} = 127.8570			S_{yx} = 135.5780	

* Significantly different from zero at the 5% level.

** Significantly different from zero at the 2% level.

Table 9. Median earnings of male farmers and farm managers equation. Model III. Equation 1b. Oregon, 1959.

Variable	Minimum step equation			Full equation		
	Partial regression coefficients	T values	Beta coefficients	Partial regression coefficients	T values	Beta coefficients
Constant	-3752.6900			-3019.5200		
Y_2	-38.9757	-2.8415**	-0.3633	-43.7348	-2.5859**	-0.4076
X_1				-243.2200	-0.6556	-0.0896
X_2	89.6657	2.2972*	0.3224	93.9488	2.0077	0.3378
X_3	508.5460	2.4427*	0.3246	504.7070	2.1835*	0.3222
X_4				-49.3264	-0.8768	-0.1218
X_5				8.2563	0.4816	0.0742
X_6	-60.5901	-1.1956	-0.1532	-62.4182	-0.9907	-0.1579
X_{10}				-19.5578	-0.3284	-0.0700
X_{14}	-0.3865	-1.3186	-0.1762	-0.2837	-0.7167	-0.1293
		R = 0.8017**			R = 0.8145**	
		R^2 = 0.6427			R^2 = 0.6634	
		S_{yx} = 127.1070			S_{yx} = 135.1530	

* Significantly different from zero at the 5% level.

** Significantly different from zero at the 2% level.

gave a value of 0.6195 which is not significant at the 5% level.

Additional Analysis

Alternative definitions for some of the variables included in the preceding analysis were utilized, in order to discern whether or not they contributed supplementary information to that already obtained. For example, in model I the length of the growing season was calculated[1] rather than using figures given by Johnsgard (30, p. 18-125). In addition, an alternative measure of education was tested which was similar to that utilized by Bryant (11, p. 69), i.e., the percentage of the rural farm population 25 years old and over who received zero to six years of schooling and those receiving six to twelve years of schooling. As a result of empirical testing, it was found that these alternative measures of education and length of growing season added nothing more to those already obtained.

Percentage of Commercial Farm Operators Employed Off the Farm Equation

Considerable emphasis in the previous chapter was devoted to a theoretical justification for the variables considered to be

[1] The calculation involved taking the average number of days between the last 28°F weather in the spring and the first in the fall, for the period 1949-1960.

important in determining earnings of male farmers and farm managers from off-farm sources. Preliminary investigations revealed no obstacles to utilizing the equations which had been theoretically formulated. Consequently, the following equations were estimated:

Equation 2A

$$Y_2 = b_0 + b_1X_1 + \ldots + b_4X_4 + b_{15}X_{15} + b_{16}X_{16} + U$$

where:

Y_2, $X_1 \ldots X_4$ are defined the same as in the preceding section.[1]

X_{15} = average value of land and buildings per farm in the county.

X_{16} = size-distance measure of location of the county.

Equation 2B

$$Y_1 = b_0 + b_1X_1 + \ldots + b_4X_4 + b_{15}X_{15} + b_{17}X_{17} + U$$

where:

X_{17} = distance measure of location of the county.

Equation 2C

$$Y_1 = b_0 + b_1X_1 + \ldots + b_4X_4 + b_{15}X_{15} + b_{18}X_{18} + U$$

where:

X_{18} = percentage of the total population of the county who are non-farm residents.

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[1]See page 74.

The results of the above regression equations (see Tables 10 to 12) revealed that time available for off-farm employment appeared to be one of the more important determinants of the percentage of commercial farm operators who work off the farm.[1] This is a reasonable result since a large amount of time available for off-farm employment carries with it the implication of relatively low earnings from agricultural pursuits, thereby necessitating an augmentation of total earnings from off-farm sources. However, although time availability for off-farm employment appears to be a necessary condition for such sources of income, other factors appear to be of importance in the determination of the size of such earnings.

Foremost among these is location. In the case of Oregon, both the distance and the size-distance variables, with their emphasis on the location of Standard Metropolitan Statistical Areas, proved to be statistically insignificant. However, the measure designed to test whether or not the conventional locational matrix theory needs to be generalized, proved to be of significance. The significance of this

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[1] This comment assumes that the average value of land and buildings is actually a satisfactory measure of time availability. An alternative measure of time availability, i. e., average specified expenditures per farm in the county (X_{19}), gave results (see Table 35 in Appendix C) that were not entirely consistent with those presented above. Unfortunately, as was discussed earlier (see page 66), there is no definite basis for deciding which of these two proxy variables is the superior measure of time available for off-farm employment.

Table 10. Equation depicting the percentage of commercial farm operators who are employed off the farm. Equation 2A. Oregon, 1959.

Variable	Minimum step equation			Full equation		
	Partial regression coefficients	T values	Beta coefficients	Partial regression coefficients	T values	Beta coefficients
Constant	8.5285			6.4069		
X_1				-0.9546	-0.2342	-0.0377
X_2				0.1812	0.4045	0.0699
X_3	3.5224	1.4920	0.2413	3.2227	1.2700	0.2207
X_4	-0.6455	-1.1999	-0.1710	-0.7167	-1.1860	-0.1899
X_{15}	-0.00023	-4.9480**	-0.7943	-0.00023	-4.1482**	-0.7832
X_{16}				0.2250	0.4475	0.0779
	R = 0.7069**			R = 0.7133**		
	R^2 = 0.4997			R^2 = 0.5088		
	S_{yx} = 0.1347			S_{yx} = 1.4190		

** Significantly different from zero at the 2% level.

Table 11. Equation depicting the percentage of commercial farm operators who are employed off the farm. Equation 2B. Oregon, 1959.

	Minimum step equation			Full equation		
Variable	Partial regression coefficients	T values	Beta coefficients	Partial regression coefficients	T values	Beta coefficients
Constant	8.5285			9.9737		
X_1				-1.3807	-0.3527	-0.0545
X_2				0.1677	0.3711	0.0647
X_3	3.5224	1.4920	0.2413	3.1780	1.2312	0.2177
X_4	-0.6455	-1.1999	-0.1710	-0.7110	-1.1663	-0.1884
X_{15}	-0.00023	-4.9480**	-0.7943	-0.00023	-4.2031**	-0.7950
X_{17}				-2.3824	-0.2674	-0.0451
		R = 0.7069**			R = 0.7113**	
		R^2 = 0.4997			R^2 = 0.5060	
		S_{yx} = 1.3469			S_{yx} = 1.4230	

** Significantly different from zero at the 2% level.

Table 12. Equation depicting the percentage of commercial farm operators who are employed off the farm. Equation 2C. Oregon, 1959.

Variable	Minimum step equation			Full equation		
	Partial regression coefficients	T values	Beta coefficients	Partial regression coefficients	T values	Beta coefficients
Constant	-38.5687			-42.1495		
X_1				-0.1087	-0.0284	-0.0043
X_2	0.5211	1.0581	0.2010	0.5923	1.1626	0.2285
X_3	3.2428	1.4036	0.2221	3.6130	1.4895	0.2475
X_4				-0.5384	-0.9134	-0.1427
X_{15}	-0.00019	-3.7830**	-0.6452	-0.00020	-3.7432**	-0.6941
X_{18}	0.3606	1.8282*	0.3791	0.3316	1.5589	0.3486
	R = 0.7311**			R = 0.7428**		
	R^2 = 0.5345			R^2 = 0.5518		
	S_{yx} = 1.3249			S_{yx} = 1.3554		

* Significantly different from zero at the 10% level.

** Significantly different from zero at the 2% level.

measure, i.e., percentage of the population of the county who are non-farm residents, was expected to be important in Oregon where off-farm employment opportunities often exist in the lumber industry. As was mentioned earlier, such an industry is not dependent for its existence on urban concentrations, and therefore it is believed that the locational matrix theory should be modified in areas where such unique employment opportunities exist.

Other factors that appeared to be of some significance in determining off-farm employment in Oregon were education and race. The beta coefficient values indicate that the age variables, size and size distance measures of location were least important. Nevertheless, in spite of the relative insignificance of some of the variables, all the signs on the coefficients are consistent with the theoretical development of Chapter III.

One of the possible disadvantages of the variable measuring the percentage of the population which is non-farm is that there are considerable numbers of farmers and farm managers who live off the farm.[1] In order to verify the importance of this measure of location,

[1] In Oregon in 1960, 20.291% of the farmers and farm managers did not live on farms.

the variable was adjusted to take account of this phenomenon.[1] The results, using the adjusted location variable (X_{20}) as shown in Table 34 in Appendix C, are very comparable to those using the unadjusted variable (X_{18}). This similarity serves to verify the conclusions concerning the desirability of generalizing the location matrix theory.

It could be hypothesized that location may play a more critical role in cases where a significant proportion of a farmer's earnings are obtained from off-farm sources, than in cases where less time is devoted to off-farm employment. Bearing this in mind, the dependent variable was substituted by a measure depicting the percentage of commercial operators who work more than 100 days off the farm (Y_3). The results shown in Table 36 of Appendix C indicate that the relative significance of the location variables appear to be unchanged. The implicit conclusion from this cursory analysis is that location is an important factor in obtaining off-farm employment irrespective of the amount of time that is devoted to such sources of earnings.

Concerning the influence of other variables in determining the

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[1] Since the average size of rural farm families in Oregon in 1960 was 3.62, the numbers of farmers and farm managers who were non-farm residents were multiplied by this figure and the results were added to the rural farm population statistics. Consequently, it was possible to compute the percentage of the population that were not farm residents and who were not farmers and farm managers living off the farm. It is, of course, recognized that this is a crude adjustment since it still does not account for farm workers who live off the farm. However, at the same time it is believed that it contributes to making the statistic more realistic.

percentage of commercial farmers and farm managers who work more than 100 days off the farm, there appears to be some evidence that the relative significance of time availability and race are greater than when less time is devoted to off-farm sources of employment.

Summary and Conclusions

From the analytical results discussed in this chapter, it appears that the main determinants of male Oregon farmer and farm manager earnings in 1959 were earnings derived from off-farm sources, the percentage of commercial farm operators who were of ages 25-44 and the formal education received by the commercial farm operators themselves. Land capability appeared to be of somewhat more marginal importance in deriving its significance from sources other than the range of choice aspect.

The over-all insignificance of the climatic variables places in some doubt the importance of the range of choice hypothesis in determining earnings of male farmers and farm managers in Oregon. Nevertheless, the range of choice hypothesis is at best suggestive and it may be that it has some significance that has not been explicitly isolated in this study. For example, the climatic variables may be unsatisfactory measures of this hypothesis. This may be particularly the case in Oregon where the counties are so large that one county may fall in more than one climatic zone, thereby complicating the task of choosing one weather station which is representative of the climatic conditions in the main agricultural part of the county. However, in spite of the limited number of observations (i.e., 30) the signs were consistent with the theory. Thus, some reservation should perhaps be attached to the conclusion that the range of choice hypothesis as formulated in this study was of no significance in determining the median earnings of male farmers and farm managers in Oregon in 1959. Finally, as was mentioned earlier,[1] only the climatic aspect of the range of choice hypothesis was considered in this study. Other aspects, e.g., education, location, irrigation, age, etc., may also be of some importance, therefore, contributing to making the range of choice hypothesis more significant than has been made apparent by the above study.

