AN ECONOMIC ANALYSIS OF FARMLAND VALUES

IN WESTERN OKLAHOMA

By

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Unnamed friends, you have my thanks for all your help and advice. A few of you rendered to me the ultimate help of timely encouragement and humor. Unnamed family, you have my thanks for love and patience and the necessary diversions of daily life. Mother, you have my thanks for your love and faith in me and for countless prayers of blessing. I dedicate this thesis to the memory of my father, Roland E. Warmann.

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CHAPTER I

INTRODUCTION

The value of farmland has always been of interest to farmers and others directly involved in the agricultural sector. Historical records of farmland prices indicate at least for the past several decades that nominal prices of farmland have generally trended upward with infrequent years of stable or falling prices. Farmland prices have recently declined, perhaps for the second or third straight year in some areas. The phenomenon of falling land prices concerns many in the farm economy. This study will attempt to provide more information on land markets to those whose life and business involve the land.

A review of price statistics shows a number of other periods of land price deflation so one can ask, why the concern now? No doubt the present concerns are of greatest importance to us because of perspective and personal involvement. There is cause for genuine concern if only for the enormous psychological impacts upon land owners, users, and lenders. Land is, after all, the single largest factor of production in agriculture and represents in dollar terms the bulk of the capital devoted to agriculture. Its importance in the balance sheet is obvious.

Lenders look to the borrower's balance sheet to make their credit decisions. These decisions can be whether to extend credit to new applicants or to suggest liquidation of current borrowers if either repayment or security falls short. When land prices fall in sufficient nominal magnitude the security becomes especially important.

For many individuals and corporations, land in general and farmland in particular is an investment item. Retired farmers often hold land in their portfolio to be transferred to the next generation through sale or bequest. Price and value information is important to them as they plan for these exchanges. As a portfolio asset the earnings of land are important. Farmland in the recent past earned returns in two forms: cash receipts and capital gains. The present situation of decreasing prices and low cash receipts, although perceived by some as temporary, affects the decisions of farmers and other holders of land assets.

Policy analysts in government and industry constantly review the market conditions in many sectors of the economy. The farmland market is a bellweather for the long term expectations of farmers and agricultural investors. Financial institutions develop and implement policy based upon the view for the long term, particularly for real estate credit, and have very acute needs for accurate and timely data on land values. The ability to forecast and explain land market fluctuations, even to a small degree, would facilitate financial policy development.

The goal of most policy is to reduce the effects of instability of a sector in the economy and the population. Models of a subsector help to describe and explain some of the economic machinery and provide a beginning for other study and a base for policy formulation.

An important aspect of land value is its inclusion in the tax base. Property taxation at the county level is based upon assessed valuation. County assessors are continually faced with questions of value and must support their assessments, their professional opinions of value, to an often critical constituency. County-wide revaluation projects, mandated by the courts, add a tremendous labor burden to the assessor's staff. Mass land appraisal systems are a suggested means of coping with this burden.

Real estate, as the term implies, is real property of estate. Valuation questions arise as properties are inventoried, taxed, and distributed to meet the requirements of law and testament. Estate planners depend on estimates of the property component of estate values and utilize many sources of information to account for all assets in an estate.

Real estate value is an important factor to the agricultural economy. Land is the most basic factor of production in any farm firm and is the basis for much of the credit extended to a farm business. Changing land prices, particularly farmland price decreases, raise concerns both within and without the agricultural sector.

The Problem

Farmers, real estate professionals, agricultural lenders, assessors and agricultural policy makers are interested in the long and short term price trends for farmland. Across Oklahoma different farmland markets can be identified. Over time there are changes in price and in the market's valuation of property features. A study of the farmland market includes basic price information as well as detailed analysis of individual and aggregate tract features which have an effect upon final selling price. This study attempts to identify markets for farmland and the extent to which certain features of individual tracts impact upon final value.

Objectives

The objectives of this study are as follows:

1. Develop an on-going system of receiving and storing agricultural land sales data for Oklahoma. This system would facilitate the publication of a periodic informational report on farmland values in the various regions of Oklahoma.
2. Develop a set of data on such variables as soil productivity, land use as indicated by land cover, population density, assessed value per square mile, road mileages per square mile, and distances from farmland tracts to population centers as potential factors influencing farmland value.
3. Develop and test econometric models to evaluate factors which affect farmland values in western Oklahoma.
4. Designate distinct agricultural land markets in western Oklahoma.
5. Develop and test econometric models to evaluate the distinct land markets in western Oklahoma.

Hypothesis testing, in the context of the econometric analysis, will consist of reviewing relevant variables and determining the extent to which these variables explain land price variation. A complete description of these variables is found in a later chapter.

Study Area

The study area extends from the eastern end of the Oklahoma panhandle into the central part of the state. All or parts of thirty-seven counties are included in the area. A list of the included counties along with general physical and demographic information about each county follows as Table I. Figure 1 is a state map with the boundaries of the study area outlined.

Agricultural Enterprises

Western Oklahoma agricultural lands are used mainly in the production of wheat and beef cattle. Some peanut and cotton production is found in several southwest counties. Livestock production utilizes both wheat as pasture and also extensive acreages of native and improved grasslands. Rangelands, having a lower animal carrying capacity than grassland areas, comprise large portions of several counties in the study area.

Irrigated cropland is important to several counties in the study area. The Ogallala aquifer underlies a major portion of Ellis county and several other counties to a lesser extent. Other groundwater sources feed irrigation in adjacent counties; center pivot irrigation systems are popular with area agricultural producers.

TABLE I

GENERAL CHARACTERISTICS OF STUDY AREA COUNTIES

OBS	COUNTY	POP1980	POPDENS	INC	AREASQMI	ASSDVAL	RAIN
1	ALFALFA	7077	8	7077	885	41623114	29
2	BECKHAM	19243	21	4705	907	74263042	26
3	BLAINE	13443	14	4473	932	63138706	29
4	CADDO	30905	24	3713	1276	92379975	30
5	CANADIAN	56452	63	5092	899	203842729	30
6	CLEVELAND	133173	238	5291	559	293889511	24
7	COMANCHE	112456	103	4663	1092	155890258	31
8	COTTON	7338	11	471	651	17008260	30
9	CUSTER	25995	26	5036	1001	95571827	27
10	DEWEY	5922	6	4844	1019	36362276	26
11	ELLIS	5596	5	5197	1242	30124935	24
12	GARFIELD	62820	60	5676	1054	218286025	32
13	GARVIN	27856	34	4895	814	61290139	35
14	GRADY	39490	36	4812	1096	91598685	32
15	GRANT	6518	6	4543	1007	50903594	32
16	GREER	7020	11	3866	638	20763094	27
17	HARMON	4519	8	3841	545	15578743	25
18	HARPER	4715	5	5122	1041	33080064	24
19	JACKSON	30356	37	4097	810	48514058	27
20	JEFFERSON	8183	10	4352	780	19676825	32
21	KINGFISHER	14187	16	5695	904	69846982	30
22	KIOWA	12711	12	3922	1034	34910354	29
23	LINCOLN	26601	27	4494	973	55941074	34
24	LOGAN	26881	36	4311	752	72117283	32
25	MCCLAIN	20291	35	4320	573	49206870	34
26	MAJOR	8772	9	5119	963	51155199	28
27	NOBLE	11573	15	5233	747	104510212	34
28	OKLAHOMA	568983	801	6250	710	1559136686	32
29	PAWNEE	15310	26	5166	600	41562994	36
30	PAYNE	62435	89	4772	700	115619220	35
31	POTWATOMIE	55239	69	4604	803	92633803	35
32	ROGERMILLS	4799	4	5430	1140	33098274	26
33	STEPHENS	43419	49	5464	894	93530371	32
34	TILLMAN	12398	14	3899	902	35666438	28
35	WASHITA	13798	14	4422	1010	48144844	28
36	WOODS	10923	8	5765	1298	45600907	26
37	WOODWARD	21172	17	5694	1255	85809559	25

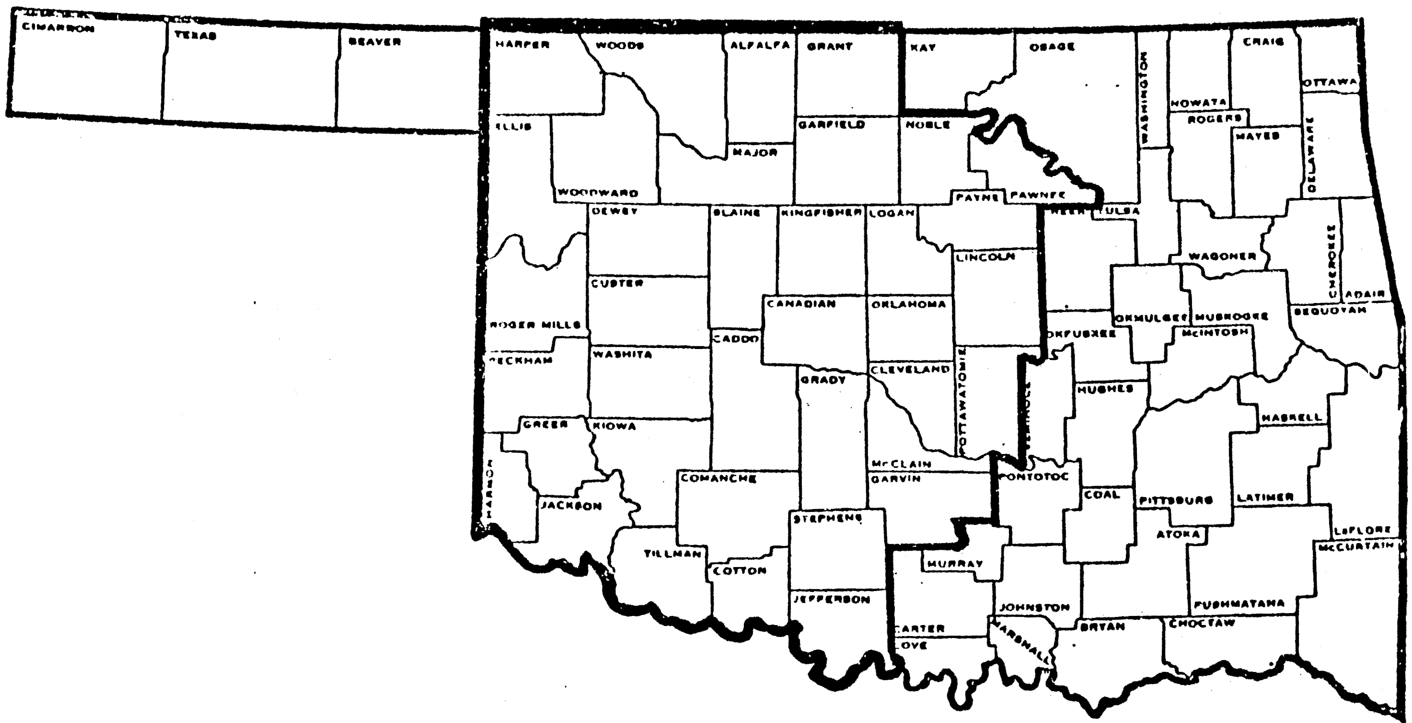

Figure 1. Western Oklahoma Study Area

Metropolitan Areas

Three metropolitan areas found in the study area are shown in Figure 2. The Oklahoma City Standard Metropolitan Statistical Area (SMSA) includes five counties in central Oklahoma with a combined population of approximately 834,000 based upon the 1980 census (39). The Lawton SMSA is comprised of Comanche County in southwest Oklahoma and had a 1980 population of 112,456. Enid, in Garfield County in northcentral Oklahoma, had a 1980 population of 62,820 in the countywide SMSA.

Oklahoma City is a major center for manufacturing, government, and trade, while Enid and Lawton offer these services and employment opportunities to a lesser extent. Other smaller cities and county seat towns provide services and employment as is usually found in a predominantly agricultural area.

Land Cover

The study area was determined in part by the LANDSAT land cover data acquired for this project. Four "scenes" of digital reflectance data were purchased through the EROS data center and processed by the Center for the Application of Remote Sensing (CARS) at Oklahoma State University. The area covered by these four "scenes" of data is shown in Figure 3. The thirty-seven county study area includes most of the land analyzed by CARS.

The analysis of the LANDSAT data and the process whereby the land cover data is made useful for this project required considerable efforts by CARS personnel and computer programmers. Generally

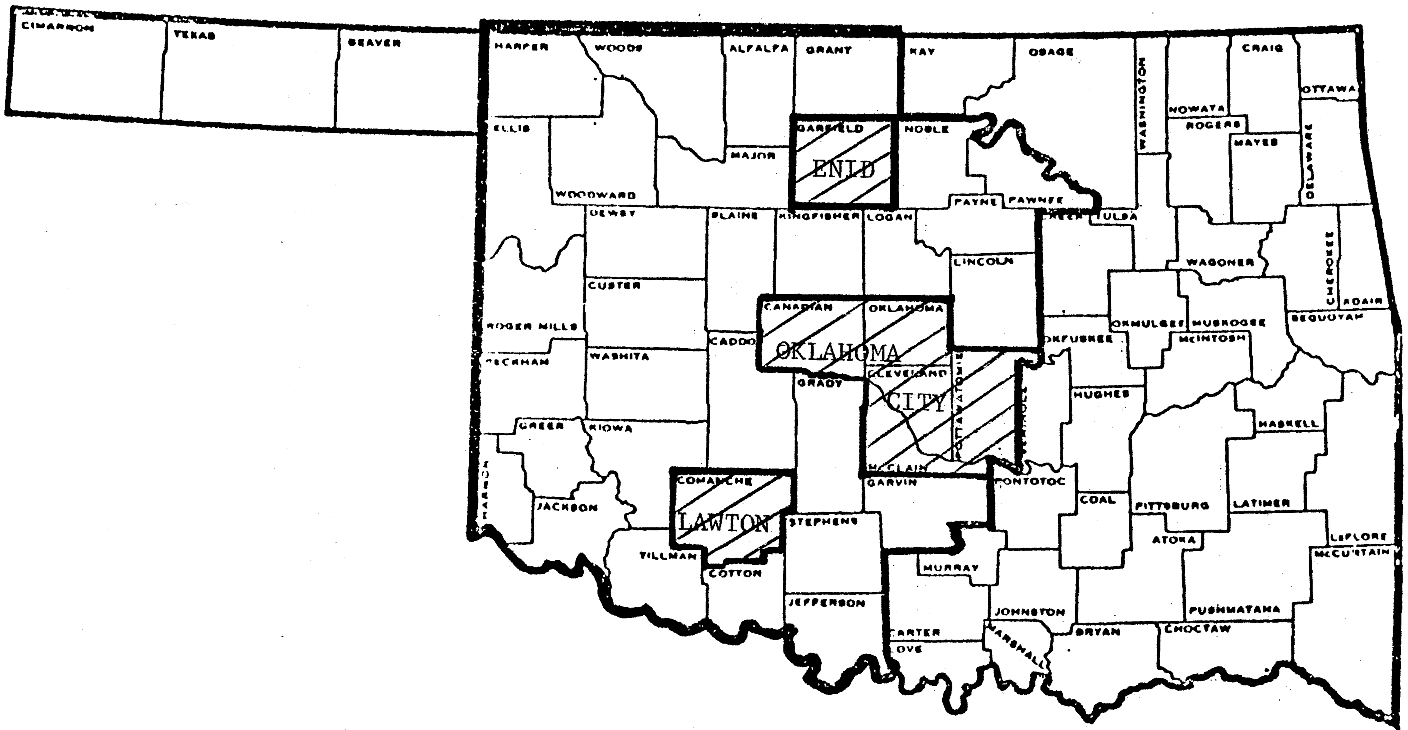

Figure 2. Standard Metropolitan Statistical Areas (SMSA)
in the Western Oklahoma Study Area

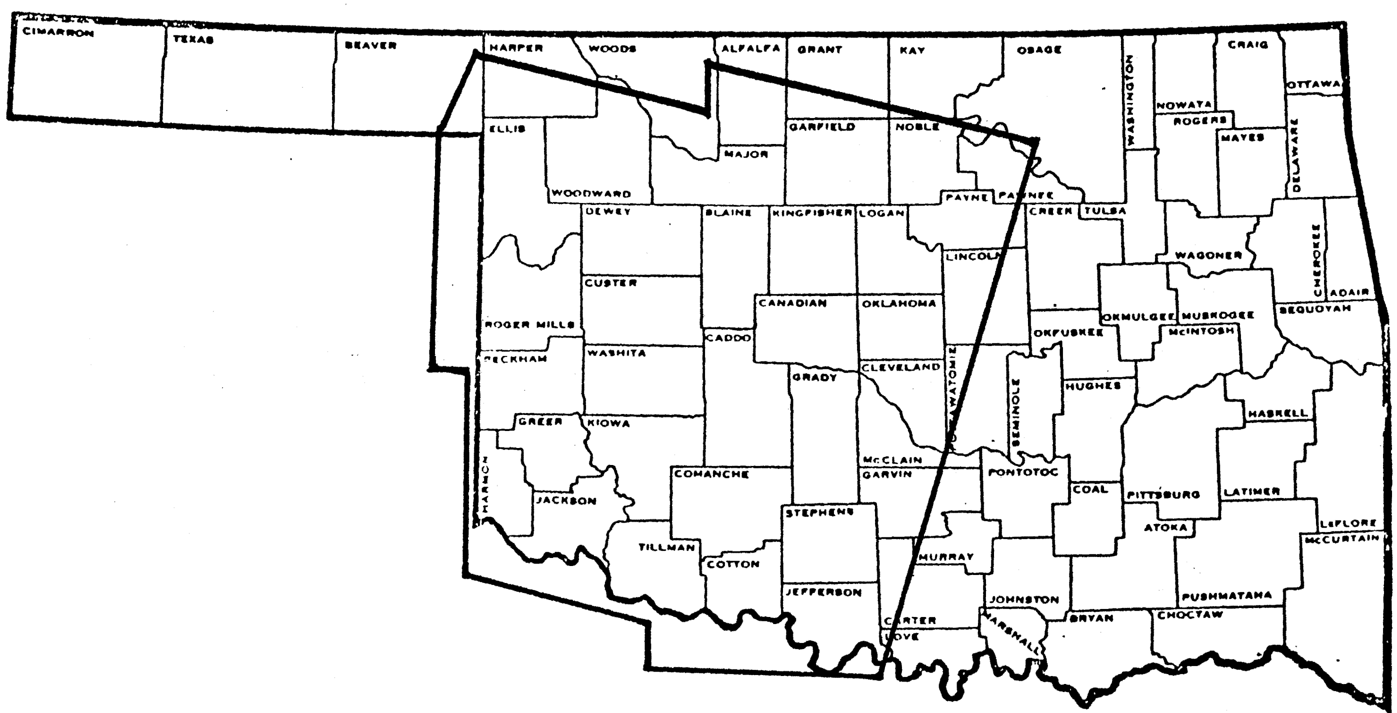

Figure 3. LANDSAT Coverage of the Western Oklahoma Study Area

landcover data has been used to inventory land resources in a defined area. For this project a method was needed to match known land locations to the land cover analysis. The nature and use of LANDSAT and land cover data as well as the location matching system are more fully discussed in a later chapter.

General Study Area Information

This western half of Oklahoma is characterized by red soils of the rolling red plains and the reddish prairies. Southeastern and eastern counties of the study area are in the cross timber soils (19). Figure 4 is a map of resource areas in Oklahoma. Land elevation is greatest at the western and northern edge of the study area - approximately 3000 feet above sea level. Lowest elevations of approximately 900 feet occur in the southeast portions of the study area. Figure 5 is a map showing the natural vegetative types found in Oklahoma.

Climatic variability has long been associated with Oklahoma. Rainfall in the study area decreases to the west varying from averages near 36 inches per year down to 22 inches per year.

Data Procedures

An empirical study such as this consumes considerable time with the accumulation of data. And data, once acquired, must be stored and processed in an orderly fashion, or their usefulness is qreatly diminished. As data were acquired, either for individual observations or for classes of observations, they were added to the data base.

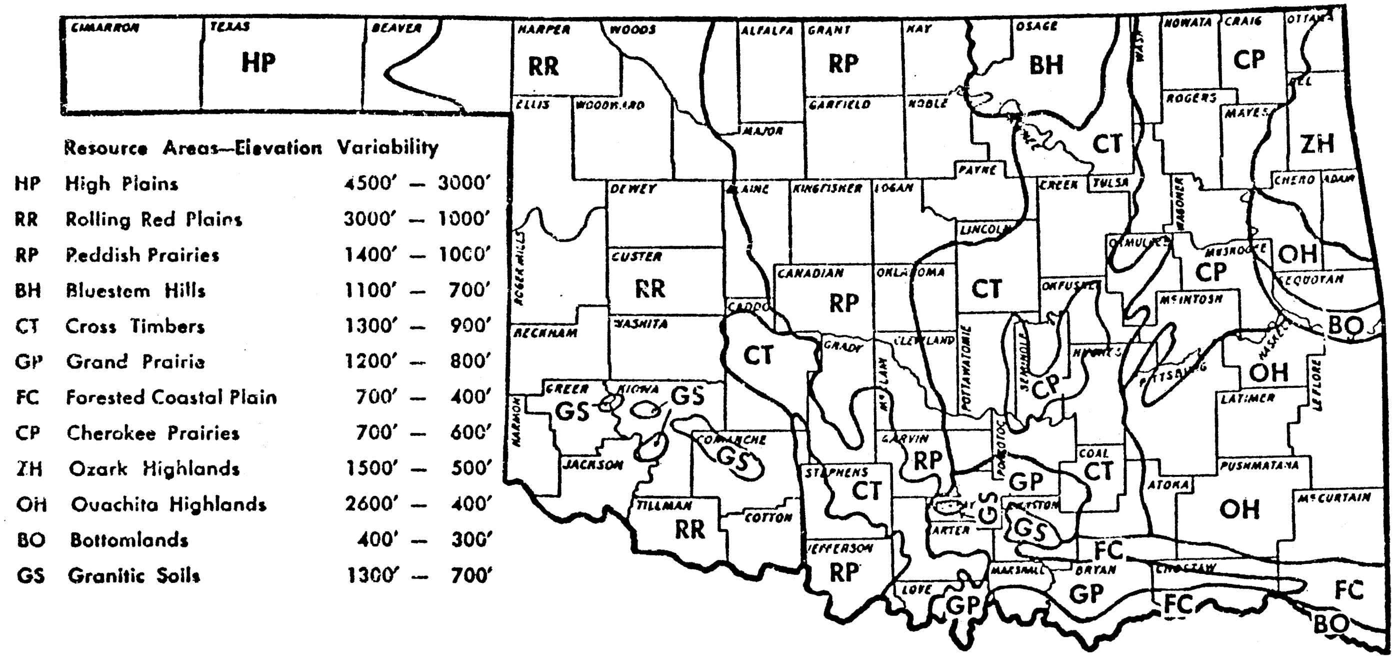

Figure 4. Oklahoma Resource Areas and Land Elevation

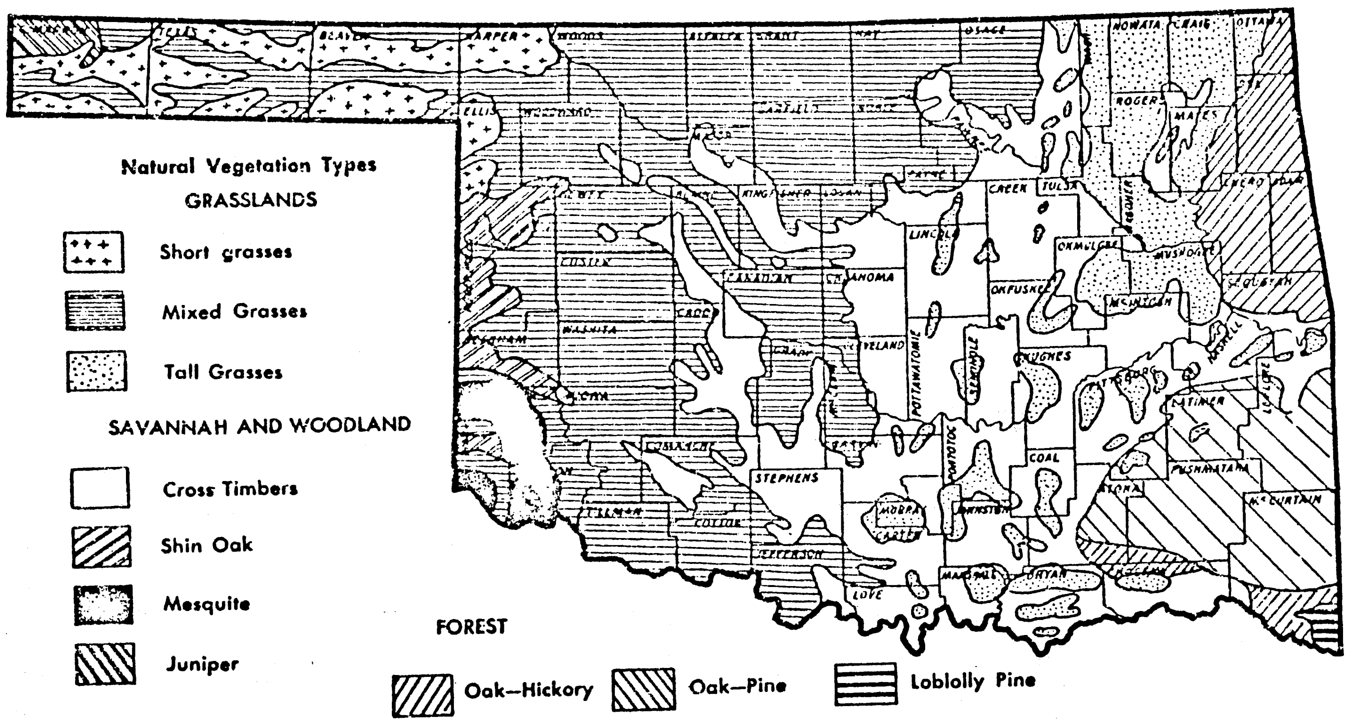

Figure 5. Oklahoma Natural Vegetative Cover

Layers of data on sale price, rainfall, population density, soil productivity and all other variables were put in place for the most important phase of the research, the empirical analysis.

Organization

The remainder of this study is divided into seven chapters. In Chapter II the pertinent theory relating to real estate asset value is discussed. A review of some of the economic literature important to real estate valuation and agricultural land value study is included. Comprehensive description and discussion of the physical, cultural, and demographic factors which are possible determinants of agricultural real estate value is followed by a brief review of the use of regression analysis by professional appraisers. Presentation of a general valuation model completes Chapter II.

This study utilizes data collected by the LANDSAT satellite system. In Chapter III the concept of remote sensing is defined and explained. LANDSAT data handling techniques are briefly reviewed. The final section of this chapter includes a summary of LANDSAT data applications in an agricultural setting.

Studies of value are in reality a part of the process of appraisal. Professional appraisers analyze individual land parcels which have sold in the open market to determine the effects of location, size, quality of land and other factors on the market value of a tract of land. General as well as specific information is utilized to render a professional opinion of land value in the form of an appraisal report. The development of a detailed agricultural appraisal report is explained in Chapter IV. General land price information showing the recent trends in the marketplace provide a basis for the appraisal report and is the initial data collection step usually taken by an appraiser. Active appraisers maintain current land price data, continually updating their information to expedite appraisal report writing. Trends in Oklahoma farmland values are reported in Chapter V.

A specific model of agricultural land value is presented, tested, and analyzed in Chapter VI. This empirical chapter addresses the main objective of this study, the identification of the relevant factors of value for agricultural land in western Oklahoma.

Chapter VII begins with a review of the techniques used to identify the distinct markets for farmland in western Oklahoma. Each of these markets is then separately analyzed with the findings included as the last section of the chapter. A summary of the study and concluding comments are presented in the final chapter.

CHAPTER II

THEORY, LITERATURE AND MODELS OF AGRICULTURAL LAND VALUE

Value of any commodity is derived from its usefulness to an owner in some tangible or intangible way. Land, as a commodity, renders to its owners a use for production, resource storage or control, as an investment, or to fulfill some aesthetic goal. Part of land's value is derived from its quality and its location. The first part of this chapter reviews some of the classical theory of land rent and the influence of location on land rent and value.

A body of literature developed through the study of land values is reviewed in the next section of this chapter. General data sources and a discussion of the variables which may affect rural agricultural land value follows. In the final section of this chapter the analysis process is explained and a generalized mathematical model is presented.

A Review of Rent Theory and Location Theory for Agriculture

Land as the basic resource to agricultural production must be efficiently organized and allocated among potential users. This spatial as well as time allocation of land toward alternative uses is explained and demonstrated by the theories of rent and location.

Rent theories developed individually by a number of Classical economists will be reviewed in the first part of this chapter. Natural links between theories of rent and theories of location will be examined. While principle attention will be directed toward the agricultural sector, there is a natural interdependence between rural or agricultural applications of these theories and urban or urbanizing applications.

Early Rent Theory

Early writers in the economics discipline acting independently developed theories of rent for agricultural land. Adam Smith's view of rent centered on rent as a monopoly return, rent as a surplus return over costs, and rent as a return over the next best alternative use for the land. For Smith, rent was "the price paid for the use of land" (17, p. 71). Other theories were disseminated through pamphlets, the usual medium of publishing short treatises on intellectual topics. These earliest writers on rent theory were T. R. Malthus, David Ricardo, Edward West, and Robert Horrens whose individual pamphlets appeared in an approximate one-month period (17).

One of the traditional approaches to appraising property is the capitalized income approach which utilizes the general formula

$$V = I/r$$

where

V is the calculated value,

I is the net income to the property, and

r is the capitalization rate.

Of particular interest in this study are elements of I, calculated net income. In some instances rental income is used to determine net income to property; net income is gross rental income less expenses for taxes and certain categories of maintenance. If the rental market operates efficiently the characteristics of a property which improves its earning potential will be known and rental bargaining will reflect positive attributes as rent increases and negative attributes as detriments to rental prices.

A well known body of theoretical writings exist which explains the theory of rents and the effects of rents upon value. David Ricardo in The Principles of Political Economy and Taxation (34) defines rent as "... that portion of the produce of the earth which is paid to the landlord for the use of the original and indestructable powers of the soil." (34, p. 33). Rents, as Ricardo thought, are paid or earned by the better quality lands. His eloquent explanation is based upon the fact that the supply of land is not inexhaustible, and also that there are many qualities of land.

This classical theory of rent, most usually attributed to David Ricardo even though he acknowledges Malthus' pamphlet on rent theory, is based upon the population principle developed by Malthus. The Napoleonic Wars and later the Corn Laws of the era restricted food trade into England. The era was further marked by large population increases. As the demand for food increased, there being a fixed amount of top quality agricultural land for production, prices rose allowing poorer quality land to be brought into production. The poorer quality land had a higher cost of production which was just covered by the market price. The original high quality farmland, whose production was greater or whose costs were less than the poorer quality land, returned a profit over normal costs and returns. It was this differential in quality and final returns which came to be called land's rent. As the population grows, increasing food demands are placed upon limited quantities of good land and lower quality land will be brought into production, the lowest quality of land will just break even and earn normal returns. This poorest land is operated at the margin of zero rents; all better grades of land earn a rent, with the best lands earning the greatest rent (17).[1]

Malthus, in his pamphlet, called the quality of soil "a gift of nature to man" and noted that the limits of earth and the then known limits to the good soils created a partial monopoly which the owner, the landed lord, would exploit (29).

Figure 6 graphically represents the differential theory of rent developed by Malthus and others. Land A is the highest quality land and lands B and C are of poorer quality with land C the last land brought into production at price of P_c. The costs of production of land C are just covered by the market price P_c, and land C earns no rent. Land C is operated at the zero rent margin. Lands A and B earn the differential rent based upon their quality as shown in costs of production.

It was this representation of differential rent which Ricardo called the extensive margin (17). Ricardo also identified the intensive margin, where additional variable inputs are applied to

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[1] Ricardo also notes that some payment of land rent is for improvements to property securing for the operator the usefulness of the improvements (34). He considered these payments as interest on the capital investment found on the land and separated it from the notion of price rent.

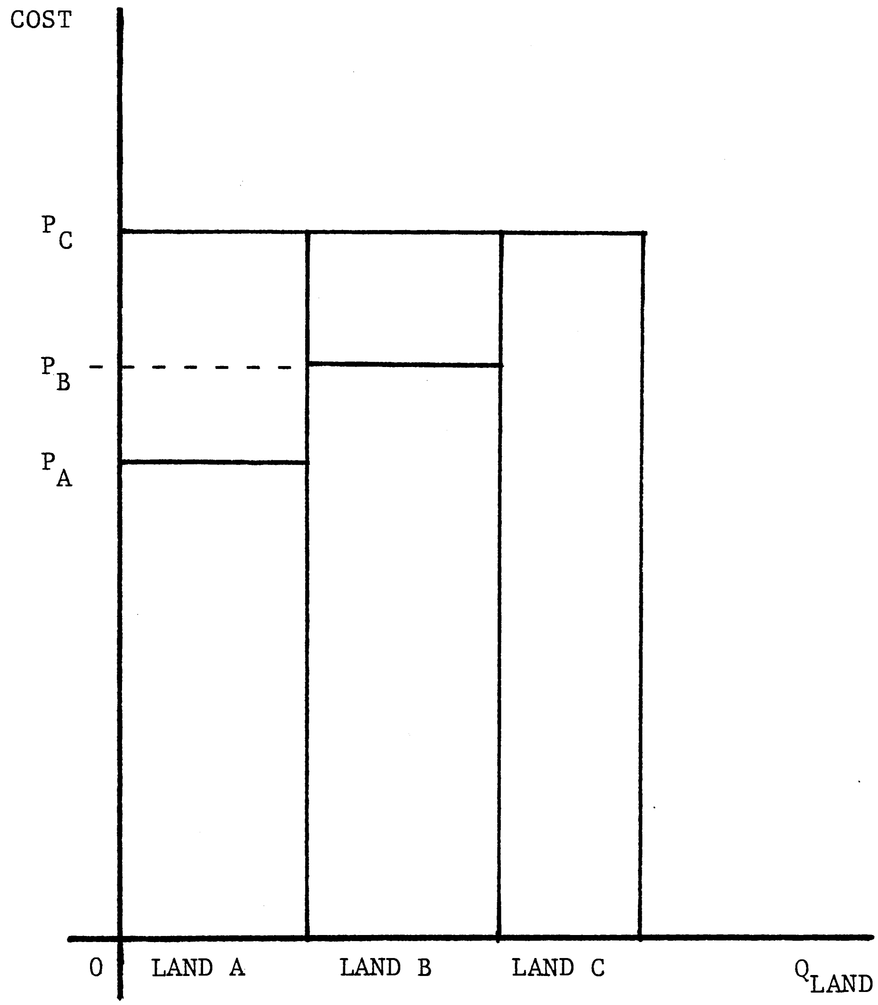


Figure 6. Cost as a Determinant of Differential Land Rent

lands of the same quality. Production could be increased through the employment of more land at the extensive margin or by increasing fertilizer, labor and other inputs. If the addition of inputs increased production at less per unit cost than expanding acreage, this land also earned a rent. Both margins may be functional, always having some land operating at the zero rent margin with costs just covered by the market price. Both the extensive margin and the intensive margin illustrate diminishing returns in agricultural production. Poorer land has lower output per unit of input. Increased output as a result of increased inputs at the intensive margin has lower output per unit of input than the production from the original level of inputs.