Location, time available for off-farm employment, education and race proved to be of greatest quantitative significance in determining the earnings of male farmers and farm managers from off-farm sources. Consideration of various location measures revealed that a modification of the present location matrix hypothesis may be of some value.

Since location is important in determining off-farm earnings and the latter is the main determinant of the earnings of farmers and farm managers, one can conclude that location has a significant influence on their earnings.

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[1]See page 30.

V. RESULTS OF EMPIRICAL ANALYSIS FOR KANSAS

Median Earnings of Male Farmers and Farm Managers Equation

A similar approach was used as in Oregon in that the models delineated in Chapter III were modified as a result of preliminary empirical analysis. However, the original models were constructed with Oregon in mind, while Kansas was used in order to determine whether or not the conclusions and implications obtained for Oregon would equally pertain to Kansas.

Several variables were excluded from the empirical investigation of Kansas for reasons which are discussed below.

First of all, preliminary results indicated that the sign on the constant depicting the percentage of commercial farm operators less than 25 years old was positive which was inconsistent with the theory developed in Chapter II. A possible reason for this may be due to the way in which the variable is defined (e.g., perhaps the variable should measure the percentage who are less than 20 years old). Alternatively, the positive sign may be due to a high degree of multicollinearity with the percentage of commercial farm operators who are more than 44 years old, which is not explicitly taken into account in the models. Since the significance of the percent of commercial farm operators less than 25 years old was negligible in the case of

Oregon, there was considered to be little value in examining this variable further.

A second variable which was excluded from empirical analysis was the percentage of male farmers and farm managers who are non-white, since data on this variable were only available for eight of the 105 counties in Kansas.

Finally, the various measures of temperature and length of the growing season defined by the number of days between killing frosts were excluded on the basis that since they were not significant in the case of Oregon, it is extremely unlikely that any different results will be obtained in Kansas where temperature and growing season conditions are far more uniform among counties.[1]

Before proceeding to the empirical results, it should be noted that, owing to the lack of data on median earnings of male farmers and farm managers, three counties were excluded from the analysis, i.e., Clark, Greeley and Wallace. The sample size, therefore, consisted of 102 counties.

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[1] This statement is substantiated by the following results:

	Kansas	Oregon
Potential evapotranspiration during the growing season:		
a. Average value	29.0945	21.5733
b. Standard deviation	1.7794	3.7282
Length of the growing season:		
a. Average value	178.7450	206.3000
b. Standard deviation	11.0576	63.6185

Once again the equation where the standard error of estimate is at a minimum, i. e., denoted as the minimum step equation, and the full equation, are presented.

Model I

As in the case of Oregon, a high degree of multicollinearity (r=0.9870) proved to exist between the precipitation effectiveness index during the growing season and the climate interaction term during the same period. As a result, two variants of model I were estimated:

Equation 1a

$$Y_1 = b_0 + b_1 Y_2 + b_2 X_1 + \ldots + b_6 X_5 + U$$

where:

Y_1 = median earnings of male farmers and farm managers in the county.

Y_2 = percentage of commercial operators in the county who work off the farm.

X_1 = percentage of farm operators in the county who are 25-44 years old.

X_2 = education index of the members of the rural farm population in the county who are 25 years of age or more.

X_3 = percentage of the farm land in the county that is irrigated.

X_4 = weighted index of land capability of the county.

X_5 = precipitation effectiveness of the county during the months when the mean temperature is $43^{\circ}F$ or more.

Equation 1b

$$Y_1 = b_0 + b_1 Y_2 + b_2 X_1 + \ldots + b_5 X_4 + b_7 X_6 + U$$

where:

Y_1, Y_2, X_1 . . . X_4 are defined the same as above.

X_6 = climate interaction term (i.e., X_5 times the thermal efficiency during the months when the temperature is $43^{\circ}F$ or more).

The results for these equations, shown in Tables 13 and 14 revealed, according to the T values and beta coefficients, that the climate, irrigation and age variables were the most important determinants of the earnings of male farmers and farm managers. In addition, the education variable proved to be of some significance although the beta coefficients indicate that its influence is somewhat less than the three variables mentioned above.

The remaining two variables, i.e., percentage of commercial farm operators who work off the farm and the weighted index of land capability, appeared to be of considerably less significance. The positive sign on the latter variable may or may not be an indication that range of choice element present in it was dominant. However,

Table 13. Median earnings of male farmers and farm managers equation. Model I. Equation 1a. Kansas, 1959.

Variable	Minimum step equation			Full equation		
	Partial regression coefficients	T values	Beta coefficients	Partial regression coefficients	T values	Beta coefficients
Constant	-881.9380			-932.9580		
Y_2				0.2147	0.0187	0.0013
X_1	57.2042	2.8033**	0.2747	57.4188	2.7464**	0.2757
X_2	207.3090	2.2002*	0.1457	206.9770	2.0956*	0.1455
X_3	90.8432	3.6805**	0.2822	91.3932	3.2528**	0.2840
X_4				2.5150	0.0642	0.0042
X_5	-29.1564	-3.2635**	-0.3023	-29.0092	-3.0897**	-0.3008
	R = 0.7985**			R = 0.7986**		
	R^2 = 0.6371			R^2 = 0.6378		
	S_{yx} = 64.0343			S_{yx} = 64.7033		

* Significantly different from zero at the 5% level.

** Significantly different from zero at the 2% level.

Table 14. Median earnings of male farmers and farm managers equation. Model I. Equation 1b. Kansas, 1959.

Variable	Minimum step equation			Full equation		
	Partial regression coefficients	T values	Beta coefficients	Partial regression coefficients	T values	Beta coefficients
Constant	-1992.2050			-2229.4200		
Y_2				2.4037	0.2032	0.0151
X_1	65.5973	3.1648**	0.3150	66.2896	3.1298**	0.3183
X_2	242.5640	2.5712**	0.1705	236.7740	2.3848**	0.1664
X_3	93.8197	3.7329**	0.2915	97.9444	3.4286**	0.3043
X_4				13.4798	0.3416	0.0226
X_6	-0.2820	-2.5746**	-0.2340	-0.2769	-2.4075**	-0.2299
		R = 0.7897**			R = 0.7901**	
		R^2 = 0.6237			R^2 = 0.6243	
		S_{yx} = 65.2650			S_{yx} = 65.8959	

** Significantly different from zero at the 2% level.

the T values and beta coefficients on these two variables were so low that it is not permissible to make definitive statements concerning them.

According to the results of this model, the range of choice hypothesis as represented by the climatic term seemed to be a dominant factor in the determination of earnings of male farmers and farm managers. Even when the weighted index of land capability was included, the range of choice hypothesis still proved to be highly significant as the following F test shows.

Equation 1a

Ho: $b_5 = b_6 = 0$

Results:

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares (SS)	Mean square (MS)
Regression SS of complete model $(\hat{b}_0 \ldots \hat{b}_6)$	9	70,727,800	
Regression SS of reduced model $(\hat{b}_0 \ldots \hat{b}_4)$	7	66,343,300	
Added SS due to $\hat{b}_5$ and $\hat{b}_6$	2	4,384,500	2,192,250
Residual SS of complete model	95	40,169,700	422,839
Total	101	110,897,000	

F = 5.1846 which is significant at the 1% level.

Conclusion: Reject the hypothesis.

A similar F test in equation 1b testing the hypothesis that b_5 and b_7 equal zero yielded a value of 3.1460 which is significant at the 5% level.

Model II

The high degree of multicollinearity (r=0.9956) existing between moisture index during the growing season and the climate interaction term necessitated the formation of two variants of model II.

Equation 1a

$$Y_1 = b_0 + b_1Y_2 + b_2X_1 + \ldots + b_5X_4 + b_8X_7 + U$$

where:

Y_1, Y_2, $X_1 \ldots X_4$ are the same as in model I.

X_7 = moisture index of the county during the period from the last killing frost in the spring to the first in the fall.

Equation 1b

$$Y_1 = b_0 + b_1Y_2 + b_2X_1 + \ldots + b_5X_4 + b_9X_8 + U$$

where:

Y_1, Y_2, $X_1 \ldots X_4$ are the same as in equation 1a.

X_8 = climate interaction term (i.e., the potential evapotranspiration during the growing season times the sum of X_7 and 50.

According to the results shown in Tables 15 and 16, the climate and irrigation terms proved to be by far the most important while the age and education variables achieved somewhat more marginal significance. Once again the land capability and off-farm employment variables were of negligible influence.

The sign on the land capability index was negative indicating that the range of choice element present in this variable was not dominant. This is inconsistent with the results obtained for the same variable in model I, but as was noted earlier, there is believed to be little desirability in drawing too many implications concerning a variable which is of so little quantitative significance. In any case, by far the most dominant aspect of the range of choice hypothesis is the climatic term. In both equations this variable had a T value which is significantly different from zero at the 0.1% level of significance. Consequently, it is possible to conclude that the range of choice hypothesis was very significant in determining the median earnings of male farmers and farm managers in Kansas in 1959. This conclusion contrasts with results found for Oregon where the range of choice hypothesis appeared to have no significant influence.

Table 15. Median earnings of male farmers and farm managers equation. Model II. Equation 1a. Kansas, 1959.

Variable	Minimum step equation			Full equation		
	Partial regression coefficients	T values	Beta coefficients	Partial regression coefficients	T values	Beta coefficients
Constant	-628.3500			116.9540		
Y_2				-4.4897	-0.4198	-0.0283
X_1	41.9896	2.2509*	0.2016	37.8059	1.9633	0.1815
X_2	117.7970	1.2881	0.0828	119.1360	1.2568	0.0837
X_3	73.9525	3.1564**	0.2298	63.6343	2.3631**	0.1977
X_4				-34.6073	-0.9163	-0.0581
X_7	-44.5962	-5.0850**	-0.4624	-47.7603	-5.0500**	-0.5005
		R = 0.8262**			R = 0.8281**	
		R^2 = 0.6826			R^2 = 0.6857	
		S_{yx} = 59.9405			S_{yx} = 60.2674	

* Significantly different from zero at the 5% level.

** Significantly different from zero at the 2% level.

Table 16. Median earnings of male farmers and farm managers equation. Model II. Equation 1b. Kansas, 1959.

Variable	Minimum step equation			Full equation		
	Partial regression coefficients	T values	Beta coefficients	Partial regression coefficients	T values	Beta coefficients
Constant	901.3680			1429.2400		
Y_2				-0.5308	-0.0482	-0.0033
X_1	43.3499	2.1919*	0.2082	40.7617	1.9936*	0.1957
X_2	141.1940	1.5117	0.09926	137.8920	1.4115	0.0969
X_3	81.9229	3.4345**	0.2545	78.0025	2.8638**	0.2423
X_4				-22.2768	-0.5779	-0.0374
X_8	-1.2386	-4.4343**	-0.4231	-1.2973	-4.3235**	-0.4431
		R = 0.8159**			R = 0.8167**	
		R^2 = 0.6657			R^2 = 0.6669	
		S_{yx} = 61.5111			S_{yx} = 62.0462	

* Significantly different from zero at the 5% level.