From this earliest notion of rent as a return to land others have expanded on why lands command different rents. Walker (46), depending heavily upon the general outline of Ricardian rent, adds comparisons of land tract size, ease of operation, slope of the terrain and the location of the market via known and established transport methods, not in distance, but in costs of transportation. The cost of production for a commodity should necessarily include the cost of transporting it to the market, for these costs must also be paid by the producer. Also, certain lands, in addition to having fertility attributes desirable to farmers, have other natural advantages which tend to decrease the cost of production. Large, level, regularly shaped fields are more convenient to manage than small irregular fields in hilly regions. These attributes, ignored in earlier discourse on rent theory, become important at the zero rent margin.

The treatment of the intensive margin is also further expanded in later work. Application of capital to land takes other form than merely labor or fertilizer. Capital, in the form of buildings, fences, or water wells, can greatly enhance the earning capacity of a tract of land. Rents earned, or in a measurable sense rents actually paid the landlord for the use of the land and improvements, can thus be decomposed into, 1) Ricardian rents, and 2) improvement rent or the interest on the capital invested in the land (46). Much depends upon the type of capital investment in land, for if the investment took the form of specialized facilities, the limited usefulness of the facilities might not be reflected in the rent to the land. Rents also can be temporal in nature; as earnings in agriculture rise, rents generally tend to follow, often with time lags or adjustments based partially on expectations of income of agriculture (42).

Location as a Factor

An important attribute of land and its rent is the location of the land parcel in relation to markets. The location factor, along with different agricultural land uses, was further studied by Isard. His graphical representation of rent per unit of land as a function of distance from the market is seen in Figure 7 (21). Lines A, B, C and D represent rent bid functions for individual crops based upon market distance and transportation costs. Farm operators, faced with a variety of cropping alternatives and rents or revenues, will choose those alternatives which maximize rents based upon the distance from the market. The kinked line AD shows rent per unit of land for the

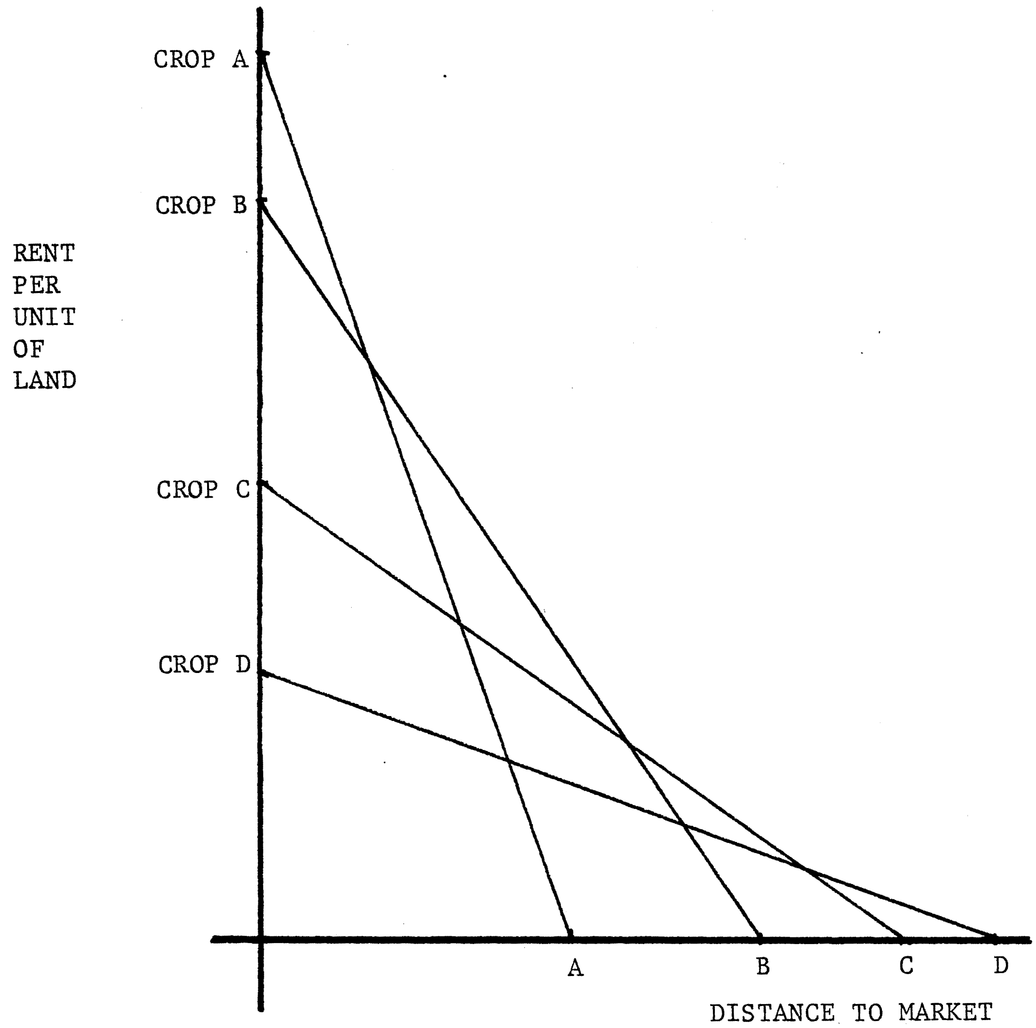


Figure 7. Rent as a Function of Distance to Market

cropping alternatives A, B, C, and D in relation to the distance from the market point.

An operator with a multidimensional utility function might seek to maximize total utility which might not simply be to maximize rents. Constraints, such as time, capital, labor training, or sociological goals might remove him from the rent frontier.

In addition to the links to the owner's utility function, rents can be related to the interest rate (21). The interest rate affects the amount of capital invested in transportation facilities which would otherwise decrease the total transportation cost component of agricultural production. This would tend to hold rents higher because of less competition from more distant points of production. Also during periods of high interest rates, the opportunity cost of capital is higher, causing the landlord to command higher rents.

Formal Location Theory

From the bases of rent theory, there emerged a consolidated theory of location. Johann Heinrich Von Thunen developed his location theory first published in Der Isolierte Staat (17). Patterns of land use develop around cities which represent the market for agricultural production and other production. The city is assumed to be in the center of a homogeneous fertile plain, and the emerging system of production reflects the added costs of transport to the production of agricultural commodities. Figure 8 shows what might result from such a model. Dairy products and horticultural products have high spoilage rates which add to the drayage costs. Production of these products would center near the market point. Cereal grains,

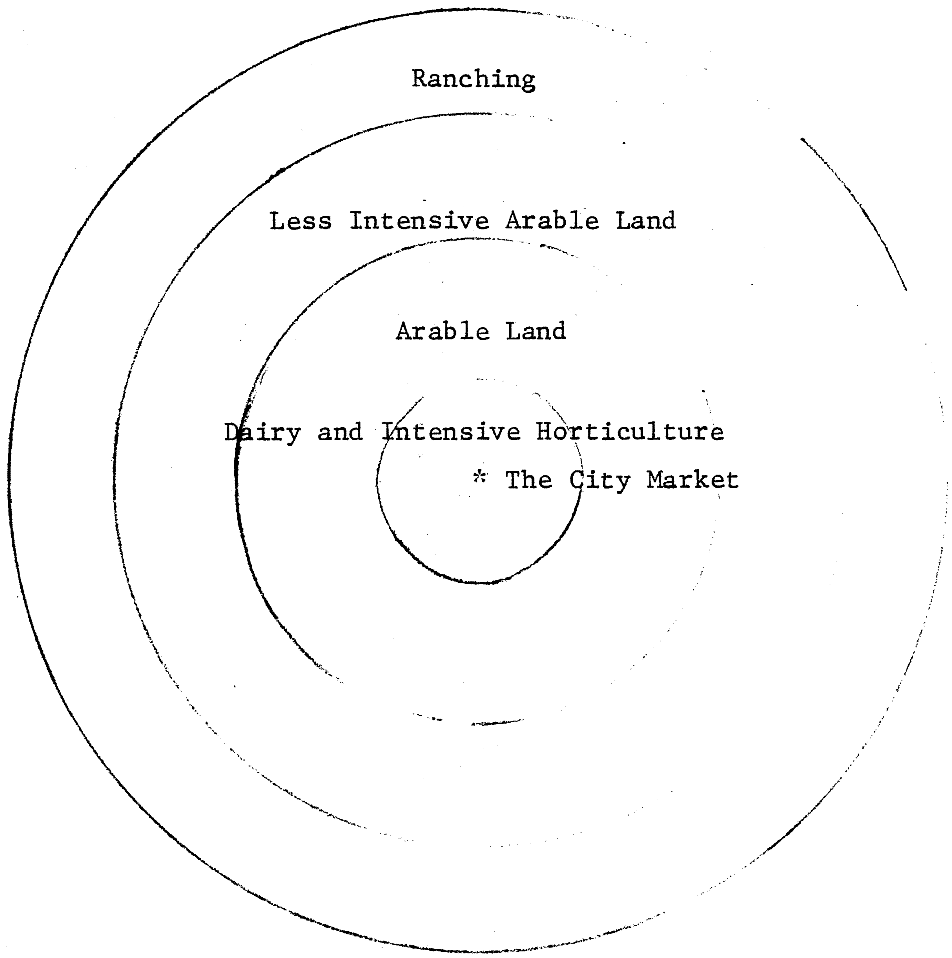


Figure 8. Von Thunen's Land Rent Model

having less transport losses, locate further out into the countryside. Ranching can be successfully pursued at great distances from the final markets because each acre of land contributes relatively little toward final product value. The rents paid to lands distant from the city market are much lower than rents paid to adjacent lands.

Transportation arteries, such as navigable rivers or highways, will distort the spatial distribution of production, but the final representation in graphical form will still be determined by effective transportation costs for the products (11).

Von Thunen's analysis, for two commodities (wheat and dairy) is graphically shown in Figure 9. Costs are measured against distance from the city market. Fixed and total costs are shown on the graph. The areas of production for dairy and wheat are evident; when total costs for dairy products are less than total costs for wheat, assuming sale units of equal value, dairy will be produced. As transportation costs increase, which include losses from spoilage, wheat becomes the preferred crop (17). Multiple crop analysis is possible; the homogeneity of the plain, assumed by Von Thunen, will yield concentrically circular production areas around the central city.

With a rectangular grid transportation system, which covers large portions of the United States, the production areas are concentric diamonds. Figure 10 shows this arrangement. The distance from point A to the city market is 2 units which equals the distance from point B to the city market (3). Here also the existence of toll roads, oblique transport routes, or geographical barriers will distort the shape of production areas. Zone shifts can cause or be the result of price changes, cost changes, or changes in the intensity of production

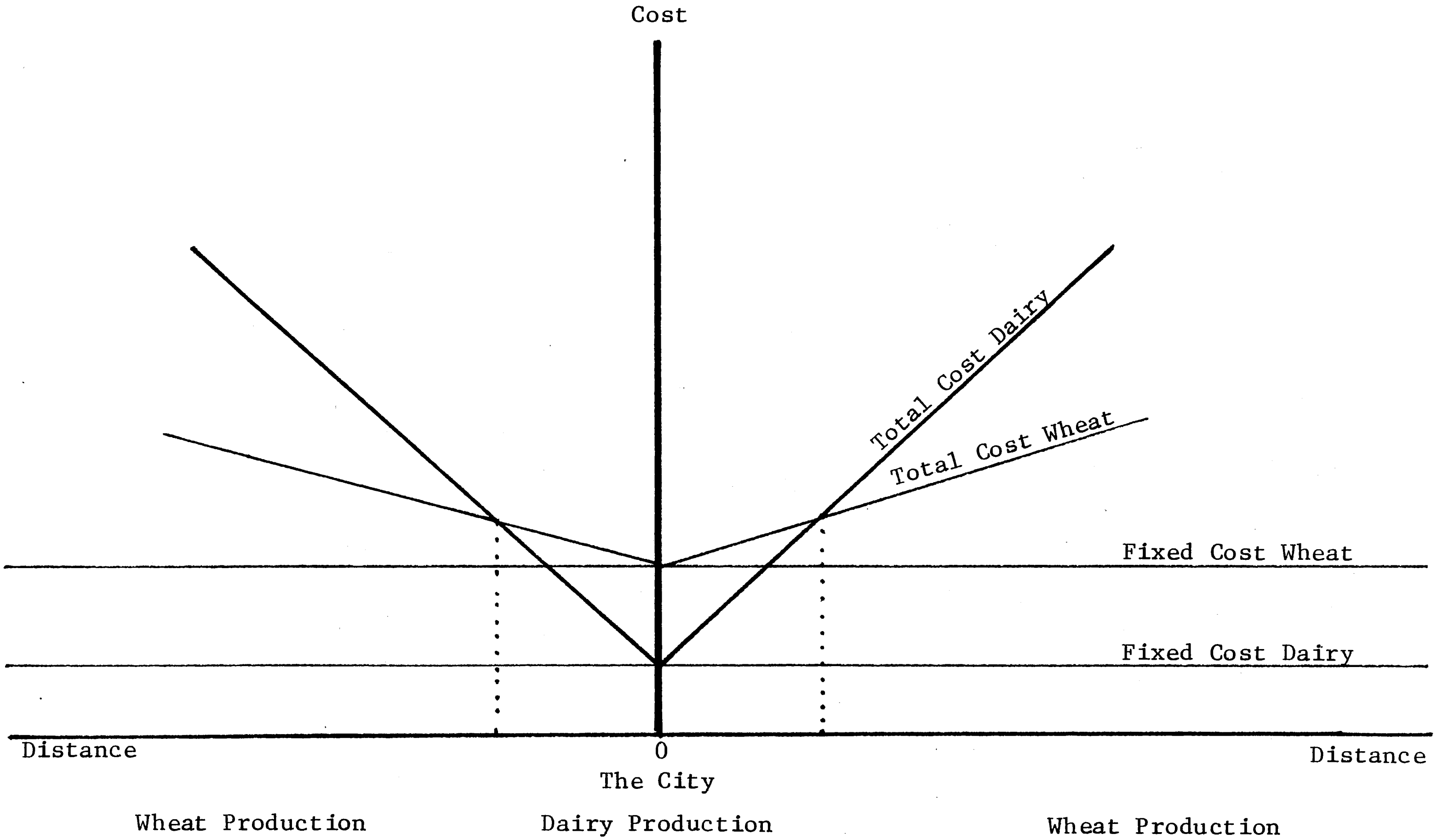


Figure 9. Graphical Representation of Two Commodity Location Analysis

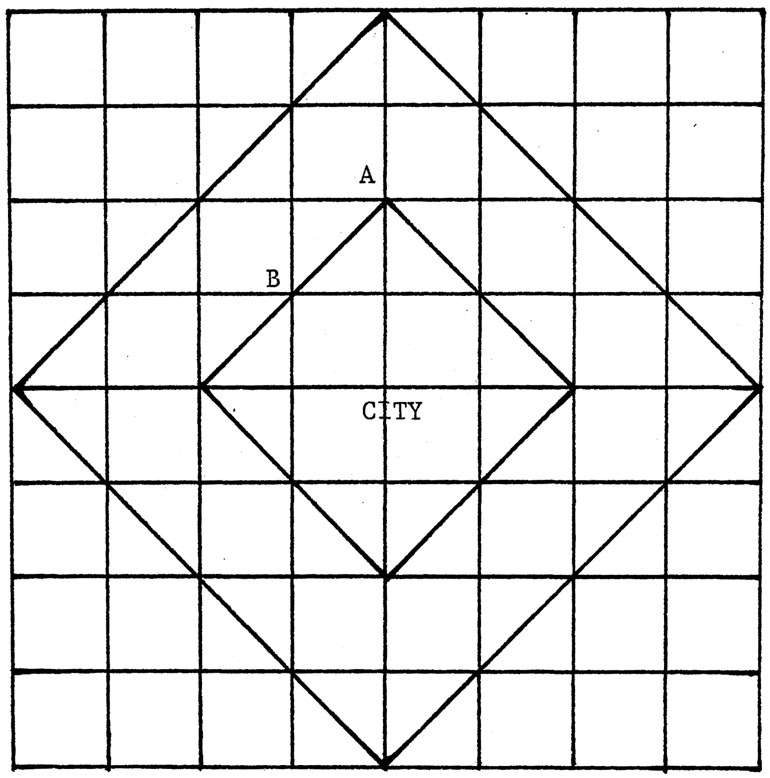


Figure 10. Concentric "Circles" in a Rectangular Transportation System

of crops in the analysis. With transport cost a function of distance, intensity of production diminishes within a crop zone with distance to the market (21).

Edgar M. Hoover's book The Location of Economic Activity (20) further reviews the elements of rent and value earlier noted in this chapter. In his analysis, the process of competitive bidding for rental services as well as outright ownership will reach an equilibrium when the rent prices are bid up to a point where the existing land holders and operators have no incentive to move (16). Landowners will extract maximum rents or returns subject to constraints.

It is obvious that the patterns of land use are indeed dynamic, as dynamic as the cost and price regime faced by individual farmers and ranchers. No doubt further changes in location will accompany the price and structural adjustments in the agricultural sector.

The theories of rent and location of agricultural activity based upon rents have been discussed in this section of the chapter. Total rent to land includes the Ricardian rent of the land and the Marshallian quasi-rent on the capital invested in land improvements.

Review of Relevant Literature

This section includes a brief review of a number of theses and articles which are a part of a wide body of literature on the topic of farmland value. The elements of basic location theory and land rent theory so eloquently expressed by the classical economists have determined the initial approach to land value studies reviewed here.

Studies of Various Factors Affecting Land Value

An earlier land market study in Oklahoma completed in 1976 by Lonnie Vandeveer (45) reviewed sales in six counties in western Oklahoma. Sales were included in the analysis if:

1. transfers were arms length transactions,
2. agriculture was the primary land use,
3. the tract was located outside corporate limits of a city or town,
4. tract size equalled or exceeded 20 acres.

Using data from the six counties which met the above requirements, models were developed using multiple regression techniques. Best models were chosen to explain the farmland markets in all counties and in individual and groupings of counties in the study area. Buyer characteristics, determined from a questionnaire administered to a percentage of all buyers, yielded additional information to be included in land price models. Table II (reproduced from Vandeveer's thesis) shows the models developed from physical data and a combination of physical and non-physical data for each bonafide sale of farmland in the study area. Among the important physical factors of value are date of sale, size of tract, the productivity index of the tract, distance to paved road, and cropland percentage. Buyer characteristics, also useful in explaining variations in farmland prices, were noted to be off farm employment, part-time employment, and the taxable income class of the buyer.

TABLE II

VANDEVEER LAND VALUE MODELS

Variables	Primary Sample Model 1	Reduced Sample Model 2
Dependent Variable	PRA (Price per acre)	PRA
Constant	347.95	424.63
WCD (West Central Area Dummy)	-119.86 (9.12)	-143.62 (6.19)
SWD (Southwest Area Dummy)	-201.97 (14.38)	-211.76 (7.91)
TI (Date of Sale)	12.32 (14.99)	11.67 (7.41)
TI^2 (Date of $Sale^2$)	- 0.077 (7.92)	- 0.064 (3.38)
SIZ^2 (Size of $Tract^2$)	0.00035 (3.29)	0.0003 (1.98)
$SIZ^{.5}$(Size of $Tract^{\frac{1}{2}}$)	- 11.11 (4.74)	-12.77 (3.13)
RPDNT (Population of nearest town ÷ distance to nearest town)	0.00277 (2.18)	0.004 (1.45)
DPR (Distance to Paved Road)	- 2.27 (1.85)	- 4.32 (1.73)
MP2 (Market Potential)	0.044 (3.19)	0.055 (1.75)
PA (Peanut Allotment Acres)	2.59 (1.68)	1.91 (0.62)
$MR^{.5}$ (Percentage Mineral Rights)	2.01 (1.42)	1.41 (0.56)
PI (Tract Productivity Index)	- 9.58 (5.24)	-10.24 (3.11)
PI^2 (Tract Productivity $Index^2$)	0.128 (8.31)	0.125 (4.56)

TABLE II (Continued)

Variables	Primary Sample Model 1	Reduced Sample Model 2
PC^2 (Cropland Percentage^2)	0.022 (12.01)	0.026 (8.08)
PIC^2 (Irrigated Cropland Percentage)	0.011 (3.16)	0.014 (2.30)
FTOFED (Full-time Employment Dummy)		-50.72 (1.79)
PTFD (Part-time Employment Dummy)		-26.86 (1.26)
ESTFOD (Established Farm Dummy)		-38.26 (1.83)
NAD (Non-Agricultural Dummy)		-22.70 (0.78)
BRPD (Buyer as Renter Dummy)		-43.31 (2.02)
INCD1 (Taxable Income 10M-30M)		18.00 (0.76)
INCD2 (Taxable Income > 30,000)		36.48 (1.47)
Standard Deviation	174.08	182.996
Number of Observations	1310	470
R^2	65	68

[a]The number in parentheses are t-values for the regression coefficients.

Jennings (22) in a study of four counties in north central Oklahoma determined that the time variable explained the largest proportion of variability in the dependent variable, price per acre. Other important variables in this study are size of tract, distance to paved road, distance to the nearest town, distance to the nearest principal market, proportion of mineral rights conveyed, percent of tract in class I and class II cropland, percent of tract in class III and class IV cropland, a cropland productivity index, and net county property value per square mile.

Models were developed to explain farmland markets in each county in the study area as well as the area taken as a whole. A time period analysis divided all data into two sub periods to determine if there were changing elements of value in the study area. One factor studied, the proximity of the tract to paved roads and nearest town, declined in importance during the study period. Factors which represent quality or productivity for a tract remained important as a determinant of price variability.

In an empirical analysis of rural land prices in east central Florida, Tower (41) identified and quantified factors influencing rural land prices. The important factors were value of buildings, land use variables, locational variables, size of tract and gross farm income. Analysis of markets in individual counties in the study area result in different models than the all-county model. Tower had success using non-linear log models to explain the relationships between independent and dependent variables.

In a study of the variables related to farm real estate values in Tennessee counties, Mundy, Gray and Thomsen (33) evaluated twelve hypothesized variables as determinants of farm real estate value. This cross sectional study based upon 1969 data evaluated farm values as county aggregates. Important variables were found to be property tax rates, cropland percentage in county, market value of production per acre of farmland in county, size of farm, population change, population density, regional variables, and county town population classes. The model developed explained 87 percent of the cross sectional variations in county level farm real estate prices in Tennessee for the study year.

Clifton and Spurlock (12) evaluated farm real estate prices in market areas of the southeast United States. Eight distinct land markets were identified using population density, percent of land in farms, percent net migration and acreage size of farms in county. For all land markets the building value, tract size, land use, and farm class were important factors in accounting for per acre price variations. Urban influences, non-farm purpose for buying the land, and a purchase to expand arm operations variable also were factors which statistically were correlated with per acre farmland prices.

Similar studies in the West have evaluated ranch prices as a function of physical variables which are important determinants of value. A study in Utah by Workman and King (48) and a similar study in Wyoming by Collins (13) identified animal carrying capacity, availability of range leases, and irrigation variables as important in determining values of ranch properties. Location parameters were not significant in the Wyoming study but were found important in the Utah land market.

In an analysis of land sales in the Oklahoma panhandle Forbes and Parcher (18) employed correlation and regression techniques to evaluate the value factors of fifty-eight school land tracts sold at public auction in a two day period in 1965. Price per acre was positively related to acres of cropland, percent cropland, acres of wheat allotment and a tract productivity index. Price was negatively correlated to distance to all weather road and wheat allotment as a percent of cropland. The final equation attempting to explain per acre variation among tracts sold explained fifty-four percent of the variation in prices.

Abdel-Badie and Parcher (1) analyzed land sales in 10 counties of western Oklahoma to identify and quantify the factors which contribute to farmland value. Regression techniques were employed in this study. Variables deemed as important determinants of value were total acres; quality variables; mineral rights conveyed; distance to town, city, Oklahoma City; crop allotments; and population of nearest town.

In an attempt to improve analyses of rural land values, Schott and White (37) employed regression techniques to determine the classes of land found in a sample of sales and to group like classes for separate analysis. Estimate ranges for land value were calculated using variable standard error values. The important tract factors were found to be land class, location relative to river (frontage), distance to interstate highway, and crop allotments.

In a study of urban fringe land markets in northern Illinois, Chicoine (10) found that proximity-distance factors to a large city were important determinants of rural land values. Large city effects overpowered the influence of smaller yet significant trade cities except where the trade city was located between the tract and the large city. Access factors, time, parcel size and soil limitation for septic tanks were other important determinants of value . Zoning factors, soil productivity and the proximity of tract to a water body were variables determined to not significantly affect rural land values in the urban fringe.

Burton (7) in a 1980 study of three eastern Oklahoma counties employed regression techniques to explain rural real estate values. For tracts which were characterized as rural and agricultural the important physical variables were identified as date of sale, size of tract in acres, value of improvements per acre, and distance to the nearest county seat town. The slope of the agricultural land was not a significant explanatory variable in the final rural agricultural land value model. Factors important to the value of non-agricultural real estate were size of tract, value of improvements, and the presence of a rural water district.

Asset Value Versus Productive Value

In a study of farm real estate price components Castle and Hoch (9) determined that real estate values were composed of a capitalized value due to rent and also a real capital gains component based upon buyer expectations of future value. Their analysis was formed on aggregate land price data from 1920 to 1978 and has limited direct application to micro land markets. Their conclusions, based upon detailed empirical analysis however, support the view that land productivity is one of the determinants of value. Their identification and explanation of capital gain components of land value similarly provides insight into the time-price trend of farmland.

The time variables represented by the date of known sale of a property reflect the influence of the general price trend, expectations on farm income, and future prices of farmland on current market price. These individual influences are changeable over time, often have first positive and negative magnitudes, and are difficult to determine and quantify. The study focused on the physical characteristics of individual properties and, while the time trend is obviously important in determining farmland values, the separate components reflected in time were left for examination in subsequent studies.

An aspect of qualitative differences in land is flexibility. Certainly better quality land has more alternative uses. In the face of changing rural economy and changing crop prices relative to alternate crops or livestock enterprises the better quality land allows owners or operators to adjust their farm business with a minimum effect on returns. Land, which because of inherent fertility or rainfall is kept in natural pasture species or in range, can only with great expense and risk be converted to another use. Higher quality land upon which high value crops are produced can be converted to cereal grains, hays or pasture if the agricultural economy changes in their favor.

Rural land buyers view this flexibility as being a positive attribute of better quality land and are willing to pay more for the better land. No doubt the higher productivity or lower operating costs of better quality land is the primary motivation for higher bids, but the flexibility issue is a part of the decision.

A parcel of land appeals to different people in different ways. Each has a personal view as to how the land should be used. This differing view of land relates back to land as a bundle of things or rights which become available to its owner. There are numerous sticks in the bundle, not all of which are relevant to a single buyer. Individuals rank their needs and use the marketplace to fulfill their needs at the lowest cost. So it is with land and the land market (15).

Important to considerations of value is the notion of "highest and best use." Dovring states that "actual use might often be a better indication of value than some theoretical calculation as to what use would be highest and best if all choices were realistically open." (15, p. 15).

Market conditions affect the price of land in the classical economic sense. There is a supply of land on the market and there is a demand for land from land buyers, those who wish to convert assets to land. Under conditions of land scarcity or expectations of high farm prices, land is "created". In truth, lower quality land is converted to a higher use. Under conditions of falling prices, land is retired to lower or alternative uses.

Rural land is also utilized for non-farm purposes like residential lots, recreation, industrialization, or public purposes. Changing rural population and rural industrialization constitute a competing demand for rural agricultural land. With all the qualitative variations in land and the many intensities of its use it is easy to see that there are many markets for land. However, each of these markets follows the demand and supply framework of an economic market.

General Data Sources

To some extent the availability of data determined the overall objectives and potential hypotheses of this study. Review of prior land value studies in Oklahoma and elsewhere was valuable in determining both the objectives of this study and the data needed to achieve these objectives.

Basic to the study of land values and the factors influencing value is the collection of land sale records. Records of land transfers were regularly collected by staff of the Oklahoma Tax Commission as they maintain data on real property value. Yearly or bi-yearly surveys were taken to collect sale data from county court house records in all parts of Oklahoma. These records of sales, chosen to be bonafide arms length transactions between a willing seller and a willing buyer free from all coercion, were generally shared and are the basic foundations of this study. Potential variables which affect land value and help explain land value differences were identified; data were then collected to complete the empirical analysis.

The Variables Analyzed

The Road System

Prior land value analysis projects have determined that a tract's access to towns and cities is an important factor of value. Some of these studies have measured the effects of road proximity on a tract's market value or sale price. Data on various road qualities are available through direct measurement of distances or through the use of proxy variables. In an attempt to determine and quantify the effects of roads on value a set of data on road density was developed.

A publication reporting the number of miles of interstate highway, other federal and state highways, paved roads, gravel roads, and dirt roads for each county in Oklahoma provides the initial data for the construction of road density variables. These linear measures were converted to densities by dividing by the county surface area in square miles. In addition, total road mileage in the county and total paved road mileage in the county, as shown in Table III were converted to density variables. The seven road density variables developed for each county are included in the analytical procedure of the study.

Population

Simple demographic information for each county is included as a variable for each tract in the farmland sales data base. Population density in per square mile units is calculated based upon 1980 census data. Per capita income for each county is included and is based upon census tract information.

Assessed Value

Information on county assessed values have been used in prior studies to measure the degree of economic development in a county. Such variables have been made a part of value analysis. Net property value as determined by the assessment procedure is included in the analysis procedure. This variable is measured in thousands of dollars per square mile for each county in the study area. Each property

TABLE III

ROAD MILEAGES FOR STUDY AREA COUNTIES

OBS	COUNTY	IH	FS	PAV	GR	DT	TOTROAD	PAVROAD
1	ALFALFA	0	149	72	353	893	1467	221
2	BECKHAM	42	161	213	84	886	1386	374
3	BLAINE	0	159	143	319	836	1457	302
4	CADDO	18	228	387	523	1006	2162	615
5	CANADIAN	22	66	144	314	323	869	210
6	CLEVELAND	13	22	165	99	58	357	187
7	COMANCHE	0	166	342	724	223	1455	508
8	COTTON	0	163	52	633	263	1111	215
9	CUSTER	28	150	298	493	642	1611	448
10	DEWEY	0	135	142	332	664	1273	277
11	ELLIS	0	156	64	655	567	1442	220
12	GARFIELD	0	125	184	959	695	1963	309
13	GARVIN	26	168	346	577	75	1192	514
14	GRADY	0	200	217	377	885	1679	417
15	GRANT	0	149	71	815	886	1921	220
16	GREER	0	84	225	464	161	934	309
17	HARMON	0	68	397	252	106	823	465
18	HARPER	0	156	100	632	311	1199	256
19	JACKSON	0	116	251	636	318	1321	367
20	JEFFERSON	0	121	52	306	341	820	173
21	KINGFISHER	0	91	164	900	491	1646	255
22	KIOWA	0	208	232	861	447	1748	440
23	LINCOLN	29	165	119	980	365	1658	284
24	LOGAN	19	121	136	751	257	1284	257
25	MCCLAIN	18	178	85	281	168	730	263
26	MAJOR	0	149	155	154	926	1384	304
27	NOBLE	29	159	50	843	242	1323	209
28	OKLAHOMA	9	22	289	35	37	392	311
29	PAWNEE	0	119	89	641	92	941	208
30	PAYNE	12	144	103	779	208	1246	247
31	POTWATOMIE	15	140	143	637	154	1089	283
32	ROGERMILLS	0	137	103	514	622	1376	240
33	STEPHENS	0	112	725	274	197	1308	837
34	TILLMAN	0	128	146	738	533	1545	274
35	WASHITA	14	159	421	397	802	1793	580
36	WOODS	0	130	141	608	704	1583	271
37	WOODWARD	0	146	148	579	744	1617	294

IH = interstate highway
FS = federal and state highway
PAV = other paved roads
GR = gravel roads
DT = dirt roads
TOTROAD = total road mileage
PAVROAD = total paved highway miles excluding interstate highways

transfer in the sale data base has an assessed value variable added for statistical analysis.

Soil Productivity

Measures of soil productivity have been shown by prior studies to have positive influences on farmland value. In Oklahoma soil productivity indices have been determined and assigned at county levels. The Soil Conservation Service of the U.S.D.A. has developed and maintained detailed soil surveys (e.g., for most counties in Oklahoma). Using these soil surveys and each soil type's appropriate productivity index, all tracts in the farm sale data base were assigned a per acre productivity rating. The soils found in each tract were determined from soil surveys, appropriate productivity indices were found on a look-up table and an acreage weighted farm productivity rating was then assigned to the particular farm tract in question.

Because the productivity indices are independently calculated for each county, some inter-county comparison is necessary. Staff of the Oklahoma Tax Commission have determined an index scale which allows comparison of soils across counties. Figure 11, in map form, represents the inter-county index developed by Oklahoma Tax Commission Staff. An adjusted productivity index is calculated for each tract reported sold in the study area using these indices and the formula shown below.