** Significantly different from zero at the 2% level.

Model III

Two variants of this model were tested, due to the high correlation (r=0.9944) between the total detention of water during the growing season and the climatic interaction term.

Equation 1a

$$Y_1 = b_0 + b_1 Y_2 + b_2 X_1 + \ldots + b_5 X_4 + b_{10} X_9 + U$$

where:

Y_1, Y_2, X_1 . . . X_4 are the same as in model I.

X_9 = total detention of water during the period from the last killing frost in the spring to the first in the fall.

Equation 1b

$$Y_1 = b_0 + b_1 Y_2 + b_2 X_1 + \ldots b_5 X_4 + b_{11} X_{10} + U$$

where:

X_1, Y_2, X_1 . . . X_4 are the same as in equation 1a.

X_{10} = climate interaction term (i.e., X_9 times the potential evapotranspiration during the growing season).

The results for these equations which are shown in Tables 17 and 18 are exactly analogous to those in model II. Once again the climate and irrigation variables were most important followed by those measuring age and education. Land capability and off-farm

Table 17. Median earnings of male farmers and farm managers equation. Model III. Equation 1a. Kansas, 1959.

Variable	Minimum step equation			Full equation		
	Partial regression coefficients	T values	Beta coefficients	Partial regression coefficients	T values	Beta coefficients
Constant	145.7920			572.3770		
Y_2				-4.8593	-0.4376	-0.0306
X_1	50.4259	2.6253**	0.2421	48.4198	2.4489**	0.2325
X_2	136.3250	1.4350	0.0958	142.8690	1.4504	0.1004
X_3	77.2508	3.1913**	0.2400	69.6869	2.5001**	0.2165
X_4				-16.2271	-0.4212	-0.0273
X_9	-71.9922	-4.2338**	-0.4012	-74.6293	-4.1231**	-0.4159
		R = 0.8128**			R = 0.8136**	
		R^2 = 0.6607			R^2 = 0.6619	
		S_{yx} = 61.9744			S_{yx} = 62.5132	

** Significantly different from zero at the 2% level.

Table 18. Median earnings of male farmers and farm managers equation. Model III. Equation 1b. Kansas, 1959.

Variable	Minimum step equation			Full equation		
	Partial regression coefficients	T values	Beta coefficients	Partial regression coefficients	T values	Beta coefficients
Constant	-320.1220			-122.9500		
Y_2				-2.5821	-0.2287	-0.0163
X_1	53.5589	2.7067**	0.2572	52.6857	2.5898**	0.2530
X_2	153.0060	1.5867	0.1076	157.1300	1.5638	0.1105
X_3	82.2476	3.3588**	0.2555	78.4476	2.7964**	0.2437
X_4				-7.9382	-0.2035	-0.0133
X_{10}	-2.0730	-3.7549**	-0.3613	-2.1072	-3.6041**	-0.3673
		R = 0.8056**			R = 0.8058**	
		R^2 = 0.6490			R^2 = 0.6493	
		S_{yx} = 63.0324			S_{yx} = 0.6366	

** Significantly different from zero at the 2% level.

employment again proved to be of no significance. Finally, the range of choice hypothesis was confirmed as being an important determinant of earnings of male farmers and farm managers in Kansas in 1960, since the T values on the climatic variables were significantly different from zero at the 0.1% level.

Equation Depicting the Percentage of Commercial Farm Operators Who Work Off the Farm

The equations depicting the percentage of commercial farm operators who work off the farm are exactly the same for all three models.

In the equations presented below, the age variable was slightly modified in that the average age of the operator was used in place of the percentage of operators who are between the ages of 25 to 44. It was believed that the use of the latter variable without its counterpart, i.e., percentage of operators who are less than 25 years old, would contribute no more to the results than the more simple average age variable. In addition, the percentage of farm operators who are 25 to 44 years old showed an unsatisfactory degree of multicollinearity with the various measures of location. For example, a correlation coefficient of -0.6923 existed between the former variable and the size-distance measure of location.

The following equations were estimated using stepwise regression.

Equation 2A

$$Y_2 = b_0 + b_2X_2 + b_{11}X_{11} + b_{12}X_{12} + b_{13}X_{13} + U$$

where:

Y_2 = percentage of farm operators in the county who work off the farm.

X_2 = weighted education index of the members of the rural farm population in the county who are at least 25 years old.

X_{11} = average age of the operators in the county.

X_{12} = average specified expenditures per farm in the county.

X_{13} = size-distance measure of location of the county.

Equation 2B

$$Y_2 = b_0 + b_2X_2 + b_{11}X_{11} + b_{12}X_{12} + b_{14}X_{14} + U$$

where:

Y_2, X_2, X_{11}, X_{12} are the same as in equation 2A.

X_{14} = distance measure of location of the county.

Equation 2C

$$Y_2 = b_0 + b_2X_2 + b_{11}X_{11} + b_{12}X_{12} + b_{15}X_{15} + U$$

where:

Y_2, X_2, X_{11}, X_{12} are the same as in equation 2A.

X_{15} = percentage of the population that is non-farm.

Since the steps at which the standard errors of estimate are at a minimum are the same as the full equations, the full results are presented in Table 19.

Education appeared to be the most important determinant of off-farm employment followed by time availability as represented by the specified farm expenditure variable.

Of the location variables, distance appeared to be the biggest barrier to off-farm employment. The negative sign on this coefficient indicated that the further the county is from a SMSA the lower will be the amount of off-farm employment. This is consistent with the theory since apart from a few unique areas, e.g., Oregon, the non-farm labor market coincides with the urban areas.

The positive sign on the coefficient of the variable representing the average age of the operators implies that the amount of off-farm employment increases with an increase in age. However, as noted earlier in this study[1] there may well be an age beyond which a negative relationship may result due to a decline in mental abilities and physical health. Apart from equation 3C, age appeared to be the least important variable, although some caution should be used in interpreting the results since some intercorrelation was found to exist between this variable and the size-distance and distance measures of location.

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[1]See page 47.

Table 19. Equations depicting percentage of commercial farm operators who work off the farm. Kansas, 1959.

(a) Equation 2A

Variable	Partial regression coefficients	T values	Beta coefficients
Constant	-25.8303		
X_2	2.4043	2.5245**	0.2683
X_{11}	0.6102	1.2542	0.1768
X_{12}	-0.000302	-1.7179*	-0.1812
X_{13}	0.2511	1.0482	0.1507
	R = 0.3775**		
	R^2 = 0.1425		
	S_{yx} = 0.6209		

(b) Equation 2B

Variable	Partial regression coefficients	T values	Beta coefficients
Constant	-10.6290		
X_2	2.3241	2.5321**	0.2593
X_{11}	0.4552	1.0777	0.1319
X_{12}	-0.000302	-1.7429*	-0.1809
X_{14}	-1.3597	-2.0677*	-0.2461
	R = 0.4116**		
	R^2 = 0.1694		
	S_{yx} = 0.6111		

(c) Equation 2C

Variable	Partial regression coefficients	T values	Beta coefficients
Constant	-34.8192		
X_2	1.9970	2.1210*	0.2228
X_{11}	0.8707	2.4477**	0.2523
X_{12}	-0.000305	-1.7402*	-0.1831
X_{15}	0.0588	1.2315	0.1195
	R = 0.3823**		
	R^2 = 0.1462		
	S_{yx} = 0.6196		

* Significantly different from zero at the 10% level.

** Significantly different from zero at the 2% level.

Summary and Conclusions

Unlike Oregon, the range of choice hypothesis proved to be of considerable importance in explaining the median earnings of male farmers and farm managers in Kansas in 1959. In addition to the significance of the climatic measures, there appeared to be some evidence, admittedly of a scanty nature, that the range of choice element is the dominating influence in the land capability index.

According to the T values and beta coefficients, the percentage of farm land irrigated appeared to be the second most important variable. This is not surprising in view of the considerable fluctuations in rainfall that are experienced in Kansas, both from year to year and within any one year.

The percentage of operators who are 25 to 44 years of age and the educational achievement of the rural farm population proved to be less significant.

The level of educational attainment also proved to be significant in determining the percentage of commercial farm operators who work off the farm. Time availability for off-farm employment was also of some significance as was the distance measure of location.

However, although the distance measure of location proved to be important in determining the amount of off-farm employment, the latter was not significant in determining the median earnings of male farmers and farm managers in Kansas in 1959. Thus, it is possible to conclude that distance is not important in determining their earnings which is consistent with Bryant's (11, p. 203) conclusions regarding areas west of the Mississippi.

Since the climatic conditions in Kansas fluctuate so violently from year to year, it would perhaps have been more realistic to have included, in addition, weather variables reflecting conditions in 1959. Such short run weather variables would have positive signs indicating that earnings in any one year would increase with increase benevolence of the weather conditions. This, of course, assumes that these improved weather conditions do not prevail throughout the country, in which case there would be a depressing influence on price and therefore earnings as a result of the increased supply, assuming that this increase was not offset by an increase in demand. However, since 1959 appeared to be a fairly normal year from the climatic point of view,[1] and the coefficients of multiple determination and standard errors of estimate were at very satisfactory levels for cross-sectional analysis, it was decided that there was little point in including these variables which would have involved a considerable amount of additional computation.

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[1] This statement is supported by 1959 Kansas data published by the U. S. Weather Bureau (99, p. 200-206).

VI. SIGNIFICANCE OF NATURAL RESOURCE CHARACTERISTICS OVER TIME

It is believed that the main determinants of incomes of farm operators may well have changed over time due to the dynamic processes existing in the economy. It is hypothesized, for example, that one of the main factors bringing about this change may well be developments in technology. Such changes in technology may have an effect of indirectly modifying the environment under which the farmer operates. In other words, because of technological developments, natural resource characteristics may become less significant with the passing of time. Whereas in former times unfavorable natural characteristics may well have been a considerable force in promoting specialization, they are now, due to the development of seed varieties better suited to such conditions, superior fertilizers, capital equipment, etc., becoming of less significance because of technological changes which allow greater control over the environment. Consequently, diversification may well become feasible in areas where formerly specialization was the only choice. On the basis of this argument, it could therefore be hypothesized that the range of choice, as determined by the natural resource complex, has and will continue to become a progressively less significant determinant of incomes of farm operators. Unfortunately, such a hypothesis is extremely difficult to test empirically, since there may well be many other complicated influences at work. For example, there may be a differential impact of technology among those farms which are specialized and those which are diversified.[1]

In addition to the range of choice variable, other determinants may also change in significance over time. For example, irrigation, as it is practiced at the present time, is a comparatively new technique, and therefore will only be a significant factor in determining incomes of farm operators in more recent years.

Land quality, as it has been defined in this study,[2] can be hypothesized to have become less important in determining incomes of farmers due to technological developments which have the effect of indirectly modifying the physical environment.

As the level of education rises through time and, due to improved communication facilities, becomes more uniform, one can hypothesize that this variable has become progressively less important in the determination of farmers' incomes.

Empirical Procedure

Ideally, in order to test the significance of these variables over time, it would be best to use time series analysis on a few specially

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[1] This remark is discussed further on pages 137 and 138 of this study.