ADJPTS - PIPOINTS/CTYINDEX x 90.

where

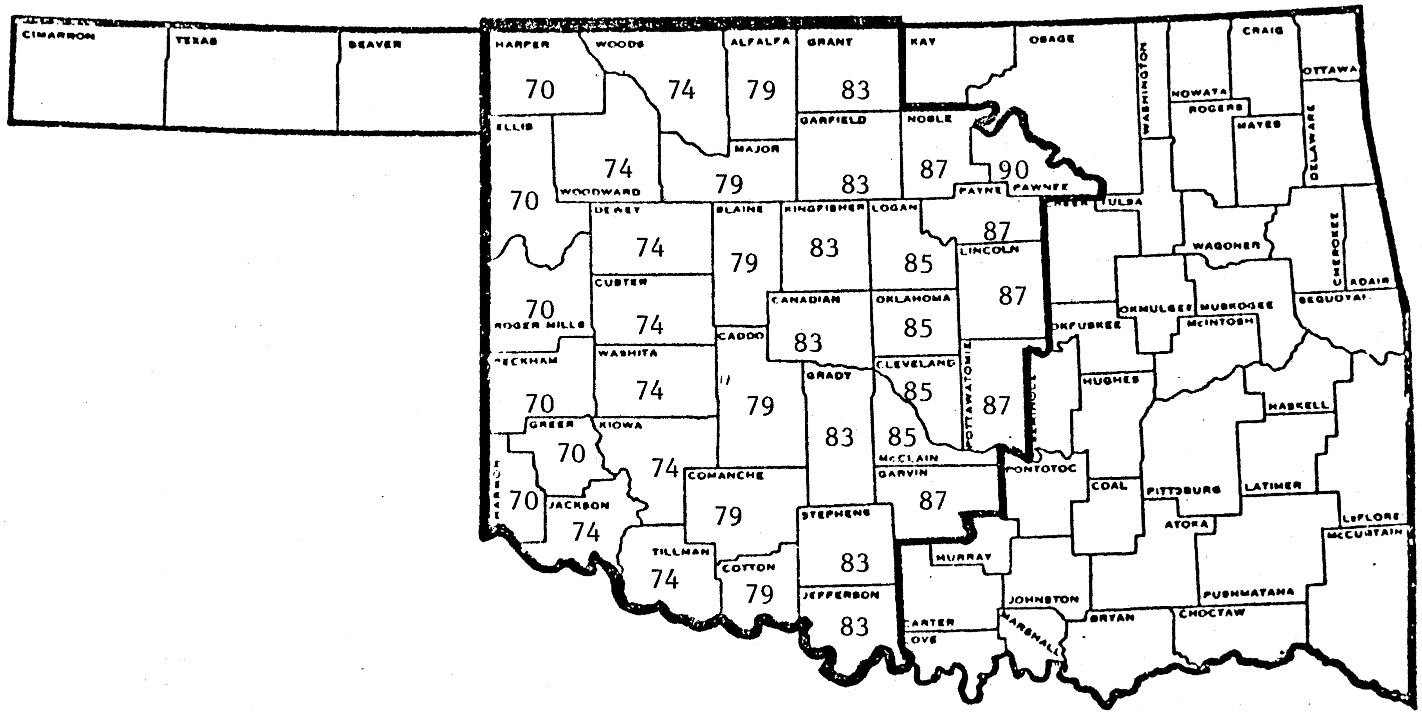


Figure 11. Soil Productivity Equalization Factors in the Study Area

ADJPTS = adjusted productivity points,

PIPOINTS = total productivity points in the tract, and

CTYINDEX = inter tract productivity index for the county.

This converts all tract productivity measures to a scale comparable to the highest index county (Pawnee) in the study area. In developing the index, factors such as rainfall, temperature, and freeze dates were utilized.

Rainfall

Climatic variability impacts upon agriculture in a variety of ways, but rainfall variation no doubt represent the single most important climate variable. Average county rainfall was determined using an average annual rainfall zone map (19). County estimates are shown in Figure 12. Each farm sale was then assigned its appropriate county average rainfall for use in the analysis section of the study.

The rainfall variable will be somewhat related to the soil productivity comparability index developed by the Oklahoma Tax Commission and described in an earlier section of this chapter. The definite importance of rainfall to agriculture and its affect on farmland values suggests its separate inclusion in the value analysis.

Distance to Towns

A property's location, usually measured in miles from cities or towns, has been shown to have an impact upon its value. Rural agricultural property similarly has value because of its location, as well as many other factors.

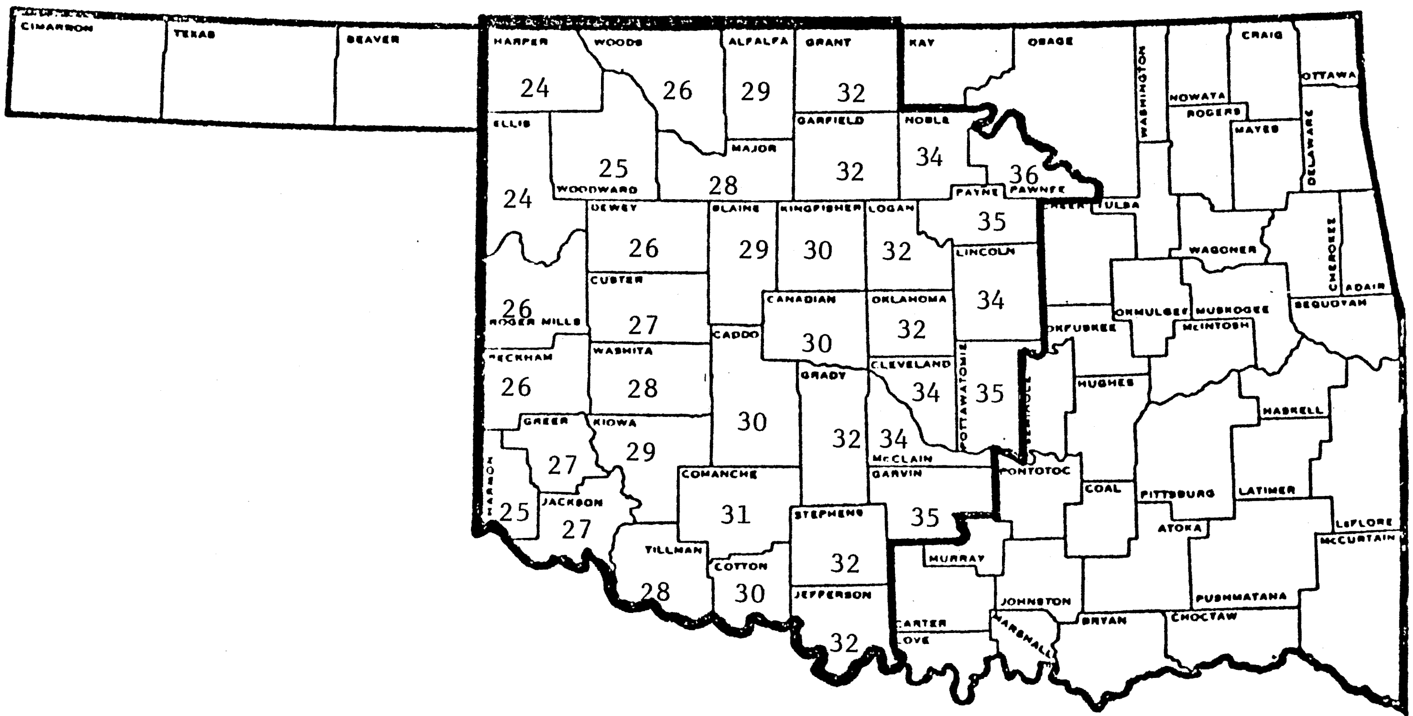


Figure 12. Average Annual Rainfall in Study Area Counties

The study area of western Oklahoma has several classes of cities and towns. For this study, cities and towns were grouped according to population. The groups chosen were: Population greater than or equal to 100,000; population from 25,000 to 100,000; population from 10,000 to 25,000; population from 5,000 to 10,000; and population from 1,000 to 5,000.

Oklahoma was developed late relative to other states and because of this has a rather orderly property survey and road system. All land is laid out in ranges east and west of a survey meridian and in townships north and south of the base line associated with the meridian. Congressional townships formed from uniform blocks of land measure six miles square. Because of uniformity, and because the general road system in Oklahoma follows section and township lines, road distances between two known locations can be calculated with relative ease.

Calculations are based upon the legal description of both a farm property and the legal description of area cities and towns. A shortest path algorithm (SPA) (2) searches for the nearest town and city in each class for every farm tract in the sale data set. The cities and towns are listed in Appendix A along with their population. For each tract in the sale data base new variables relating to location are calculated; the nearest city and its population for each class of city described earlier become ten new location variables for each reported sale.

Building Assessed Value

Data collected by staff members of the Oklahoma Tax Commission include the assessed values of buildings if the property has been improved. Assessment rates are not uniform statewide, however an attempt is made to equalize the effects of differing assessments.

Property Transfer Stamps

When a property is sold and conveyed by warranty deed or through deed from seller to buyer the state taxes the seller on the sales price requiring that "tax stamps" be affixed to the conveying instrument. If stamps are not actually affixed to the deed the amount of tax paid is usually noted in the margin of the deed. In certain cases as set by statute the tax is not required or is less than for the full sale price.

These stamps or marginal notations are the basis for estimates of the property's sales price. Prior to August 1, 1978, the transfer tax rate was $1.10 per $1000 in value conveyed; after that date the rate became $1.50 per $1000 in value. Using these known rates, the data on tax stamps for each conveying deed, and the date of the transaction, reasonably good estimates of total sale price can be made.

A seller and buyer may agree to place more stamps on a deed than required by law, thus preventing the public from ascertaining the sales price of a property. Motivation for this action would be rare, and in the case of these data, it is highly likely that all calculated sales prices are sufficiently accurate to provide a good sales data base for the proposed economic analysis.

LANDSAT Cover Data

Data from the LANDSAT system can be used in a variety of ways. The data and methodology of its use are discussed more fully in

Chapter III. For this study, the LANDSAT cover data are used to determine vegetative or non-vegetative cover on the land in the study area. Nine cover classifications from water and bare soil to timber are inventoried across the study area. Land cover and the percentage in each cover category are determined for each farm tract in the sale data set. This process determines the percentage of cropland, pasture or other cover type for each tract in the study. These physical variables then are analyzed, along with all others, to determine the effect of land use on farmland value. Here the land cover as determined by remotely sensed LANDSAT data allows us to make certain assumptions about the current and past use of the land. Primary interest is in agricultural land uses.

Date of Sale

All observations in the farmland sale data set include information on the date the sale occurred. This is the date the property title was transferred from seller to buyer and is the only available information in the records analyzed. On this date the warranty deed or some other deed was presented to the County Clerk and made a part of the public record.

Sale negotiations and the activities necessary to present and transfer property title often take considerable time. Negotiations on a price may be completed a month or more in advance of final property transfer. After a price is set on a property, usually by a legal contract to sell and to buy, the seller must provide a merchantable title to the buyer. These legal proceedings, usually a search of the record for other instruments in law which may affect the real property which is sold, take time. The buyer also may need time to make arrangements for payment perhaps by selling other real estate or chattels or by securing credit.

In this study the date of sale is the same as the date the deed was recorded. It is acknowledged that the price was set at some earlier time, but because there is no way to accurately and easily determine the actual date of price discovery, this date of public record is used. All properties represented in the sale data set have some degree of time error connected with this assumption. The overall effect, similar for most tracts, is considered to be negligible, since the lag between pricing and recording the land transfer would generally not exceed ninety days.

Legal Description

The use of the rectangular survey system in Oklahoma simplifies legal descriptions for real property. Since the sale transactions include a legal description, questions of location, distance to other features, soils, and land use can be answered. Legal descriptions include section, township and range numbers as well as the appropriate fractional designation for the section. The traditional homestead included 160 acres and was described in general as the southwest quarter of section 1, township 7 north, and range 7 west, of a designated meridian. Fractional divisions of these quarter sections can practically describe tracts as small as 2 1/2 acres. Combinations are seemingly endless as two or more such descriptions are included in the description of separate land parcels.

Total farm size can be calculated using the tract legal description. Quarter sections include 160 acres, half quarters have 80 acres, and here, too, summation of parts is easily done.

Size of Farm

As described above the size of farm tracts is calculated from the appropriate legal descriptions. The total acres variable is important in the formation of land use share variables as well as being an important determinant of farm value in its own right. Large acreages are different commodities than small acreages. They attract different buyers and in general have different per acre prices than small tracts, all other factors remaining the same.

Analysis of Agricultural Land Value

Professional real estate appraisers have recently become more interested in employing systematic and statistically based mathematical models to solve certain questions of market value (38). Generally the appraisal team will determine the relationship between a small number of common property characteristics and market value through the use of regression analysis of comparable sale records. Because of limits in locating a large number of comparable sales, the model will normally be restricted to a few explanatory variables. In these instances the appraiser may have already identified the important factors of value; quantifying the specific effects of the known variables or the subject property is the desired goal of the regression analysis.

Regression analysis has also been used in mass land appraisal projects (47). A large data base of comparable sales and a high degree of homogeneity in physical characteristics contributed to the success of mass land appraisal projects.

General Procedures

Farm sale data from 1975 through 1982 in the study area were analyzed using multiple linear regression techniques. Land price was the dependent variable, and other model variables were chosen to explain the variation in land prices in the study area for the time period having available sale data. Utilization of multiple linear regression analysis rests on the assumption that relationships exist between the dependent variable, per acre land price, and the independent explanatory variables.

Correlation analysis of the model variables verifies the hypothesized influences among independent and dependent variables and identifies if independent variables are correlated. Once all independent variables are selected either based upon the correlation matrix or from a priori decisions, the full model can be analyzed using multiple linear regression techniques.

The Ordinary Least Squares Model

For n observations of Y, the dependent variable, land price, and X_k, the K independent variables which are functionally related to Y the model statement in general form is:

$$Yi = B_1 + B_2X_{2i}+B_3+\ldots+B_kX_{ki}+U_i$$

$$i = 1,2,3\ldots, n.$$

Unknown parameters to be estimated are the B coefficients and the parameters of the error term distribution, u. Estimation procedures yield the following regression equation:

$$Yi = b_0+b_1X_{1j}+b_2X_{2j}+\ldots+b_kX_{kj}$$

where

Yi is the estimate for Y for the ith observed values of the X's and

b_0, b_1, b_2, ..., b_k are the estimates for B_0, B_1, B_2, ..., B_k.

Yi is the ith observed value of Y expressed fully as

$$Yi = b_0+b_1X_{1i}+b_2X_{2i}+\ldots\pm b_kX_{ki}e_i$$

The unexplained variation in Y, e_i, can be expressed as e_i = Y-Yi, and is minimized by the procedure.

In this chapter the relevant theory of land rent and the value of location have been discussed. Important literature detailing prior research on land value and the methodologies of land value research have been reviewed. An important part of this research project is the utilization of remotely sensed land cover data. In the following chapter the ideas of remote sensing and the techniques of land cover analysis will be presented in further detail.

CHAPTER III

REMOTE SENSING AND LAND COVER ANALYSIS

The value of rural agricultural real estate is determined in a market process as buyers accept the prices of willing sellers. The item in the trade of money for goods, here rural land, has both positive and negative attributes which are the sticks in the bundle of rights and assets received through the purchase of land. One aspect of land which is readily determined is its current use. Agricultural land is usually used in one or a combination of ways. Land is used as dry or irrigated cropland; as native or improved pasture; or as rangeland, assuming that rangeland uses differ from pasture uses. Woodlands, wastelands, or lands covered by water are used differently, perhaps less intensively than other land types.

In attempting to analyze the vegetative cover, and thereby inferring something about use, of a large number of farm tracts transferred from seller to buyer, it became obvious that an automated data analysis system was needed. Remotely sensed data, specifically LANDSAT-satellite data, acquired from a government agency and processed through a private contractor, became an early solution to the data problems and was a logical choice to complete the study. LANDSAT data provide a vantage point of earth observation; computer compatability of sensed data; wavelength extension beyond the visible portion of the spectrum; and data collected at an appropriate resolution for this research.

In the following sections, selected concepts of remote sensing will be explained. Data sources and methods of acquisition will be discussed, as well as the procedures whereby remotely sensed data are processed and made usable for resource studies. Land classification systems, and mapping criteria and methodology will be discussed, in addition to the final land cover classification.

What is Remote Sensing?

Remote sensing is the collection of information about an object or area without having the sensors in physical contact with the object (36). A variety of techniques are utilized to accomplish the goal of remote sensing which is the collection of data. Aerial photography and satellite imagery and digital data comprise the predominantly applied method of remotely sensed data acquisition. Other efforts to gather data without having physical contact with the observing entity involve radiometry, thermography, and geiger counters; these are all remote sensing devices in a technical sense.

LANDSAT is the name of a series of satellites launched in the 1970's and 1980's which collect reflected light, and more recently, emitted energy from the earth's surface. This study employed the multispectral scanner on-board LANDSAT, which senses from 0.5-0.6 microns, 0.6-0.7 microns, 0.7-0.8 microns, and 0.8-1.1 microns. Four separate bands of received reflected energy at a unit resolution of approximately 1.12 acres give each picture element or pixel (resolution unit) a spectral signature which facilitates the process of analysis. A single LANDSAT scene analogous to an aerial photograph covers an area 115 miles square. These data are packaged as computer tapes of digital data or as black and white, or color composite prints. Tape format digital data are the most useful for machine processing, and in the case of large study areas, represent the only efficient means of detailed land cover analysis.

The LANDSAT satellites, launched in a near polar orbit provide 18 day repeating coverage of study areas. Satellite path and row locations over Oklahoma are shown in Figure 13. Data "scenes" are selected based upon the study area, path of the satellite, time of year needed to receive the appropriate land cover, and chance cloud cover of the desired area. Anyone can acquire raw data from the EROS Data Center, Sioux Falls, South Dakota 57198 (36). Western Oklahoma is mostly covered by two passes of the satellite providing a total of four scenes of data for land cover classification.

Land Cover Inventory

Land cover data provide an inventory of the vegetation, bare soil or water covering the surface of an area. These cover features are evidence of the land use (8).

Remotely sensed data combined with ancillary data such as population centers, soil maps, rainfall belts, and road system data can be employed in a wide variety of resource inventory studies. Orderly arrangement of different types of data in a data base expand

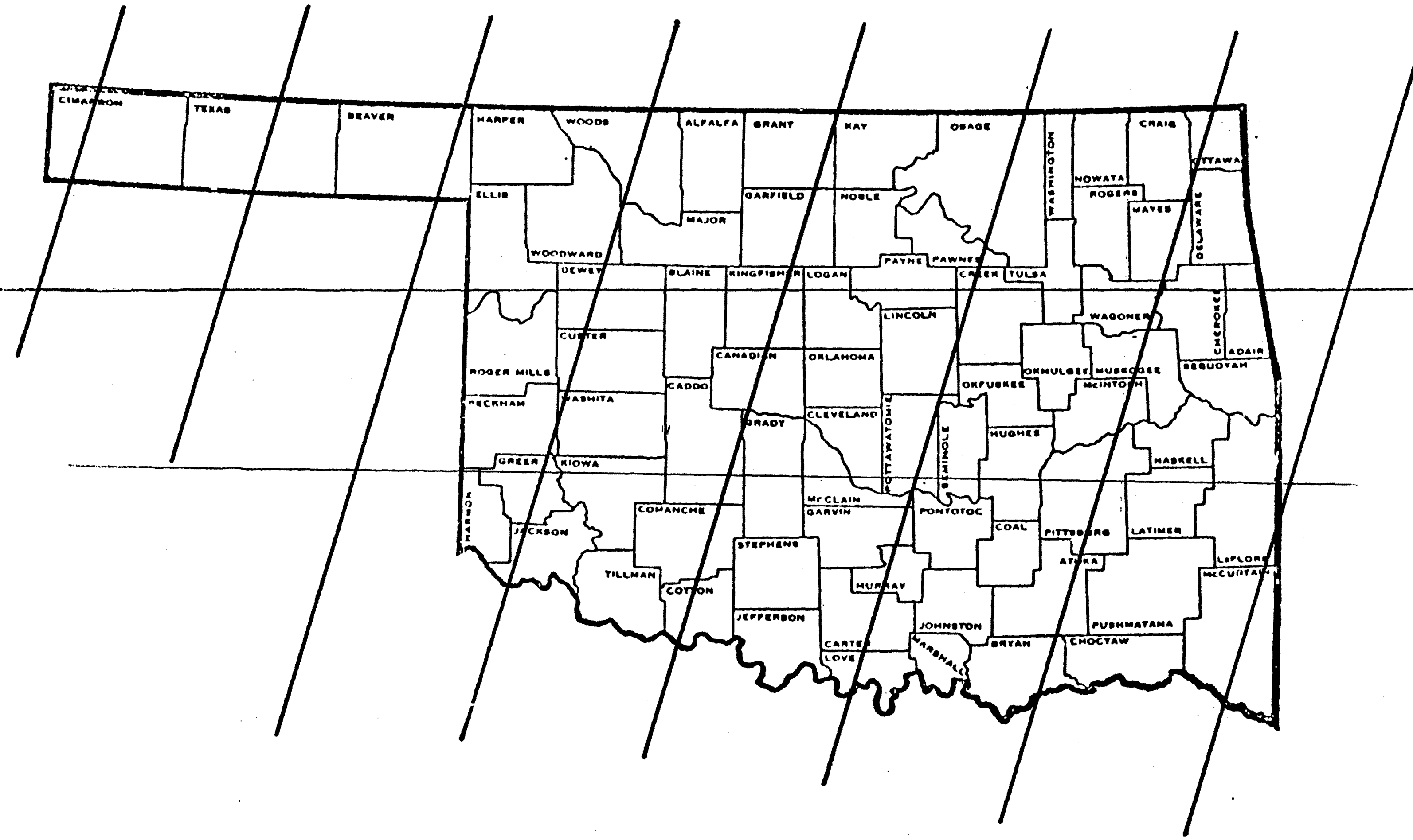


Figure 13. Path and Row Locations of LANDSAT Data over Oklahoma

research opportunities and provide efficient means for natural resource planning processes (23).

There is considerable interest in land use inventory and in measuring changes of land use in urbanizing areas. Conventional mapping techniques require substantial investment in planning, implementing, and completing inventories of large land areas. Luney and Dill (28) in an early review of land use mapping techniques express an optimistic view that satellite based data, when augmented with ground based mapping techniques, can provide reliable land cover information at a scale useful to regional studies with an added benefit of repeated coverage for studies of resource changes through time. The large scale mapping made possible with the use of satellite data avoids the difficulties of piece meal mapping techniques providing a continuous mosaic map of land use indicators.

Throughout the development and use of remote sensing, there was need for a logical and systematic classification of data. Currently, land cover data are classified according to guidelines provided by the U.S. Geological Service (4). Table IV is the system designed for land use and land cover data acquired by a remote sensing technique (4). Additional levels of mapping detail can be obtained by acquiring increasing levels of sensor resolution.

Data Classification

After acquiring desired LANDSAT digital data, computer processing reduces those data to a manageable and useable form. Classification of land cover types can proceed toward final land use categories which

TABLE IV

SYSTEM OF LAND COVER CLASSIFICATION

Level I	Level II
Urban or Built-up Land	Residential Commercial and Services Industrial Trans., Commun., and Util. Indust. and Commer. Complexes Mixed Urban or Built-up Land Other Urban or Built-up Land
Agricultural Land	Cropland and Pasture Orchards, Groves, Vineyards, Nurseries and Orn. Horticulture Confined Feeding Operations Other Agricultural Land
Rangeland	Herbaceous Rangeland Shrub and Brush Rangeland Mixed Rangeland
Forest Land	Deciduous Forest Land Evergreen Forest Land Mixed Forest Land
Water	Streams and Canals Lakes Reservoirs Bays and Estuaries
Wetland	Forested Wetland Nonforested Wetland
Barren Land	Dry Salt Flats Beaches Other Sandy Areas Bare Exposed Rock Strip Mines, Quarries, Pits Transitional Areas Mixed Barren Land
Tundra	Shrub and Brush Tundra Herbaceous Tundra Bare Ground Tundra Wet Tundra Mixed Tundra
Perennial Snow or Ice	Perennial Snowfields Glaciers

are consistent with the USGS system or which are fashioned from several different levels of the land cover classification system. The homogeneity, range, and variety of cover likely present in a study area is an important consideration in selection of classes to be differentiated, in addition to the overall mapping objectives. The desired resolution level and machine processing capabilities may also be factors in the selection of land classes, the processing technique, and the data storage method.

LANDSAT data for the study area were classified into nine categories of land cover as shown in Table V. Classification of digital data follows one of two forms. Supervised classification uses data from known cover types in the study area to define limits of spectral data for each cover type desired until complete or desired levels of coverage are attained. These "training fields", or areas of known land cover, must be carefully selected to completely and accurately represent the desired cover classes (8).

The other form of classification, called unsupervised classification, uses statistical models to find natural groupings of raw data. These natural groupings are then assigned to the cover classes based upon the knowledge of the analyst, prior experience in the geographic area, and with the aid of ground truth. In any case the analysis includes direct observation and matching of existing land cover with the unsupervised classification (8). Detailed, complete ground truth expeditions allow some amalgamation of cover classifications as spectral difference due only to shadow, sun angle, wind sweep, and surface texture are discovered.

TABLE V

PROJECT LAND COVER CLASSES

Class Code	Cover Type
1	Water
2	Barren, Urban, Non-Agricultural Bare Soil
3	Agricultural Cropland
4	Rangeland, Sand Sage---Sparse Grasses
5	Native and Improved Grassland
6	Native Grass With Scattered Shinnery, Cedars, Mesquite---Grasses are dominant
7	Trees with Native Grasses---Trees are Dominant
8	Forest Land---Dense Cedars, Shinnery, Post Oak, Blackjack Oak; Riparian Land---Deciduous, Coniferous and Mixed Stands
9	Clouds, Shadows, Jet Airplane Contrails

LANDSAT data can be classified down to its unit resolution (1.12 acres), however, such minute classification would result in high costs for computer operation, data storage, and data manipulation. For this study the land cover was aggregated into 10.0 acre cells. Errors due to absent data and mis-classified data can occur, thus there is a need to verify by inspection the accuracy of the classification (8).

Once the digital data are classified into the desired land cover classes, analysis of the cover data can begin. Using the unsupervised classification method, processed land cover digital data are converted to numeric code with each cell in the scene having a two number location designation and the classified cover code. These X, Y, and Z values are the cover data in usable format. For each ten acre cell in the study area, there are unique X and Y values denoting its location in a geographic sense and in a data base sense. Linked to each X, and Y combination in the data base is the Z-value which is the land cover at the location in question. These X, Y, and Z values, once determined, are stored on tape for further analysis.

Legal Description and Location

In order to have accurate location reference points across the land cover data, certain known points were located on supplemental maps and these points were "digitized" onto the cover data. Reference points accurately located on the cover data allow subsequent distance and area measurement as well as accurate matching of land cover with location.

The legal system of land survey in Oklahoma and in many other states as well as Canadian provinces facilitates land measurement, legal land description, and an analytically uniform system of land ownership records. Lands were originally surveyed from beginning points or lines called meridians which run north and south. Western Oklahoma land survey is based upon two such meridians: the Cimarron Meridian at the west end of the state, and the Indian Meridian in Central Oklahoma. Each meridian has a corresponding base line with townships surveyed north and south of the base line and east and west of the meridian. Range lines east and west of the meridian and township lines north and south of the base line occur at approximately six mile intervals. Figure 14 shows how this grid of survey lines might appear on a map. This grid of survey lines shows congressional townships, each with thirty-six sections of land. Because of the curvature of the earth these survey lines and the individual sections of land in a township cannot be perfectly square. However the survey system adjusts for this curvature in a systematic manner by forcing all curvature adjustment to fall in the northern tier and the western tier of sections in a township. All other sections are square in shape, uniform in size and contain 640 acres. Figure 15 shows the section numbering system and the adjustment acres in a township.

It can be seen that the southeast corner of every congressional township is an important reference point. The sections to the north and west of this point are of equal size and can be accurately designated by distances. These southeast corners of townships were accurately determined on maps and transferred to the cover data set; each corner has its own X and Y value. Legal land descriptions from most of a township then can be converted to combinations of X and Y values from the cover data set. An inventory of the cover found

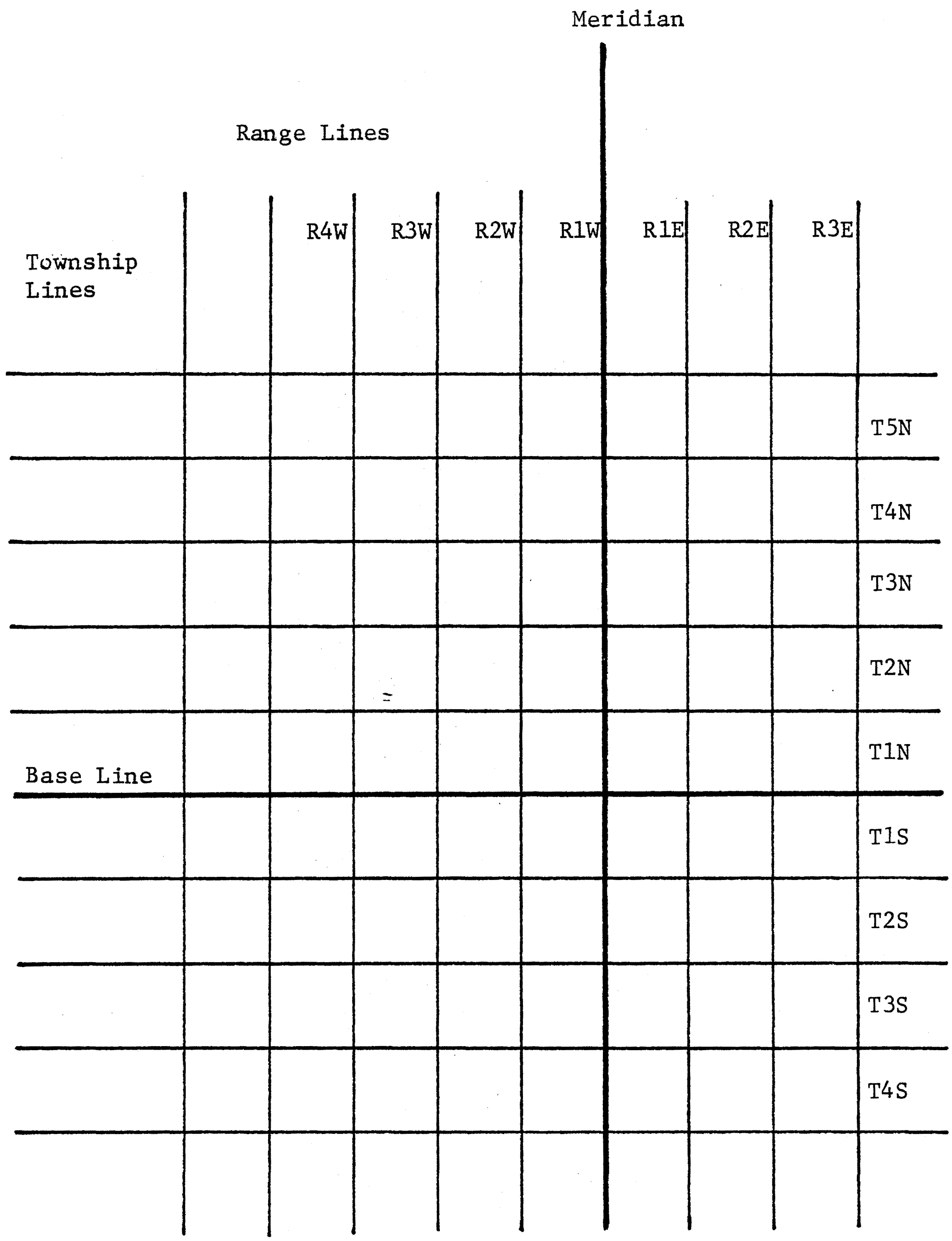


Figure 14. Congressional Townships - A Basis for Legal Land Descriptions

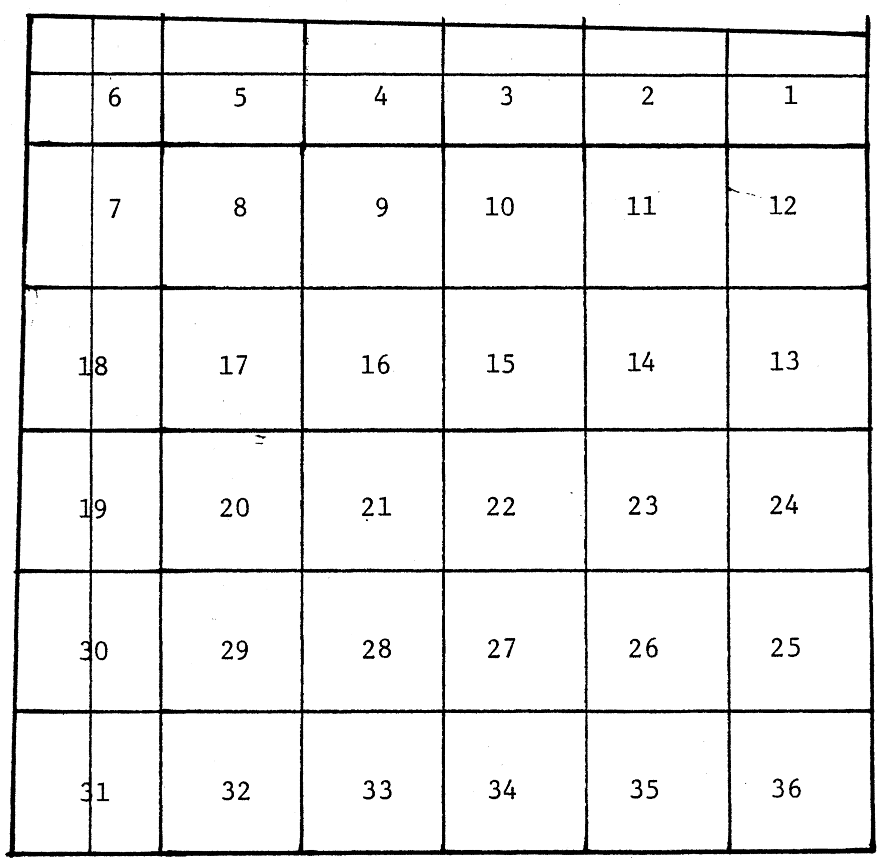


Figure 15. Township Adjustments and Section Numbering in the Rectangular Survey System

within these distance limits is then converted to a description of the land in terms of cover type.

Land sale records which included the legal description of the real estate parcel are the basis for this study. Each legal description is referenced to a set of cells in the cover data set and from this grid, the land cover is inventoried and retained for further analysis. Some legal descriptions occur in the adjustment area of a township, and these were necessarily deleted.