[2] See page 42.

selected counties. However, a lack of data prevented this, and it was decided to utilize a cross-sectional analysis approach. Once again limitations imposed by the lack of data permitted only the census years of 1959-1960, 1950, and 1940 to be examined. The shortness of this period meant that it was somewhat difficult to determine any discernible trend in the significance of the variables over time.

Since data on the earnings of farmers and farm managers were only available for 1959, it was necessary to find some other variable that would reflect the incomes of farm operators. For this purpose, the value of products sold per farm[1] was utilized. It is recognized, however, that there are some disadvantages concerning this measure.[2]

In order to simplify the computational burden and to use statistics which were available for all three years, the following basic model was utilized:

$$Y_i = b_0 + b_1 X_{1i} + b_2 X_{2i} + b_3 X_{3i} + b_4 X_{4i} + b_5 X_5 + b_6 X_6 + U$$

where:

Y_i = value of products sold per farm in the county.

i = 1 refers to the year 1939.

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[1]Until 1945 this statistic included the value of products sold, traded and used, while after this date, it was defined solely as the value of products sold.

[2]For a discussion of this variable, see Appendix A.

i = 2 refers to the year 1949.

i = 3 refers to the year 1959.

X_{1i} = percentage of operators in the county who were employed off the farm in year i.

X_{2i} = median age of operators in the county in year i.

X_{3i} = median number of years of schooling of the members of the rural farm population, 25 years old or more, in the county in year i.

X_{4i} = percentage of farmland in the county that was irrigated in year i.

X_5 = land capability index of the county.

X_6 = climatic interaction term.

The theoretical justification behind the inclusion of these variables is discussed in detail in Chapters II and III. All the variables except those depicting land capability and climate will change over time. The latter two may also change slightly as a result of actions by man, but this possibility would be a long-run phenomenon and in addition was not taken into consideration in the original construction of these variables.

Table 20 provides in summarized form the hypothesized signs on the coefficients of the variables included in the model. Also included is a summary of the expected direction of importance of the variables through time.

Table 20. Hypothesized results to be obtained for the equation depicting value of products sold per farm.

Variable	Expected sign on the regression coefficient	Hypothesized direction of importance over time
X_1	negative	a
X_2	negative or positive[b]	a
X_3	positive	decrease
X_4	positive	increase
X_5	negative or positive[c]	decrease
X_6	negative	decrease

[a] There is no theoretical reason for any particular direction in the significance of this variable over time.

[b] See page 48 for the reason behind this uncertainty.

[c] See page 43 for the reason behind this uncertainty.

In order to make the results comparable between 1939, 1949, and 1959, the same model was also used for 1959. However, it should be noted that the estimating equation should be confined to this use, since the median earnings of male farmers and farm managers equation considered in the preceding two chapters was superior both theoretically and empirically. Finally, in order to make the results comparable, the same counties in Oregon and Kansas were omitted from the empirical analysis as in the preceding two chapters. These counties were Clatsop, Curry, Gilliam, Harney, Lincoln and Wheeler in Oregon and Clark, Greeley and Wallace in Kansas.

Test of Differences in Importance of Variables Over Time and Between Two Areas at One Point in Time

In order to test the hypothesized direction of importance of the variables over time, a T test was utilized. The T statistic used was a modified form of the one given by Li (37, p. 128) which is designed to handle two normal populations having different variances. The test is accomplished as follows:

Ho: $|b_{i1}| - |b_{i2}| = 0$

H_A: (a) $|b_{i1}| > |b_{i2}|$ i.e., during the time period under consideration, variable i has decreased in importance.

(b) $|b_{i1}| < |b_{i2}|$ i.e., during the time period under consideration, variable i has increased in importance.

The test statistic:

$$T = \frac{|b_{i1}| - |b_{i2}|}{\sqrt{S^2_{b_{i1}} + S^2_{b_{i2}}}} \quad {}^{1}$$

$$V = \frac{(S^2_{b_{i1}} + S^2_{b_{i2}})^2}{\frac{(S^2_{b_{i1}})^2}{n_1 - 1} + \frac{(S^2_{b_{i2}})^2}{n_2 - 1}}$$

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[1]If the two partial regression coefficients are of opposite sign then the absolute values are added rather than subtracted from each other. The absolute values are used in order to simplify the decision as to which alternative hypothesis should be accepted if the null hypothesis is rejected.

where:

b_{i1} = the partial regression coefficient of variable i in year 1 (i.e., 1939).

b_{i2} = the partial regression coefficient of variable i in year 2 (i.e., 1959).

$S^2_{b_{i1}}$ = sample variance of b_{i1}.

$S^2_{b_{i2}}$ = sample variance of b_{i2}.

V = degrees of freedom.

n_1 = sample size in year 1.

n_2 = sample size in year 2.

If the computed T value falls in the left (right) critical region, the null hypothesis is rejected, which implies accepting alternative hypothesis (a) ((b)). Finally, if the T value falls outside the critical regions then the null hypothesis is not rejected.

For a comparison of the importance of the i'th variable between two areas (e.g., Kansas and Oregon) at one point in time, the term "year 1" is simply substituted with Oregon while Kansas is used in place of "year 2". In addition, the alternative hypotheses could be restated as follows:

H_A: (a) $|b_{i1}| > |b_{i2}|$ i.e., at the time under consideration, variable i was more important in Oregon than in Kansas.

(b) $|b_{i1}| < |b_{i2}|$ i.e., at the time under consideration, variable i was less important in Oregon than in Kansas.

It is recognized that this test statistic has some limitations but on the other hand, it does provide a simple rigorous test of the hypotheses advanced in this chapter. Concerning the disadvantages of this statistic, Li (37, p. 129) has stated that this approximate method should only be used as a last resort since it only approximately follows the T distribution with V degrees of freedom.

It may be of interest to note that Heady and Shaw (27, p. 251) and Stoevener (61, p. 42) have used a similar T test in comparing differences in marginal productivities of resources in different areas. The superficial difference between the statistic used by these investigators and that discussed above is due to their use of a Cobb-Douglas function, and the resulting differences that arise in computing the marginal value products for the resources.[1]

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[1]If S is cash sales, then the MVP of input X_1 in a Cobb-Douglas function would be as follows:

$$S = b_0 X_1^{b_1} X_2^{b_2}$$

$$\frac{\partial S}{\partial X} = b_1 \frac{S}{X_1} = MVP_{X_1}$$

However, for the same variables in a linear multiple regression model, the MVP of input X_1 would be as follows:

$$S = b_0 + b_1 X_1 + b_2 X_2$$

$$\frac{\partial S}{\partial X_1} = b_1 = MVP_{X_1}$$

Empirical Results for Oregon

In the case of Oregon, the climate interaction term utilized was the one utilized in model III, i.e., the potential evapotranspiration during the growing season times the total detention of water during the same period.

The empirical results obtained for the years 1939, 1949, and 1959 are presented in Tables 21, 22 and 23. A consideration of these results reveals that the signs on the coefficients were consistent with those hypothesized in Table 20. In fact, the only exception was the irrigation variable in 1959 which in any case was insignificant. The sign on the age variable was consistently negative indicating that the median age of operators may be beyond the point at which mental and physical abilities may be at a peak.[1]

The percentage of off-farm employment was consistently the most significant variable, while the age of operator and land capability were also of some significance in the determination of the value of products sold per farm. Educational achievement and the range of choice or climatic interaction term appeared to be of less influence. Finally, according to the T values and beta coefficients, the irrigation variable was generally of least quantitative influence.

The above remarks are not entirely consistent with the results

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[1] In 1939 the average age of operator was 50.1, while in 1949 and 1959 it was 50.5 and 50.9 respectively.

Table 21. Equation depicting the value of products sold per farm. Oregon, 1939.

	Minimum step equation			Full equation		
Variable	Partial regression coefficients	T values	Beta coefficients	Partial regression coefficients	T values	Beta coefficients
Constant	6905.5700			7172.2070		
X_1	-80.7428	-3.4147**	-0.5337	-82.4310	-2.8521**	-0.5449
X_2	-160.4310	-1.6409	-0.2374	-158.8030	-1.5720	-0.2350
X_3	1021.9100	1.5067	0.1942	991.3080	1.3216	0.1883
X_4				1.3370	0.1063	0.0165
X_5	-92.2365	-1.8251	-0.2352	-94.0505	-1.7301*	-0.2398
X_6	-0.4047	-1.3689	-0.1863	-0.3838	-1.0650	-0.1767
	R = 0.8483**			R = 0.8484**		
	R^2 = 0.7197			R^2 = 0.7198		
	S_{yx} = 113.9080			S_{yx} = 116.3290		

* Significantly different from zero at the 10% level.

** Significantly different from zero at the 2% level.

Table 22. Equation depicting value of products sold per farm. Oregon, 1949.

Variable	Minimum step equation			Full equation		
	Partial regression coefficients	T values	Beta coefficients	Partial regression coefficients	T values	Beta coefficients
Constant	20994.8000					
X_1	-306.8980	-8.3038**	-0.8209	-284.8450	-4.3449**	-0.7620
X_2				-333.7720	-0.7090	-0.0998
X_3	905.1980	1.2710	0.1267	861.2590	1.1406	0.1206
X_4				13.9669	0.2534	0.0277
X_5	-390.6080	-2.5555**	-0.2273	-438.4850	-2.5753**	-0.2552
X_6				0.0762	0.0598	0.0080
		R = 0.8984**			R = 0.9015**	
		R^2 = 0.8072			R^2 = 0.8128	
		S_{yx} = 389.7610			S_{yx} = 408.3510	

** Significantly different from zero at the 2% level.

Table 23. Equation depicting value of products sold per farm. Oregon, 1959.

Variable	Minimum step equation			Full equation		
	Partial regression coefficients	T values	Beta coefficients	Partial regression coefficients	T values	Beta coefficients
Constant	99939.1000			100208.0000		
X_1	-494.4910	-6.1366**	-0.6656	-485.3170	-5.3872**	-0.6532
X_2	-1296.7600	-1.9314*	-0.2023	-1315.2600	-1.9091*	-0.2052
X_3	1379.7100	1.1897	0.1090	1425.9900	1.1907	0.1126
X_4				-20.2971	-0.2489	-0.0225
X_5	-516.8150	-1.8946*	-0.1612	-522.2600	-1.8710*	-0.1629
X_6	-1.9103	-1.1092	-0.1075	-2.0411	-1.1130	-0.1149
	R = 0.9217**			R = 0.9219**		
	R^2 = 0.8495			R^2 = 0.8499		
	S_{yx} = 670.7510			S_{yx} = 684.2570		

* Significantly different from zero at the 10% level.

** Significantly different from zero at the 2% level.

obtained for 1949 in which the age and climatic interaction terms were less significant than in 1939 and 1959. The occurrence of the Korean War may have caused some special forces to operate in 1949, which consequently caused changes in the significance of some of the variables. Finally, it may not be amiss to note that the results obtained for 1959 are in general consistent with those obtained in Chapter IV, when the median earnings of male farmers and farm managers were used as the dependent variable.