A computer algorithm was developed to convert legal land descriptions into a form compatible with the land cover data. Separate portions of the legal description were individually interpreted and combined into a single tract cover analysis. Each legal description entering the algorithm yields a vector of cover types, which inventories the nine categories of cover data, as well as, noting if cover data is missing for cells contained in the legal description. For instance, a legal description such as Southeast Quarter, Section 27, Township 16N, Range 13W might have two cells or 20 acres of cropland and two cells or 20 acres of rangeland for a total of four cells or 40 acres. This legal description is unique and describes only one parcel of land, and the corresponding land cover data gives the characteristics of this tract. In this case the tract is fifty percent cropland and fifty percent rangeland.

The algorithm used to convert legal descriptions into cell combinations will be more fully described and illustrated in a forthcoming publication (31). This algorithm is written as a PL/I computer program and stores the output in a form compatible with statistical analyses. Other forms of output would be possible.

The use of LANDSAT data in this study was dependent upon the development of this systematic conversion of legal description to numeric X and Y location values. Considerable computer programming efforts were made by staff at the Center for Application of Remote Sensing at Oklahoma State University and also by programmers in the Department of Agricultural Economics. These efforts resulted in the development of techniques of data analysis and data matching between the legal description record system and processed satellite imagery. Application of these techniques including the use of subsequently obtained land cover data would facilitate other types of land resource studies where ownership patterns are important. Many large scale projects would benefit from the use of these data and the data handling techniques demonstrated in this research project.

CHAPTER IV

THE FARMLAND APPRAISAL PROCESS

This research project has attempted to investigate the market for agricultural land in western Oklahoma. Various attributes of farm properties such as productivity, current use, location, and size of tract have been analyzed to determine the extent to which individual attributes determine the value of a tract. The analysis has been somewhat analogous to the approach taken by professional appraisers as they develop reports on property value. This chapter includes an outline of the process of farmland appraisal which illustrates the types of information needed by appraisers to monitor farmland price trends. An appraiser studies both general and specific price trends and farm tract sales to keep abreast of the market and to evaluate the unique characteristics of farm tracts which are valued and paid for by buyers.

Definition of an Appraisal

An appraisal is an unbiased estimate of the nature, quality, value, or utility of an interest in real estate (5). While appraisals can be performed by anyone, appraisals required for a variety of circumstances should be prepared by professional appraisers whose training and experience make them qualified to render judgements concerning the value of real estate.

Others who may appraise property are credit officers or directors of financial institutions, county assessing officers, real estate brokers and agents, and individuals who wish to determine the value of a parcel of real property. Professional appraisers, through experience and specialized education, have developed a systematic and logical procedure used to perform the function of real property appraisal.

A professional appraiser when contacted to develop an appraisal of value for a property makes an initial estimate of the effort which will be required to complete the appraisal report. The property to be appraised is accurately described, usually with a legal description, and the specific property rights to be valued are identified. An appraiser's client usually requests an appraisal for a certain purpose and for a specific date. Both of these factors influence the total effort required of the appraiser. In this initial stage the precise definition of value desired by the client must be specified to ensure that the appraiser gathers sufficient data to meet the needs of the client. The appraiser utilizes this preliminary information to draft an agreement between appraiser and client to define the appraisal assignment and bind the client to an agreed upon fee for the appraisal service.

Once formally contracted to perform an appraisal the appraiser continues in the process of valuation by collecting general socioeconomic data and specific site features and costs. The highest and best use of the subject property is determined early in the appraisal process for data needs depend upon the use of the subject property. As the pertinent data are collected and organized for use in the appraisal the appraiser applies the three approaches to value: the market data approach, the cost approach, and the capitalized income approach. The results of the three approaches are compared and reconciled, and a final report of defined value is drafted for the client.

Appraisal Data Needs

Information is needed from many sources in order to complete a farm appraisal report. A good place to begin the information gathering process is the courthouse in the county in which the subject property is located. First, one needs to know the exact legal description of the subject property. From the county highway map one can determine the property's general location, and its section, township and range numbers can be ascertained. With the help of a clerk in the county clerk's office the exact legal description of the subject property can be located either on an earlier deed conveying the property between seller and buyer or on some encumbering instrument such as a mortgage.

Appraisers in general utilize recent sales of similar property to develop and support their opinion of value for a subject property. A record of all real property transfers, as part of the public record, is to be found in the office of the County Clerk in the courthouse. With the assistance of an office employee, recent transactions of farmland tracts can be noted, along with the grantor and grantee (in most cases these are seller and buyer) and legal descriptions of the comparable sales. It will be necessary to verify that these transfers are indeed arm's length transactions or sales unaffected by relationship or other forms of favoritism, and also to ascertain the correct sales price and terms of sale of the properties. The terms of a sale may have implications for the price.

A sufficient number of comparable sales which are arms-length transactions are needed to describe the land market in the neighborhood of the subject property. Ideally four or five recent nearby sales can be found. Adjustments in value should be made for differences in location and date of sale (and other factors) between each comparable sale and the subject property.

To make these adjustments, and to determine a time adjusted sales price (TASP) for the comparable sales it will be necessary to ascertain the recent general trends in farmland values for the area of the subject farm and the comparables. This general trend in farmland prices allows a direct percentage adjustment in all comparable sales up to the date of appraisal for the subject property. Initial evaluation of the comparable properties begins with the review of all time adjusted sales prices of each comparable to see how each one varies with respect to the average price of land in the area. Those properties with time adjusted sales prices which compare reasonably with the area average remain viable comparable sales for the appraisal process.

Much additional information can be obtained from the comparable sales. The typical organization of farm firms can be verified by observing how the comparable sale properties are organized and operated.

Soils and cropping information can be obtained from the County ASCS office. Individual farm yields for the comparables and the subject can be determined and then compared with county average yields. Livestock carrying capacity can be determined by reviewing soils and using the judgment of people involved in production agriculture in the area. Exact acreages of land types can be calculated, and combined with a judgment of the typical farm organization, a reasonable estimate of gross farm income can be calculated for each comparable and for the subject property.

Typical organization of a farm property, or highest and best use, recognizes that in the future the use of property may change but for the present and the near future the operation will be organized to maximize expected returns subject to some set of limits or non-monetary objectives of the owner or operator. The term "typical" refers to that which is reasonably expected of the average operator or owner in the area. Since agriculture is a dynamic sector and part of a dynamic system, the typical operation may change over time in response to changing price relationships, cost structures, technology, or consumer demands.

Value from Capitalized Income

One of the approaches to value, the income capitalization approach, utilizes an estimate of typical net farm income and a capitalization rate to determine the value of a subject property. A capitalization rate, like a rate of return, compares the net returns of an investment to its cost or value. By estimating typical incomes for each comparable property and comparing these incomes with the time adjusted sales price of each respective property, an estimate of the area capitalization rate is developed. If the properties chosen as comparable sales are reasonably uniform in quality, organization, and land type mix, the estimated capitalization rate, used with the subject property's estimated net income, can lead to an estimate of value for the subject as follows:

$$\text{Appraised Value} = \frac{\text{Net Income}}{\text{Capitalization Rate}}$$

To simplify the process of estimation of net income for the comparables and the subject property it is assumed that all properties are operated under some form of lease arrangement. Incomes to each property depend upon typical farm lease arrangements. Typical yields and prices for commodities and pasture production must be estimated. Reasonable estimates of landlord costs for taxes, repair and maintenance of fences and buildings, and landlord shares of production expenses must also be calculated. Incomes from improvements should be based upon known rental income for similar property in the area. Tax information, which is public information, can be obtained from the county assessor's office. Maintenance expenses can be estimated based upon improvement values or with the assistance of knowledgeable local individuals like insurance agents or contractors. Landlord production expenses should be typical and expected of landlords in the area of the subject and comparable properties.

With a range of capitalization rates to choose from, another judgement is required with justification of the final capitalization rate explained in the narrative of the appraisal report. One could choose the capitalization rate of the comparable most like the subject property, or if none were very nearly like the subject, a rate of the most comparable property might be most appropriate. The combinations are endless but should be limited by the maximum and minimum of the capitalization rates among the comparables. If a capitalization rate outside the range is chosen, there is some doubt about the viability of the comparables selected as the basis for the appraisal.

Value From Component Costs

The cost approach to value uses information from comparable sale properties and calculated estimates of the value of improvements on the subject property. The components of the subject, the farmland types and the improvements, are separately valued and the sum of these components is the final estimate of value.

The subject property often is improved with fences, agricultural buildings, and perhaps a dwelling. Land, therefore, is a component of value which can be considered separately from the improvements. Thorough analysis of the comparable sales will allow valuation of each farmland type found among the comparable sale tracts and the subject property. One comparable may consist of all pasture. An estimate of the current value of pasture can then be calculated from the time adjusted sale price of this comparable. In similar manner analysis of the group of comparables can yield an estimate of value for each land type component of the subject.

The estimation of improvement values on both the subject property and the comparables is often cited as the most difficult part of the appraisal process. It is necessary to completely examine all improvements to determine the age, construction, and condition of improvements. With adequate improvement descriptions an estimate of total current value can be calculated with the aid of engineering or appraisal manuals. One such manual designed specifically for the valuation of buildings is The Boeckh Building Valuation Manual.(6.) Local replacement costs (new) for many building types can be estimated by following the detailed instructions found in this important appraisal resource.

Depreciation factors are indicated from the physical condition of buildings or improvements. Due to changing farm practices certain improvements become obsolete over time. Functional and economic obsolescence of improvements should be recognized, and an estimate of their total effect should reflect in the final valuation of each improvement component.

Each improvement may have an estimated value based upon condition, age and obsolescence factors, but because of the size of the farm unit or the location of the improvement, it may not contribute one hundred percent of this value to the tract's total farm properties of this size in this area have values enhanced by the full value of the improvements. The subject property improvements are value. Once again we look to the comparable sales to determine if expected to contribute to the total tract value in like manner as the comparables.

As all components of the subject property are individually valued a final estimate of value is possible. Because of ranges in the many component value estimates this final value may be represented as a single number or a range which approximates the tract's value.

Value From Market Data

Location is an important factor in any property's value. The land market can indicate the extent to which location affects value.

Likewise the size of a tract may be reflected in its sale price. It is generally agreed that larger tracts sell on average for lower per acre prices than smaller tracts. The smaller relative total purchase price of a small tract attracts more interest among potential buyers as more are able to obtain the needed credit or meet the repayment schedule for a purchase. The extremely large tracts attract fewer bidders because of the total dollars involved.

The comparable sales will need some adjustment due to size and location factors. An appraiser uses market information and judgment to determine the adjustments of the comparables to the subject property.

Quality of land and soil productivity are other significantly important factors of value. Soil productivity is an indicator of income. Therefore, direct comparison between comparables and subject is possible. Some farms are more workable than others because of field shape, size or location. Certain improvements can complement farms, while others may be economically obsolete. An appraiser must use best judgment to compare the comparable sale properties with the subject property.

Recognition and adequate consideration of property hazards and detriments to value must be included in the appraisal process. Hazards may affect the comparables as well as the subject property and if present, may require some adjustment of comparable tracts to the subject property. Considered among possible property hazards are easements or rights-of-way which may have current or future possible uses detrimental to value.

Location factors include road type and quality as well as the degree of access. A limited access interstate highway may in truth be a hazard and a detriment to value. Distances to market towns or other sources of public services are important factors of value.

Comparables should all be located in the same judicial subdivisions because of natural differences in tax rates across jurisdictional lines. Tax rates are captured in the market for property, and if there are different tax rates for the comparables and the subject, some adjustment in value may be required.

After all justified adjustments are made to the comparables equalizing these properties to the subject property, a final judgment of value is made. The subject may be valued for the same per acre price as the comparable most nearly like the subject, or the subject's final value may reflect the influence of two or more of the comparable adjusted values.

Consolidated Value From The Three Approaches

Final appraised value is made using the information from all three separate approaches to value. The narrative report of appraised value may justify departure from comparable values, component values, or income capitalization rates based upon special features of the subject which alter its value or these factors from the comparables. An appraisal is, after all, a written opinion of value based upon the systematic application of a mixture of market information and judgment.

Special Considerations

Appraisers attempt to consider all valid factors in developing their opinions of value for properties. Real property is really made up of the rights and privileges which are a part of our legal system and which are applicable to owning, buying, developing or selling these rights. To hold all legal rights for a property is called fee simple ownership. Some property rights can be sold, such as the rights to sell or develop the minerals under the surface. An appraiser must know the degree of property rights available, or his opinion of value may not include all pertinent factors.

Value is determined in large part by the typical current or expected use of a property. Appraisers determine the highest and best use of a property and base their judgment of value on this use. Properties in a development area may have a current use far different from the expected typical use. Once again, a judgment is required.

The purchase and ownership of real property has tax implications which should be considered in the selection and analysis of comparable sales. Proper and thorough verification of prices paid for the comparables and some thought toward the buyer and seller characteristics may eliminate mistaken judgments on the local land market.

Summary

In developing a written appraisal report an appraiser uses many different types of information about property. Information forms the basis for judgments about the component values of the subject property, the earning potential of the subject property, and the neighborhood market forces which affect prices of property. This information and the necessary judgments are analyzed in a systematic and logical fashion in order to develop the final opinion of value is called an appraisal. Individuals interested in value questions can use the systematic procedures employed by professional appraisers to be better informed about real property and property values.

CHAPTER V

TRENDS IN OKLAHOMA FARMLAND VALUES

An appraiser or anyone interested in farmland values begins with certain basic general price information which reflects the current situation in the land market. Land prices have changed considerably over the past decade. This chapter is a review of some of the reported sales of farmland across Oklahoma for the years 1971 through 1982. Because of data limitations, collection of farmland price information may or may not represent the market. Individual transaction data provide only a part of the desired information. However, a large data base of transactions involving many sellers and buyers, different types and locations of land, and tracts of differing size should provide sufficient information from which land value trends can be determined.

Information on transfers of land by sale is included in the public records found in county court houses in each county. The sale price of most real property transferred can be calculated from the ownership transfer tax required by state law. Before the calculated price is used it should be verified by knowledgeable local individuals. The information reported herein was obtained from secondary sources and is believed to be reliable. However, it is possible that many sales throughout Oklahoma are not included.

Likewise for some areas of the state, sales information may be inadequate to accurately determine trends in the market value of land.

Information in this chapter is presented for each of the nine Federal Crop reporting districts in Oklahoma and is given for the years 1971 through 1982. Following is a discussion of land values per acre, changes in land values, effects of inflation, and other factors which might affect land values.

Farmland sales data are made available at yearly intervals and are organized similarly each year facilitating the analysis process. Records of land sales are collected at a central point, connected to computer records and maintained on tape format for subsequent analysis. Statistical analysis of these data yield the general farmland price trend information presented below. Systematic and regular collection and analysis of these data will facilitate a yearly report on farmland price trends in the Crop Reporting Districts and at state level.

Farmland Prices in Oklahoma

USDA Crop Reporting Districts are shown in Figure 16. Average per acre sales prices for Oklahoma farmland statewide and by USDA Crop Reporting District are shown in Table VI.