The results of the T test designed to determine the direction of importance of the variables through time proved to be somewhat inconclusive. In fact, column two of Table 24 shows that the only variable that changed significantly in importance between 1939 and 1959 was the percentage of operators employed off the farm. The increasing importance of this variable may reflect the fact that as the lumber industry has grown,[1] off-farm employment opportunities and wage rates have correspondingly increased. Consequently, location and time availability for off-farm employment could

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[1] An idea of the increased significance of the lumber industry in Oregon, over the last 20 years, can be gleaned from the following statistics, which were provided by Mrs. Elvera Horrell, Extension Agricultural Economist at Oregon State University.

Year	Value of products	Number of employees
1939	$ 138.4	31,621
1959	$ 1,300.0	68,019

These figures include logging camps and contractors, sawmills, pulp mills, and lumber and timber products.

Table 24. Results of T tests to determine importance of the determinants of the value of products sold per farm through time, and at one point in time between Oregon and Kansas.

Variable	T ratios			
	Oregon between 1939 and 1959	Kansas between 1935 and 1959	1939 between Oregon and Kansas	1959 between Oregon and Kansas
X_1	-4.2584**	-1.0487	3.4294**	4.0213**
X_2	-1.6618	a	a	a
X_3	0.3076	0.2383	-0.7992	0.0416
X_4	-0.2622	-5.8235**	0.3817	-5.4840**
X_5	-1.5057	-0.6683	b	b
X_6	-0.8868	-2.8936**	1.3914	-2.1923*

* Significantly different from zero at the 5% level.

** Significantly different from zero at the 2% level.

[a] The age variable (X_2) was omitted from these equations.

[b] There was considered to be no justification for determining T values for the land capability index (X_5) since this variable has different influences in Oregon and Kansas.

conceivably have been factors in contributing to the increased importance of this variable.

The fact that it was only possible to investigate changes in importance of the variables over a period of 20 years may well be a factor contributing to inconclusive results obtained for most of the variables. It may well be, for example, that such variables have changed in importance, but in a manner that only a much longer period would reveal. This fact could quite conceivably be especially important in the case of the range of choice hypothesis as represented by the climatic interaction term.

Empirical Results for Kansas

In Kansas, the climatic interaction term utilized was the one empirically tested in model II, i.e., the potential evapotranspiration during the growing season times the sum of the moisture index and 50, during the same period.

As a result of preliminary analysis, a high degree of multicollinearity was discerned between the age variable and the climatic interaction term (e.g., r=0.8286 in 1959). Consequently, it was decided to exclude the age variable from subsequent investigations.

The results of the modified model are presented in Tables 25, 26 and 27. Once again the majority of signs on the coefficients were consistent with those hypothesized in Table 20. The only important

Table 25. Equation depicting value of products sold per farm. Kansas, 1939.

Variable	Minimum step equation			Full equation		
	Partial regression coefficients	T values	Beta coefficients	Partial regression coefficients	T values	Beta coefficients
Constant	-14034.7000			-14029.2000		
X_1	-23.0308	-3.2715**	-0.2627	-22.9677	-3.2454**	-0.2620
X_3	1843.6100	7.3132**	0.5918	1845.1000	7.2827**	0.5923
X_4				-17.1429	-0.2800	-0.0228
X_5	39.0956	1.6023	0.1246	38.8153	1.5819	0.1237
X_6	0.2182	1.6935	0.1412	0.2070	1.5281	0.1340
		R = 0.6564**			R = 0.6567**	
		R^2 = 0.4308			R^2 = 0.4312	
		S_{yx} = 42.3351			S_{yx} = 42.5377	

** Significantly different from zero at the 2% level.

Table 26. Equation depicting value of products sold per farm. Kansas, 1949.

Variable	Minimum step equation			Full equation		
	Partial regression coefficients	T values	Beta coefficients	Partial regression coefficients	T values	Beta coefficients
Constant	513.4910			-1533.6700		
X_1	-105.9210	-2.3222*	-0.1651	-111.5610	-2.4063*	-0.1739
X_3	1609.9500	4.0876**	0.2785	1651.7200	4.1409**	0.2857
X_4	1524.0900	4.5084**	0.3194	1562.8600	4.5573**	0.3282
X_5				119.6420	0.7364	0.0496
X_6	-4.4096	-4.6232**	-0.3614	-4.2157	-2.4063**	-0.3455
	R = 0.7832** R^2 = 0.6133 S_{yx} = 273.3290			R = 0.7846** R^2 = 0.6156 S_{yx} = 273.9970		

* Significantly different from zero at the 5% level.

** Significantly different from zero at the 2% level.

Table 27. Equation depicting value of products sold per farm. Kansas, 1959.

Variable	Minimum step equation			Full equation		
	Partial regression coefficients	T values	Beta coefficients	Partial regression coefficients	T values	Beta coefficients
Constant	4167.2400			35.0295		
X_1	-107.8910	-1.3182	-0.0912	-109.3030	-1.3327	-0.0924
X_3	1674.2500	3.4177**	0.2411	1712.9600	3.4735**	0.2467
X_4	1134.1900	6.0576**	0.4605	1180.6900	6.0128**	0.4794
X_5				238.5230	0.8009	0.0522
X_6	-5.6183	-3.1491**	-0.2498	-5.1976	-2.7900**	-0.2311
		R = 0.8002**			R = 0.8018**	
		R^2 = 0.6404			R^2 = 0.6428	
		S_{yx} = 490.0180			S_{yx} = 490.9270	

** Significantly different from zero at the 2% level.

exception was the positive sign resulting on the climatic interaction term in 1939. One possible reason for this is that there may have been unusual influences of some sort in Kansas during 1939 which consequently upset the usual relationship between this variable and value of products sold per farm. The figures in Table 28 comparing average value of products sold per farm per county in Oregon and Kansas help substantiate the conjecture that in 1939 there may have been unusual conditions existing in Kansas.

Table 28. Comparison of average value of products sold per farm per county in Kansas and Oregon, 1929-1949.

	Value of products sold per farm		
Year	Kansas	Oregon	Difference
1929	3,256	3,159	97
1939	1,432	2,225	-793
1944	5,878	5,487	391
1949	6,962	6,734	228

One of the reasons for the comparatively lower value of products sold per farm in Kansas in 1939 may be due to the influence of short run unfavorable climatic conditions. According to the U. S. Weather Bureau (99, p. 97), 1939 was the fifth driest year during the 53 years in which Kansas state weather data had been collected. The dry April and May meant that much of the wheat was harmed and, in fact, many fields failed to germinate. Since most of the wheat in

Kansas is grown on specialized rather than diversified farms, the former type of farm was more adversely affected. The relatively lower sales from farms which specialized in wheat could perhaps disrupt the normal negative relationship between the climatic interaction term and the value of products sold per farm.

A perusal of the results indicates that education achievement and the climatic interaction term were consistently significant in the determination of value of products sold per farm in 1939, 1949, and 1959. In 1939 land capability was significant as was the off farm employment while in the latest year, i.e., 1959, irrigation had surpassed these in terms of significance. It is interesting to note that the positive sign on the land capability index helped to substantiate the tentative conclusion in Chapter V that in Kansas the range of choice element present in this variable is dominant.

Table 24 shows that over time the percentage of farmland that is irrigated has become increasingly important during the last 20 years in determining the value of products sold per farm. This is not surprising since in 1939 the mean percentage of farmland irrigated per county was only 0.18% while by 1959 it had risen to 1.51%.

Table 24 also indicates that the climatic interaction term has increased in importance over time although this may not be a very valid conclusion due to the unusual climatic conditions which prevailed in Kansas in 1939. A similar T test carried out between

1949 and 1959 yielded a value of -0.4653 which was not statistically significant. At any rate for the time period under consideration, there is no evidence that the range of choice hypothesis, as represented by the climatic interaction term and the land capability index, has actually decreased in importance. As was mentioned earlier, one of the main reasons for the lack of conclusions may well be that the time period analyzed was too short.

However, there may be some other reason for the fact that the influence of the range of choice hypothesis did not appear to decrease in importance during this period. For example, there may be a differential impact of technology between those farms which are specialized and those which are diversified. The application of many technological improvements is dependent on the size of enterprise involved. In other words, many technological innovations can only be applied to enterprises which are of a significant size, e.g., specialized farms. Consequently, the proportion of technological improvements which can be adopted by diversified farms is low.[1] This is because the quantitative size of each enterprise on such a farm tends to be lower. Consequently, it seems plausible to conjecture

[1] For example, technological improvements in raising hogs have had a differential impact. On farms that specialize in hog production, technological improvements in the form of work organization, feed and controlled environment have been possible, whereas such improvements cannot always be economically justified in the case of diversified farms where the hog enterprise is not of significant size.

that the differential impact of technology may have the effect of lowering the average cost curves of the specialized farms relative to those of the diversified farms, thereby maintaining the differentials in farm incomes. Thus, the range of choice hypothesis which originally caused farm income differentials to arise may well give an impression of being a continuing influence although in actual fact the situation existing at the present time may be due to other causes, e.g., differential impact of technology.[1] However, it can also be hypothesized that in the long run, economic forces will decrease the importance of the differential impact of technology, thereby resulting in an apparent decrease in the importance of the range of choice hypothesis.

Comparison of Oregon and Kansas at Specified Points in Time

The results in this chapter and the two preceding ones indicate that the main determinants of farmers' incomes in Oregon and Kansas were different.

In order to determine whether or not these determinants were significantly different in their impact in the two states, a model for

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[1] This fact highlights one of the problems of regression analysis in that as Ezekiel and Fox (19, p. 475) have noted, such analysis can never provide the interpretation of cause and effect but can only establish the facts of the relations.

Oregon exactly similar to that used for Kansas in the preceding section, was constructed.[1]

The results of the T tests are shown in columns four and five of Table 24. In both 1939 and 1959, off-farm employment was more important in Oregon than in Kansas in determining the value of products sold per farm. Education appeared to be equally important in the two states, while in 1959 irrigation and the climatic interaction term were significantly more important in Kansas than in Oregon.

Table 29 shows that the variance of the climate interaction term was much higher in Oregon than in Kansas. Because of this and the fact that the sample size was so much smaller in Oregon, it is difficult to visualize that the 30 weather stations chosen in Oregon were as representative of the agricultural areas in that state as were the 102 chosen in Kansas. In other words, the measurement errors in the climate variables in Oregon may be significant. This may be a factor contributing to the lack of significance of this variable in Oregon.[2]

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[1]In other words the age variable was omitted and the climate interaction term was defined the same as on page 80.

[2]An alternative approach to measuring the range of choice hypothesis may be possible in the near future, which will eliminate this possible source of bias. Mr. Robert Callihan of the Farm Crops department at Oregon State University is proposing in his Ph. D. dissertation to assess the crop potentials of various soils in

Table 29. Comparison of the climatic interaction term values for Oregon and Kansas.

State	Number of counties in sample	Climate interaction term[a]	
		Average	Standard deviation
Kansas	102	1,161.230	357.913
Oregon	30	1,021.480	1,134.490

[a] This is measured by the product of the potential evapotranspiration during the growing season and the modified moisture index during the same period. The moisture index is modified in the manner described in Appendix B.

Another factor which may contribute to the greater importance of the range of choice hypothesis in Kansas is the year to year fluctuation in weather conditions. As Table 30 shows, such fluctuations are greater in Kansas than in Oregon. Farmers who are specialized and therefore have high incomes may be better able to survive a higher maximum loss in an unfavorable year than those who are diversified. The latter type of farmers with their lower annual incomes are less able to accumulate sufficient savings during good years in order to keep them in business in an unfavorable year. In Kansas where the annual weather conditions, particularly precipitation, fluctuate so markedly, there may therefore be an additional

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Oregon in terms of thermal efficiency. Heat units will be used to determine the number and types of crops that potentially could be grown in a given area. Thus, an area where a large number of crops could potentially be grown (i.e., where the range of choice is large) would encourage diversification and hence lower incomes, than where few crops could be grown.

reason for the over-all significance of the range of choice hypothesis relative to that in Oregon. The difference in yearly fluctuations in weather conditions in Oregon and Kansas is further extenuated by the fact that irrigation to mitigate unfavorable moisture conditions is less highly developed in Kansas than in Oregon.[1]

Table 30. Coefficients of variation of annual temperature and precipitation at specified weather stations in Kansas and Oregon, 1931-1955.

State	Weather station[a]	Coefficient of variation	
		Temperature	Precipitation
Kansas	Alton 6E	3.429	29.534
	Larned	2.659	21.554
	Leavenworth	2.894	23.609
	Ottawa	3.147	24.916
	Winfield	3.069	27.273
	Mean for the five stations in Kansas	3.040	25.377
Oregon	Corvallis State College	2.711	22.528
	Enterprise	3.719	21.694
	La Grande	3.318	20.472
	Modoc Orchard	2.004	23.933
	Pendleton WBAP	2.537	22.441
	Mean for the five stations in Oregon	2.858	22.214

[a] The weather stations were selected with a random number table from those listed in Tables 32 and 33.

From the analysis presented in this chapter, it is possible to conclude that the factors important in determining farm incomes vary considerably from region to region.

[1] In 1959, the average percentage of farmland irrigated per county in Oregon was 7.47% while in Kansas it was only 1.51%.

VII. SUMMARY AND CONCLUSIONS

In this study an attempt was made to obtain a more general explanation for the geographical pattern of agricultural income than had previously been formulated. Specifically, this involved integrating in one model the various determinants of agricultural income which other researchers have found important, i. e., location, education, age, together with a number of variables designed to measure various characteristics of natural resources. Natural resource characteristics in particular have been neglected in previous investigations. Consequently, a sub-objective of this study was to assess the over-all importance of natural resources in determining the geographical pattern of agricultural income together with the more specific aim of testing the validity of the range of choice hypothesis advanced by Castle (13, p. 2).

In order to fulfill these objectives, three models were constructed consisting basically of two equations. These differed only with respect to the climatic measures employed, which were patterned on those developed by Thornthwaite and Mather (65, p. 636-649 and 66, p. 185-311) and were selected to reflect the range of choice hypothesis. The first equation with the median earnings of male farmers and farm managers as the dependent variable included in addition to the climatic variables, measures of land capability, irrigation, age, education and earnings from off-farm employment. It was believed that the most significant effect of location operates through the labor market and therefore three different measures of location were included in three variants of the second equation having the percentage of commercial farm operators employed off the farm as the dependent variable. The latter was a proxy variable designed to reflect earnings from off-farm employment. Also included in this equation were variables measuring time available for off-farm employment, age, education and race.

For the subsequent empirical analysis, heavy emphasis was placed on the use of linear multiple regression techniques. The models, which were tested utilizing county data in both Kansas and Oregon, yielded results that may be summarized as follows:

1. The range of choice hypothesis proved to be far more significant in Kansas than in Oregon. In addition, the expected decrease in importance of this hypothesis through time did not materialize in either Oregon or Kansas. Possible reasons for this are the shortness of the time period studied and/or a differential impact of technology.

2. Off-farm employment, age of the operator and education also proved to be important variables in determining median earnings of male farmers and farm managers in Oregon. In Kansas, apart from the range of choice hypothesis, the most important determinants

of earnings of farmers and farm managers were irrigation, and age and education variables. A consideration of the importance of these variables over time revealed that in Oregon, off-farm employment had increased in importance between 1939 and 1959 while in Kansas a similar trend was found to exist in the case of the irrigation variable.

3. In both Oregon and Kansas in 1959 land capability proved to be of little quantitative significance.

4. A study of the results for the equation depicting the percentage of commercial farm operators who work off the farm revealed that in both Oregon and Kansas location appeared to achieve some importance. However, in the latter state the distance variable was the most significant location variable while in the former state, the percentage of the population that are non-farm residents proved to be most significant. The significance of this locational measure in Oregon implies that it may be desirable to generalize the locational matrix theory, which was originally formulated by Schultz (49, p. 205). More specifically, the presence of the lumber industry in Oregon is not dependent on urban concentrations. However, at the same time it provides off-farm employment opportunities. This implies that in certain areas the location matrix theory should be modified so that the presence of off-farm employment opportunities is the locational criterion rather than urban concentrations with

which it is usually but not always synonymous. Since location was important in determining off-farm employment in both Oregon and Kansas, it was possible to make inferences concerning its impact on the earnings of male farmers and farm managers. In Oregon, off-farm employment and hence location were significant in explaining agricultural income. However, in Kansas off-farm employment was not significant in determining farm earnings, and therefore location, in the context in which it was considered in this study, was of little importance in determining the earnings of farmers and farm managers.

5. Other variables which were also of importance in determining the percentage of commercial farm operators who worked off the farm in Kansas and Oregon in 1959 were time availability for off-farm employment and education.

An extended discussion of policy issues is beyond the scope of this dissertation. Nevertheless, certain policy implications with regard to natural resource characteristics can be briefly identified. One of the more general conclusions that can be drawn from this study is that there appears to be some justification in arguing that a national farm policy should be sufficiently flexible in order to be adaptable to the peculiarities of each region. This is because the significance of the various determinants of farm incomes, e.g., natural resource characteristics, changes from region to region.

Schultz (52, p. 134-139) and Denison (17, p. 88) have found empirically that the returns to natural resources decrease with economic growth. The reason for this trend is that technological developments have been extremely effective in substituting other inputs for the limitations imposed by the natural resource characteristics. Economic forces encouraging specialization have served to compel the adoption of these technological developments, and in doing so have also contributed to the decreased importance of natural resources. However, the use of public funds for natural resource development may serve to delay this adjustment process by increasing the returns to natural resources in the short-run although in the long-run such effects will be negated. Such funds may be used in modifying the natural resource complex, thereby encouraging diversified farms to persist. These modifications may be indirect, e.g., through fertilizers, seeds and plants better adapted to severe climatic conditions, etc., or direct in nature, e.g., through irrigation and range land improvement projects, and control of weather conditions.[1] The effects of public funds investment in natural resource development will not always be the same. The relevant distinction would appear to be whether the innovation is land "saving" or land

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[1] This facet may soon become a practical possibility. Castle and Stoevener (14, p. 1-24) have discussed some of the problems involved in assessing the economic feasibility of weather modification.

"using" per entrepreneurial unit. Investments which are land "saving" may postpone inevitable adjustments. The development of irrigation, for example, increases the per unit productivity of land and increases the range of choice open to the entrepreneur. Consequently, the use of public funds in such a manner may have the effect of slowing down the rate of the adjustment process.

The question now arises as to whether such a policy is desirable from a societal point of view. If considerable unemployment exists in the economy and the social overhead costs, e.g., education, highway, law enforcement and mail facilities, etc., in rural areas are very high, there may be some justification for arguing that policies of the kind delineated above may be desirable. Under such conditions the marginal productivity of farmers' labor in agriculture is likely to be greater than in non-farm employment. However, in a dynamic full employment economy the rational agricultural policy designed to maximize the net national product would be one that would encourage farmers to leave agriculture and to provide some educational program designed to make them better equipped to take non-farm jobs where the marginal productivity of their labor would be considerably higher than in farming. Thus, in such an economy there would be little justification in advocating a policy which modifies the full effect of the economic and range of choice forces. In any case, in the long-run these forces will dominate over such policies which offer only a short-run solution.

There appears to be no doubt that further research into the issues considered in this study would be desirable. More specifically, there may be a more general formulation of the range of choice hypothesis in which risk and uncertainty may play a greater role than has been recognized to date. It is to be hoped that arising out of this analysis, there will be a more general hypothesis concerning the determinants of agricultural income.

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APPENDICES

APPENDIX A

COMMENTS ON THE POSSIBLE MEASURES OF AGRICULTURAL INCOME

The reasons why the median earnings of male farmers and farm managers were considered the most suitable measure of income are discussed in Chapter II.

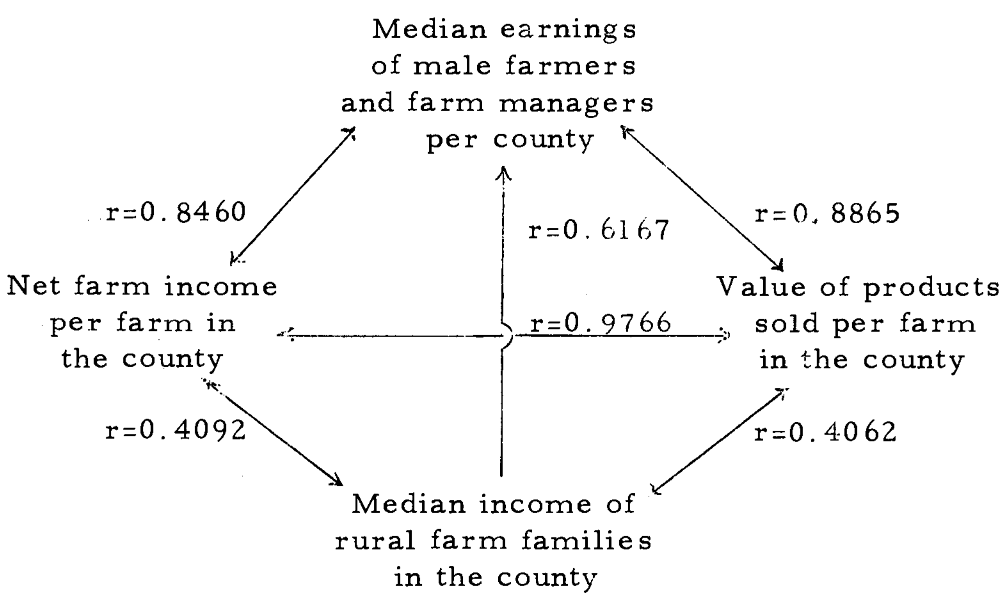
However, other measures of farm income could be and in fact have been used by various investigators, namely value of products sold per farm per county, "net farm" income per farm per county and median income of rural farm families. All these alternative measures have disadvantages, which are now briefly considered.

1. Average value of products sold per farm in the county. This measure is roughly equivalent to the average gross income per farm in the county without adjustments for government payments, value of home consumption and gross rental value of home dwellings. Possible disadvantages of this income measure are:

(a) It does not take into account income derived from off-farm sources. However, the influence of off-farm earnings could be standardized by including as an independent variable, the percentage of operators who work off the farm. It is recognized that this method of correction may not be ideal, but on the other hand, it is considered to be desirable because the value of products sold per farm may be low due to inefficiency on the part of the farmer or because of a higher proportion of time devoted to obtaining earnings from off-farm sources.

(b) Production expenses may vary considerably between counties depending on variations in emphasis on different enterprises, e.g., wheat, livestock, etc. Consequently, net incomes may not be highly correlated with this measure of income. However, the results in Figure 4 indicate that this objection may not be very important.

Figure 4. Correlation coefficients between the various measures of agricultural income in Oregon, 1959.



Thus, as a last resort this income measure may be used with some degree of validity, but it is also believed that for the purposes of this study the earnings of farmers and managers is a superior measure and should be used whenever possible.

2. Median income of rural farm families in the county. This measure was considered unsuitable for the purposes of this study since it includes income derived by all members of the family from all sources. Some of these family members may in no way contribute to the agricultural income of the family. Unfortunately, empirically it would be very difficult to determine the extent to which this is true, therefore making this statistic of somewhat doubtful value.

3. "Net farm" income per farm in the county is a derived statistic computed from data published in the Census of Agriculture. It is obtained by subtracting from the value of products sold the following specified expenditures, i. e., feed for livestock and poultry, purchases of livestock and poultry, machine hire, hired labor and purchases of gas, oil, seeds, bulbs, plants and trees. However, these expenditures only constituted 49.13% of the total production costs for the state of Oregon in 1959, therefore making this approximate measure of net farm income of somewhat doubtful value.

APPENDIX B

COMPUTATIONAL ASPECTS UNDERLYING THE CLIMATIC VARIABLES

Temperature

Two main measures were used which depicted temperature. These were the thermal efficiency during the growing season, which was employed in model I and the potential evapotranspiration during the growing season used in models II and III.

1. Thermal efficiency index.

Thornthwaite (65, p. 646) devised the original formula which was slightly modified to meet the needs of the present study. The modified thermal index was accordingly calculated as follows:

$$T_{HGi} = \sum_{n=1}^{k} \left(\frac{T_i - 32}{4} \right)_n$$

where:

T_{HGi} = thermal efficiency of county i during the months when the average temperature was 43°F or more.

k = the number of months when the average temperature is 43°F or more.

T_{in} = mean temperature in county i in month n.

2. Potential evapotranspiration.

The computational aspects involved in obtaining the potential evapotranspiration during the growing season are somewhat more complex. However, Thornthwaite and Mather (66, p. 185-243) have derived an ingenious method of computing this measure which only requires information on temperatures and latitude of the weather station. Since the computational procedures are very clearly delineated in the publication cited above, there is little point in discussing these in detail. Nevertheless, a rough idea of the computations involved can be obtained from Table 31, which shows the procedure involved in obtaining climatic measures for one county, i.e., Shawnee.

In the case of Oregon, data were already available on potential evapotranspiration (30, p. 18-125).

Due to data differences the growing season was defined differently in Oregon and Kansas. In the case of Oregon the growing season was defined as being the frost free season which is the period between the last day in the spring when temperatures dipped to 28°F and the first day in the fall when such a temperature is reached. Information on the frost free season was obtained from the publication cited above (30, p. 18-125).

In Kansas the growing season was defined as being the period between the last killing frost in the spring and the first killing frost

Table 31. Computation of potential evapotranspiration, moisture deficit and surplus, and total detention of water at Topeka, Kansas.[a]

Line	Month	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	Temperature	28.8	33.1	41.7	54.4	64.4	74.7	79.9	78.4	69.4	58.2	42.6	33.4
2	Monthly heat value	0	0.04	1.12	3.97	6.95	10.56	12.57	11.97	8.64	5.04	1.28	0.06
3	Unadjusted daily P_E[b]	0	0	0.02	0.06	0.10	0.15	0.18	0.17	0.12	0.07	0.02	0
4	Adjusted P_E[b]	0	0	0.62	2.00	3.69	5.58	6.75	6.02	3.74	2.02	0.50	0
5	Precipitation	1.02	1.05	2.01	3.29	4.38	4.51	3.60	4.29	2.98	2.34	1.50	1.39
6	Line 5 - line 4	1.02	1.05	1.39	1.29	0.69	-1.07	-3.15	-1.73	-0.76	0.32	1.00	1.39
7	Accum. potential water loss						-1.07	-4.22	-5.95	-6.71	-7.03		
8	Storage	4.07	4.00	4.00	4.00	4.00	3.05	1.35	0.87	0.72	0.66	1.66	3.05
9	Change in storage	0.61	0	0	0	0	-0.95	-1.70	-0.48	-0.15	-0.06	1.00	1.39
10	Actual evapotranspiration	0	0	0.62	2.00	3.69	5.46	5.30	4.77	3.13	2.02	0.50	0
11	Moisture deficit	0	0	0	0	0	0.12	1.45	1.25	0.61	0	0	0
12	Moisture surplus	0	1.05	1.39	1.29	0.69	0	0	0	0	0	0	0
13	Water runoff	0	0.53	0.96	1.12	0.91	0.45	0.23	0.11	0	0	0	0
14	Snow melt runoff	0	0.01	0	0	0	0	0	0	0	0	0	0
15	Total runoff	0	0.54	0.96	1.12	0.91	0.45	0.23	0.11	0	0	0	0
16	Total moisture detention	4.07	4.54	4.96	5.12	4.91	3.50	1.58	0.98	0.72	0.66	1.66	1.39

Additional information: 1) Latitude -- 39° 04'
2) Last killing frost in spring -- April 8th
First killing frost in fall -- October 20th

Additional computations:

$P_{EVG} = 29.80$ $\qquad I_{XG} = \frac{198-205.8}{29.8} = -0.2617$ $\qquad T_{DG} = 17.47$

$I_N^2 = 1482.2013$ $\qquad I_N^3 = 520.6060$

[a] The actual method of computing each step is described in a publication by Thornthwaite and Mather (66, p. 188-195).

[b] P_{EV} = potential evapotranspiration.

in the fall. Such data on killing frost dates were obtained from the 1941 Yearbook of Agriculture (93, p. 873-875).

In models II and III all the climatic variables for Oregon and Kansas were defined for the period of months between and including the months in which the relevant growing season dates appeared.[1]

Precipitation

In measuring moisture availability, three different measures were employed. Precipitation effectiveness during the growing season was used in model I, moisture index during the growing season in model II and total detention during the growing season in model III.

1. Precipitation effectiveness.

As a result of empirical investigation, Thornthwaite (65, p. 640) constructed a formula measuring precipitation effectiveness which appears here in a slightly modified form.

$$P_{EGi} = \sum_{n=1}^{k} 115 \left(\frac{P_i}{T_i - 10} \right)_n^{10/9}$$

---

[1] If the last killing frost, or 28°F weather, in the spring occurred during the last half of the month, then values for only half of that month were used. A similar procedure was followed if the first killing frost, or 28°F weather, in the fall occurred in the first half of the month.

where:

k and T_{in} are defined the same as on page 161.

P_{EGi} = precipitation effectiveness of county i during the months when the average temperature is $43^{o}F$ or more.

P_{in} = precipitation of county i in month n.

2. Moisture index.

Once again in order to meet the needs of this study, the moisture index as originally proposed by Thornthwaite (64, p. 76) was slightly modified.

$$I_{XGi} = \frac{100S_{Gi} - 60D_{Gi}}{P_{EVGi}}$$

where:

I_{XGi} = moisture index of county i during the growing season.

S_{Gi} = moisture surplus of county i during the growing season.

D_{Gi} = moisture deficit of county i during the growing season.

3. Total detention of water.

An idea of the complex procedure involved in computing the total detention of water during the growing season (T_{DGi}) as well as of the moisture surplus and deficit necessary for the moisture index can be obtained from a perusal of Table 31. Thornthwaite and Mather (66, p. 188-195) have given a detailed description of the steps involved in computing these variables.

Climate Interaction Terms

Three different climatic interaction terms were employed. Definitions of the terms together with the models in which they were used are as follows:

1. Model I.

$$I^1_{Ni} = T_{HGi} \cdot P_{EGi}$$

2. Model II.

$$I^2_{Ni} = P_{EVGi} \cdot (I_{XGi} + 50)$$

Adjustment of the moisture index during the growing season was necessary due to the fact that the index values themselves could be negative or positive.

3. Model III.

$$I^3_{Ni} = P_{EVGi} \cdot T_{DGi}$$

Selection of Weather Stations

Lists of the weather stations selected as being most representative of the agricultural regions of each county are shown in Tables 32 and 33.

Table 32. List of weather stations chosen as being most representative of the agricultural region of each county in Oregon.

County	Weather station	Years for which average was taken[a] Temperature	Precipitation
Baker	Baker KBKR	1931-1960	1931-1960
Benton	Corvallis State College	1931-1960	1931-1960
Clackamas	Estacada 2SE	1931-1960	1931-1960
Columbia	Vernonia (Clatskanie 3W)[b]	1949-1960	1949-1960
Coos	North Bend FAA AP	1931-1960	1931-1960
Crook	Prineville 4NW	1931-1960	1931-1960
Deschutes	Bend	1931-1960	1931-1960
Douglas	Drain INNE	1949-1960	1949-1960
Grant	John Day (Dayville)[b]	1953-1960	1953-1960
Hood River	Parkdale	1931-1960	1931-1960
Jackson	Modoc Orchard	1931-1960	1931-1960
Jefferson	Madras	1931-1960	1931-1960
Josephine	Grants Pass	1931-1960	1931-1960
Klamath	Chiloquin (Klamath Falls 2SSW)[b]	1949-1960	1931-1960
Lake	Valley Falls	1931-1960	1931-1960
Lane	Cottage Grove 1S	1931-1960	1931-1960
Linn	Lacomb 1WNW	1949-1960	1949-1960
Malheur	Vale	1931-1960	1931-1960
Marion	Stayton (Salem WBAP)[b]	1952-1960	1952-1960
Morrow	Heppner	1931-1960	1931-1960
Multnomah	Portland City WB	1931-1960	1931-1960
Polk	Dallas	1949-1960	1949-1960
Sherman	Moro	1931-1960	1931-1960
Tillamook	Tillamook	1949-1960	1931-1960
Umatilla	Pendleton WBAP	1931-1960	1931-1960
Union	La Grande	1931-1960	1931-1960
Wallowa	Enterprise (Wallowa)[b]	1931-1960	1931-1960
Wasco	The Dalles (Dufur)[b]	1931-1960	1931-1960
Washington	Forest Grove	1931-1960	1931-1960
Yamhill	McMinnville	1949-1960	1949-1960

[a] The years shown are those used in computing temperature and precipitation data which were utilized in the calculation of the primitive climatic variables of model one. The years used for the other climatic variables are shown in the report by Johnsgard (30, p. 18-125) from which values of potential evapotranspiration were obtained.

[b] For varying reasons the data for the stations in parentheses were substituted for that of the other stations, when the more sophisticated measures of climate were computed.

Table 33. List of weather stations chosen as being most representative of the agricultural region of each county in Kansas.

County	Weather station	Years for which average was taken[a] Temperature	Precipitation
Allen	Iola 1W	1931-1960	1931-1960
Anderson	Garnett	1931-1954	1931-1960
Atchison	Atchison	1931-1960	1931-1960
Barber	Medicine Lodge	1931-1960	1931-1960
Barton	Great Bend	1931-1950	1931-1960
Bourbon	Fort Scott	1931-1960	1931-1960
Brown	Horton	1931-1960	1931-1960
Butler	El Dorado	1931-1960	1931-1960
Chase	Cottonwood Falls	1931-1960	1931-1960
Chautauqua	Sedan	1931-1960	1931-1960
Cherokee	Columbus 6NNW	1931-1960	1931-1960
Cheyenne	St. Francis	1931-1960	1931-1960
Clay	Clay Center	1931-1960	1931-1960
Cloud	Concordia City WB	1931-1960	1931-1950
Coffey	Burlington	1931-1960	1931-1960
Comanche	Coldwater	1931-1960	1931-1960
Cowley	Winfield	1931-1960	1931-1960
Crawford	Girard (Walnut)[b]	1957-1960	1957-1960
Decatur	Oberlin	1931-1960	1931-1960
Dickinson	Herington 3W3W	1931-1960	1931-1960
Doniphan	St. Joseph	1931-1960	1931-1960
Douglas	Lawrence	1931-1960	1931-1960
Edwards	Kinsley	1949-1960	1931-1950
Elk	Howard 5NE	1950-1960	1931-1960
Ellis	Hays 1S	1931-1960	1931-1950
Ellsworth	Ellsworth	1931-1960	1931-1960
Finney	Garden City CAA AP	1931-1950	1931-1950
Ford	Dodge City WBAP	1931-1960	1931-1960
Franklin	Ottawa	1931-1960	1931-1960
Geary	Junction City	1931-1950	1931-1960
Gove	Quinter (Gove)[b]	1931-1950	1931-1960
Graham	Hill City FAA AP	1931-1960	1931-1960
Grant	Ulysses	1931-1960	1931-1960
Gray	Cimarron	1931-1960	1931-1960
Greenwood	Eureka	1931-1960	1931-1960
Hamilton	Syracuse 2WNW	1931-1950	1931-1960
Harper	Anthony	1931-1960	1931-1960
Harvey	Newton 2SW	1931-1960	1931-1960

Table 33. (continued).

County	Weather station	Years for which average was taken[a] Temperature	Precipitation
Haskell	Sublette	1931-1960	1931-1960
Hodgeman	Jetmore	1931-1960	1931-1960
Jackson	Holton	1951-1960	1931-1960
Jefferson	Valley Falls 2E	1931-1950	1931-1950
Jewell	Mankato (Burr Oak)[b]	1958-1960	1958-1960
Johnson	Olathe 3E	1931-1960	1931-1960
Kearny	Lakin	1931-1960	1931-1960
Kingman	Kingman (Norwich)[b]	1951-1960	1931-1950
Kiowa	Greensburg	1931-1960	1931-1960
Labette	Parsons (Oswego)[b]	1931-1960	1931-1960
Lane	Healey	1931-1960	1931-1960
Leavenworth	Leavenworth	1931-1960	1931-1960
Lincoln	Lincoln 2ESE	1931-1960	1931-1960
Linn	Mound City (Pleasanton)[b]	1949-1960	1949-1960
Logan	Oakley	1931-1960	1931-1960
Lyon	Emporia FAA AP	1931-1953	1931-1950
McPherson	McPherson 2S	1931-1960	1931-1960
Marion	Florence (Marion)[b]	1950-1960	1931-1960
Marshall	Marysville (Oketo)[b]	1949-1960	1949-1960
Meade	Meade	1931-1950	1931-1950
Miami	Oswatomie (Paola)[b]	1951-1960	1931-1950
Mitchell	Beloit 1ESE	1954-1960	1931-1960
Montgomery	Independence	1931-1960	1931-1960
Morris	Council Grove	1931-1960	1931-1960
Morton	Elkhart	1931-1950	1931-1960
Nemaha	Centralia	1931-1960	1931-1960
Neosho	Chanute FAA AP	1931-1960	1931-1960
Ness	Ness City	1931-1950	1931-1960
Norton	Norton 8SSE	1931-1960	1931-1960
Osage	Osage City	1931-1960	1931-1960
Osborne	Alton 6E	1931-1960	1931-1960
Ottawa	Minneapolis 2	1931-1960	1931-1960
Pawnee	Larned	1931-1960	1931-1960
Phillips	Phillipsburg	1931-1960	1931-1960
Pottawatomie	Wamego	1931-1960	1931-1960
Pratt	Pratt	1931-1960	1931-1960
Rawlins	Atwood	1931-1960	1931-1960
Reno	Hutchinson KNBW	1949-1960	1949-1960
Republic	Belleville	1931-1950	1931-1950
Rice	Geneso (Alden)[b]	1931-1950	1931-1950
Riley	Manhattan No. 2	1931-1960	1931-1960
Rooks	Plainville	1931-1960	1931-1960
Rush	Bison	1931-1960	1931-1960
Russell	Russell	1931-1950	1931-1950

Table 33. (continued).

County	Weather station	Years for which average was taken[a]	
		Temperature	Precipitation
Saline	Salina FAA AP	1931-1951	1931-1951
Scott	Scott City	1931-1960	1931-1960
Sedgewick	Wichita WBAP	1931-1960	1931-1960
Seward	Liberal	1931-1960	1931-1960
Shawnee	Topeka WBAP	1931-1960	1931-1960
Sheridan	Hoxie	1931-1960	1931-1960
Sherman	Goodland WBAP	1931-1960	1931-1960
Smith	Smith Center 3W	1952-1960	1931-1960
Stafford	Hudson (Macksville)[b]	1951-1960	1931-1960
Stanton	Johnson 11ESE	1931-1960	1931-1960
Stevens	Hugoton	1950-1960	1931-1960
Sumner	Wellington	1931-1960	1931-1960
Thomas	Colby 1SW	1931-1960	1930-1960
Trego	Wakeeney	1931-1960	1931-1960
Wabaunsee	Eskridge	1931-1960	1931-1960
Washington	Washington (Hanover)[b]	1952-1960	1952-1960
Wichita	Leoti	1931-1960	1931-1960
Wilson	Fredonia 1E	1931-1960	1931-1960
Woodson	Yates Center (Toronto)[b]	1955-1960	1931-1950
Wyandotte	Kansas City WBAP	1931-1960	1931-1960

[a] The length of growing season, determined by the number of days between killing frosts, was obtained by an average over a different period of years. The periods for these data are given in Climate and Man (93, p. 873-875).

[b] When data on the length of the growing season were not available for the stations chosen, killing frost data for the stations in parentheses were substituted for these stations.

APPENDIX C

SUPPLEMENTARY EMPIRICAL RESULTS FOR OREGON

The results presented in this appendix are discussed in Chapter IV. Basically, the models in Tables 34 to 36 consist of various empirical measurements of the theoretical constructs represented in equation (8) on page 21.

The variables which are not enumerated at some point in Chapter IV are defined as follows:

X_{19} = average specified expenditures per farm in the county.

X_{20} = percentage of the population in the county who are not farm residents or farmers and farm managers living off farms.

Table 34. Equation depicting the percentage of commercial farm operators who are employed off the farm, using an alternative measure of location. Oregon, 1959.

Variable	Minimum step equation			Full equation		
	Partial regression coefficients	T values	Beta coefficients	Partial regression coefficients	T values	Beta coefficients
Constant	-38.7400			-41.7023		
X_1				0.0097	0.0025	0.00038
X_2	0.5509	1.1200	0.2135	0.6162	1.2111	0.2377
X_3	3.3409	1.4520	0.2288	3.6813	1.5182	0.2522
X_4				-0.5251	-0.8935	-0.1391
X_{15}	-0.00018	-3.6830**	-0.6313	-0.00020	-3.6483**	-0.6809
X_{20}	0.3396	1.9138*	0.4035	0.3110	1.6276	0.3696
	R_2 = 0.7347**			R_2 = 0.7456**		
	R^2 = 0.5397			R^2 = 0.5559		
	S_{yx} = 1.3175			S_{yx} = 1.3492		

* Significantly different from zero at the 10% level.

** Significantly different from zero at the 2% level.

Table 35. Minimum step equations depicting the percentage of commercial farm operators working off the farm, with average specified expenditures per farm being used as measure of time availability. Oregon, 1959.

(a) Equation 2Aa

Variable	Partial regression coefficients	T values	Beta coefficients
Constant	35.3704		
X_{16}	0.9810	1.9116*	
	$R = 0.3397$** $R^2 = 0.1154$ $S_{yx} = 1.7258$		

(b) Equation 2Ba

Variable	Partial regression coefficients	T values	Beta coefficients
Constant	45.4212		
X_{17}	-1.6780	-1.7715*	
	$R = 0.3175$** $R^2 = 0.1008$ $S_{yx} = 1.7401$		

(c) Equation 2Ca

Variable	Partial regression coefficients	T values	Beta coefficients
Constant	-30.9486		
X_2	0.7026	1.1855	0.2711
X_{18}	0.6315	2.9209**	0.2354
X_{19}	-0.00068	-1.1133	-0.1841
	$R = 0.5490$** $R^2 = 0.3014$ $S_{yx} = 1.5916$		

* Significantly different from zero at the 10% level.

** Significantly different from zero at the 2% level.

Table 36. Influence of location variables on the determination of the percentage of male farmers and farm managers who work more than 100 days off the farm. Minimum step equations. Oregon, 1959.

(a) Equation 3A

Variable	Partial regression coefficients	T values	Beta coefficients
Constant	1.6741		
X_3	2.1620	1.2436	0.1837
X_4	-0.9546	-2.4108*	-0.3138
X_{15}	-0.00017	-4.5429**	-0.7161
X_{16}	0.4526	1.4157	0.1944
	$R = 0.7756$**		
	$R^2 = 0.6015$		
	$S_{yx} = 0.9885$		

(b) Equation 3B

Variable	Partial regression coefficients	T values	Beta coefficients
Constant	8.3559		
X_1	-2.7186	-1.0140	-0.1331
X_3	2.1469	1.2077	0.1824
X_4	-1.0430	-2.5777**	-0.3428
X_{15}	-0.00019	-5.3938**	-0.8030
	$R = 0.7658$**		
	$R^2 = 0.5865$		
	$S_{yx} = 1.0069$		

(c) Equation 3C

Variable	Partial regression coefficients	T values	Beta coefficients
Constant	-18.0395		
X_3	2.6247	1.5130	0.2230
X_4	-0.8065	-1.9499*	-0.2651
X_{15}	-0.00016	-4.1778**	-0.6863
X_{18}	0.1782	1.4897	0.2324
	$R = 0.7776$**		
	$R^2 = 0.6046$		
	$S_{yx} = 0.9846$		

* Significantly different from zero at the 10% level.

** Significantly different from zero at the 2% level.