The most striking feature of Table VI is the consistent pattern of price increases. Only in 1976 and 1982 did statewide values decline. For the state as a whole average land values increased from $281 in 1971 to $1,038 in 1982, an average of 12.6 percent (compounded) per year. Table VII also illustrates the wide variability of land values in Oklahoma. In 1982, land values in

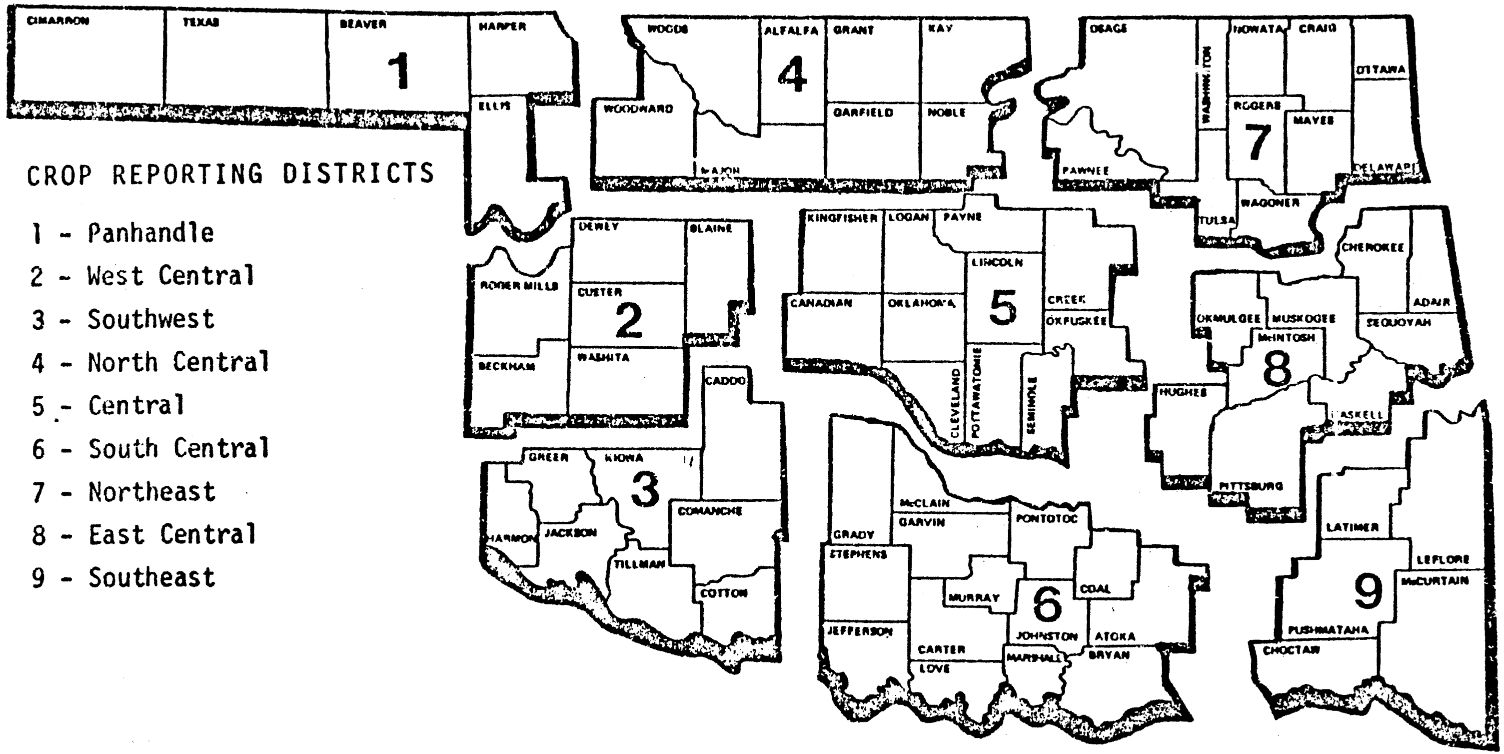


Figure 16. USDA Crop Reporting Districts in Oklahoma

TABLE VI

FARMLAND SALE PRICES IN OKLAHOMA - 1971-1982

Crop Reporting District	Year											
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
	Dollars Per Acre											
1. Panhandle	158	146	215	312	336	460	728	1102	907	789	537	606
2. West Central	226	246	330	421	572	570	767	820	1056	1247	1250	1071
3. Southwest	257	228	315	471	510	584	641	1030	968	1023	1112	829
4. North Central	284	343	449	731	822	874	971	1276	1331	1409	1566	1268
5. Central	373	406	501	688	800	655	1027	1309	1377	1229	1265	1187
6. South Central	267	230	341	481	496	570	656	1069	1019	1190	1254	1043
7. Northeast	428	541	661	808	853	707	849	1354	1244	1287	1536	1148
8. East Central	280	242	423	515	496	501	503	944	1156	920	1115	903
9. Southeast	329	226	315	372	367	488	668	738	742	961	767	598
STATEWIDE	281	303	425	564	657	648	795	1132	1141	1169	1248	1038
Statewide Percent Change from year earlier		+7.8	+40.3	+32.7	+16.5	-1.4	+22.7	+42.4	+0.8	+2.4	+6.8	-16.8

Central and North Central Oklahoma are almost twice the values in Southeast Oklahoma and the Oklahoma Panhandle (Northwestern Oklahoma).

Values of cropland and pasture, respectively, are presented in Tables VII and VIII. Table VII includes sales larger than or equal to 40 acres with between 70 and 100 percent cropland. Table IX is restricted to sales with equivalent percentages of pasture. These tables can be used to relate cropland and pasture land prices in the districts of the state. In some instances, insufficient sales were available to determine land values.

As expected, tracts which are mostly cropland had higher average sales prices than pasture land tracts in the same crop reporting district. Cropland values for the State over all years averaged 66 percent greater than pasture values. The 1982 farmland market indicates a premium of over $700 for cropland vs. pastureland in Crop Reporting District Number 2 (West Central) and in Crop Reporting District Number 4 (North Central). Predominantly cropland tracts sold for nearly $200 more per acre than pasture tracts in the Panhandle for the 1982 farmland market.

Price Changes in the Oklahoma Farmland Market

Percentage changes in farmland prices for each Oklahoma crop reporting district and for the entire state are shown in Table IX. A small percentage decrease in 1976 follows four years of substantial price appreciation. From 1977 to 1981 general farmland prices increased each year but annual increases varied from over 40 percent to less than one percent. The halting trend of upward prices during

TABLE VII

CROPLAND SALE PRICES IN OKLAHOMA - 1971-1982

Crop Reporting District	Year											
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
	Dollars Per Acre											
1. Panhandle	183	170	221	307	325	339	335	404	452	482	448	472
2. West Central	291	333	407	546	600	689	758	805	1006	1076	1228	1254
3. Southwest	305	246	349	426	497	579	628	683	832	856	961	896
4. North Central	333	384	520	745	825	896	892	1000	1028	1132	1466	1431
5. Central	480	417	568	767	792	830	859	918	1090	1411	1549	1215
6. South Central	362	416	411	738	732	800	710	704	799	1139	1204	1267
7. Northeast	380	982	500	*	539	677	802	1089	983	1166	1386	1123
8. East Central	219	250	344	363	651	732	546	681	987	*	871	975
9. Southeast	*	*	*	*	*	*	*	*	*	*	*	*

* too little data to be reliable

TABLE VIII

PASTURE SALE PRICES IN OKLAHOMA - 1971-1982

Crop Reporting District	Year											
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
	Dollars Per Acre											
1. Panhandle	131	116	214	251	235	231	243	257	295	301	424	275
2. West Central	123	124	229	265	271	346	314	355	547	509	588	532
3. Southwest	205	195	284	289	343	376	387	578	522	661	634	658
4. North Central	219	198	252	370	445	403	468	510	860	1042	951	664
5. Central	235	235	337	423	381	429	488	643	721	713	796	882
6. South Central	192	192	261	312	323	358	380	441	503	573	631	802
7. Northeast	289	412	551	597	435	523	500	703	864	944	986	887
8. East Central	231	209	351	345	369	387	402	549	588	570	648	684
9. Southeast	218	196	274	297	343	335	386	435	*	537	494	550

* too little data to be reliable

TABLE IX

FARMLAND PRICE CHANGES IN OKLAHOMA - 1971-1982

Crop Reporting District	Year										
	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
	Percent Change from Year Earlier										
1. Panhandle	-7.6	47.3	45.1	7.7	36.9	58.3	51.4	-17.7	-13	-31.9	12.8
2. West Central	8.8	34.1	27.6	35.9	-.3	34.6	6.9	28.8	18.1	.2	-14.3
3. Southwest	-11.3	38.2	49.5	8.3	14.5	9.8	60.7	-6.0	5.7	8.7	-25.5
4. North Central	20.8	30.9	62.8	12.4	6.3	11.1	31.4	4.3	5.9	11.1	-19.0
5. Central	8.8	23.4	37.3	16.3	-18.1	56.8	27.5	5.2	-5.7	2.9	-6.2
6. South Central	-13.9	48.3	41.1	3.1	14.9	15.1	63.0	-4.7	16.8	5.4	-16.8
7. Northeast	26.4	22.2	22.2	5.6	-17.1	20.1	59.5	-8.1	3.5	19.3	-25.3
8. East Central	-13.6	74.8	21.7	-3.7	1.0	0.4	87.7	22.5	-20.4	21.2	-19.0
9. Southeast	-31.3	39.4	18.1	-1.3	33.0	36.9	10.5	0.5	29.5	-20.2	-22.0
STATEWIDE	7.8	40.3	32.7	16.5	-1.4	22.7	42.4	0.8	2.4	6.8	-16.8

this period is shown in Figure 17. In 1982, price decreases amounting to 16.8 percent of 1981 values brought farmland prices back to 1977-78 levels.

Nominal and Real Farmland Prices in Oklahoma

All aspects of the economy experienced price changes during the 1970's, mostly in the form of general inflation. To better compare real farmland prices for this period statewide average farm prices were adjusted to the general price index using the 1967 based Consumer Price Index. Results of these arithmetic manipulations are shown in Figure 18 and Table X. Figure 18 is a plot of nominal and real farmland prices from 1971 to 1982. It can be seen that real prices of Oklahoma farmland have decreased in a rather steady fashion since 1978. Real prices in 1982, however, were considerably higher than during the first part of the 1970s. Between 1971 and the end of 1982 real farmland prices increased 55 percent, which is equivalent to an annual increase of four percent compounded for the eleven year period.

Effects of Price on Farmland Tract Size

As per acre prices increase total purchase prices for entire land tracts must increase or tract sizes must decrease. In Table XI yearly average tract sizes are presented for all crop reporting districts and for the entire state from 1971 through 1982. Tract sizes through this time period are plotted in Figure 19. It can be seen that the average size of farmland tracts sold in Oklahoma

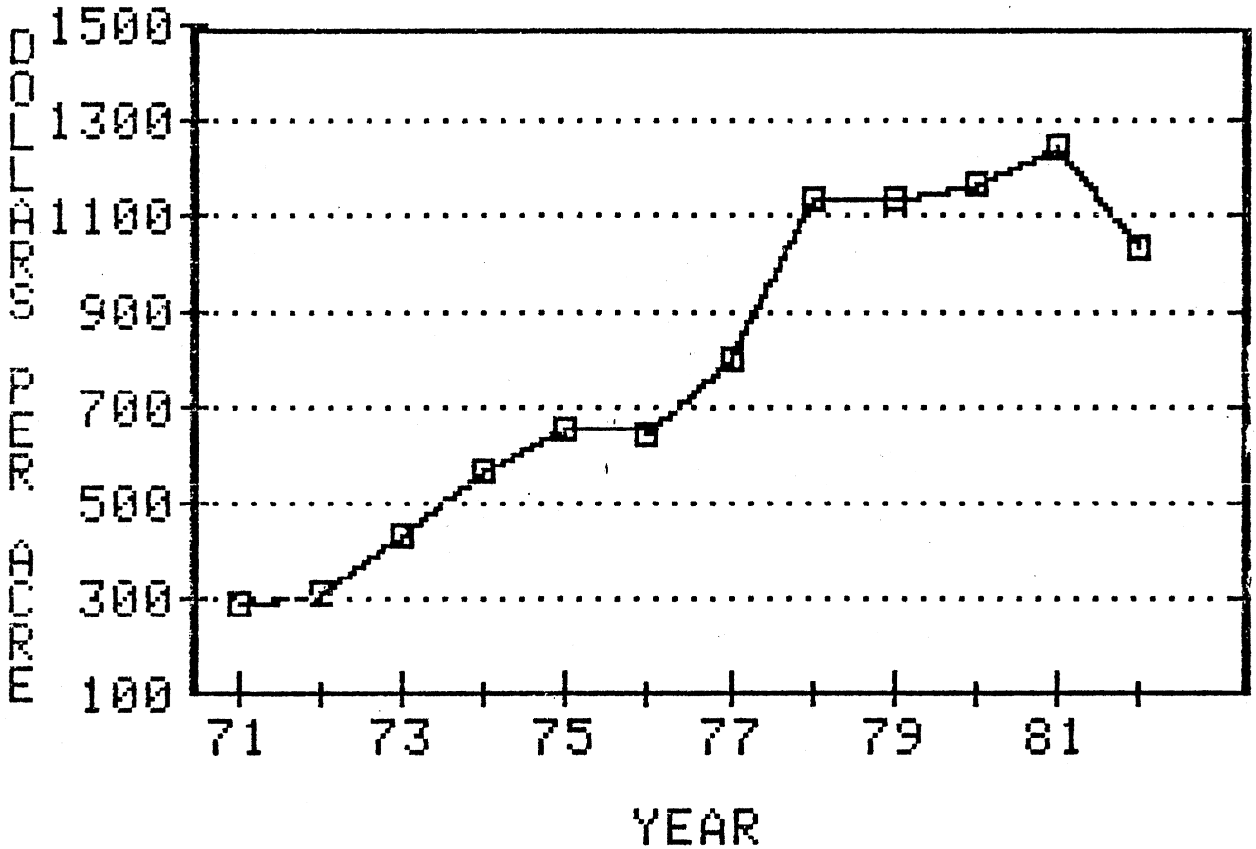


Figure 17. Farmland Price Trends in Oklahoma - 1971-1982

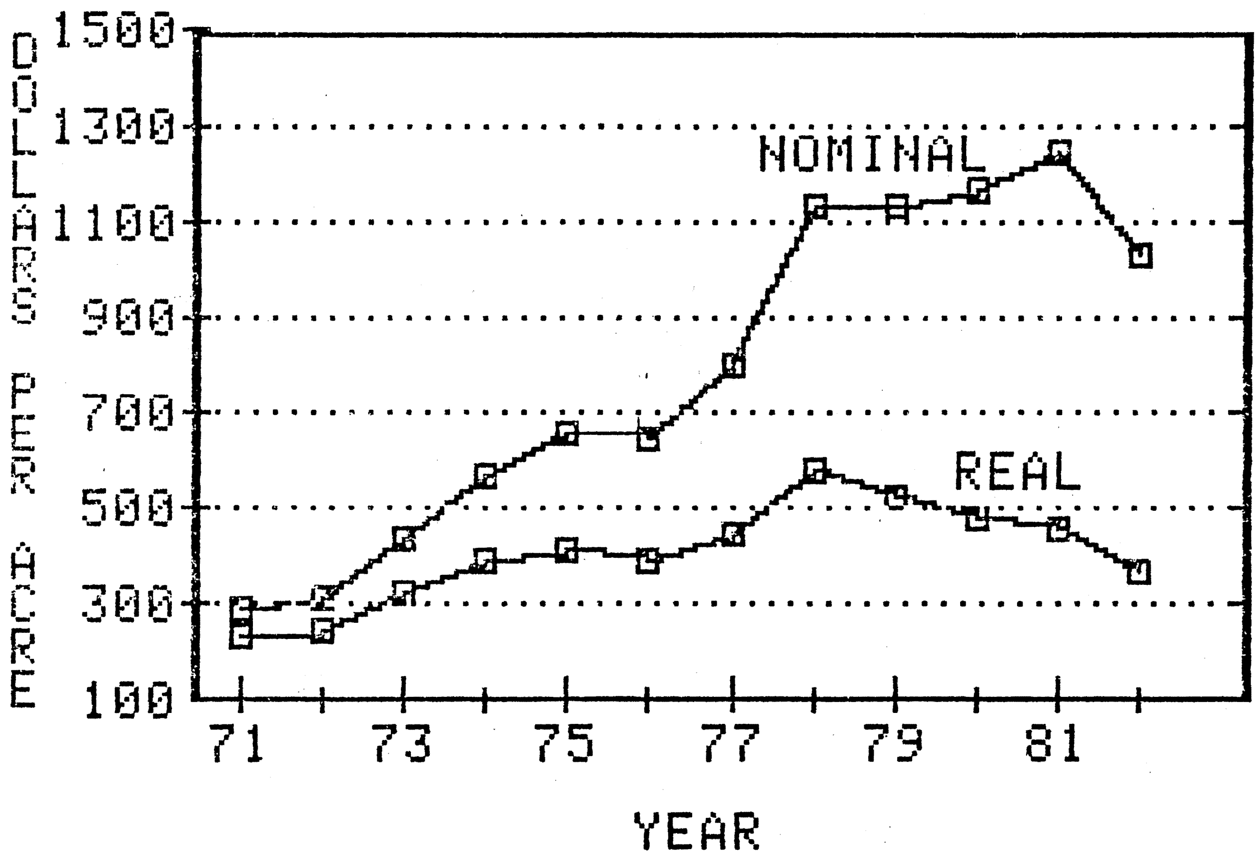


Figure 18. Nominal and Real Farmland Prices in Oklahoma - 1971-1982

TABLE X

NOMINAL AND REAL FARMLAND PRICES IN OKLAHOMA - 1971-1982

Year	CPI (unadj., all items (1967 = 100)	Nominal Price (current dollar)	Real Price (1967 dollar)	Change from Previous Year	
				Real Change	Percent Real Change
		($/acre)	($/acre)		
1971	121.3	281	232		
1972	125.3	303	242	10	4.3
1973	133.1	425	319	77	31.8
1974	147.9	564	381	62	19.4
1975	161.2	657	408	27	7.1
1976	170.5	648	380	-28	-6.9
1977	181.5	795	438	58	15.3
1978	195.4	1123	579	141	32.2
1979	217.4	1141	525	-54	-9.3
1980	246.8	1169	474	-51	-9.7
1981	272.4	1248	458	-16	-3.4
1982	289.4	1038	359	-99	-21.6

TABLE XI

SIZE OF TRACT REPORTED SOLD IN OKLAHOMA - 1971-1982

Crop Reporting District	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
	Year Average Acreage of Tracts Reported Sold											
1. Panhandle	324	361	568	360	266	286	236	281	329	228	237	248
2. West Central	200	213	217	236	212	192	142	156	146	134	215	163
3. Southwest	165	191	175	183	138	165	136	114	129	142	140	160
4. North Central	160	170	204	179	146	175	124	104	112	122	142	160
5. Central	203	173	174	145	156	116	85	82	78	95	106	98
6. South Central	347	221	367	240	260	208	154	125	125	126	162	126
7. Northeast	135	654	250	293	210	201	128	124	147	191	105	176
8. East Central	172	216	221	167	129	127	115	94	130	126	109	124
9. Southeast	212	249	278	373	318	180	231	240	179	231	373	205
STATEWIDE	205	241	241	220	181	173	134	122	132	142	149	156

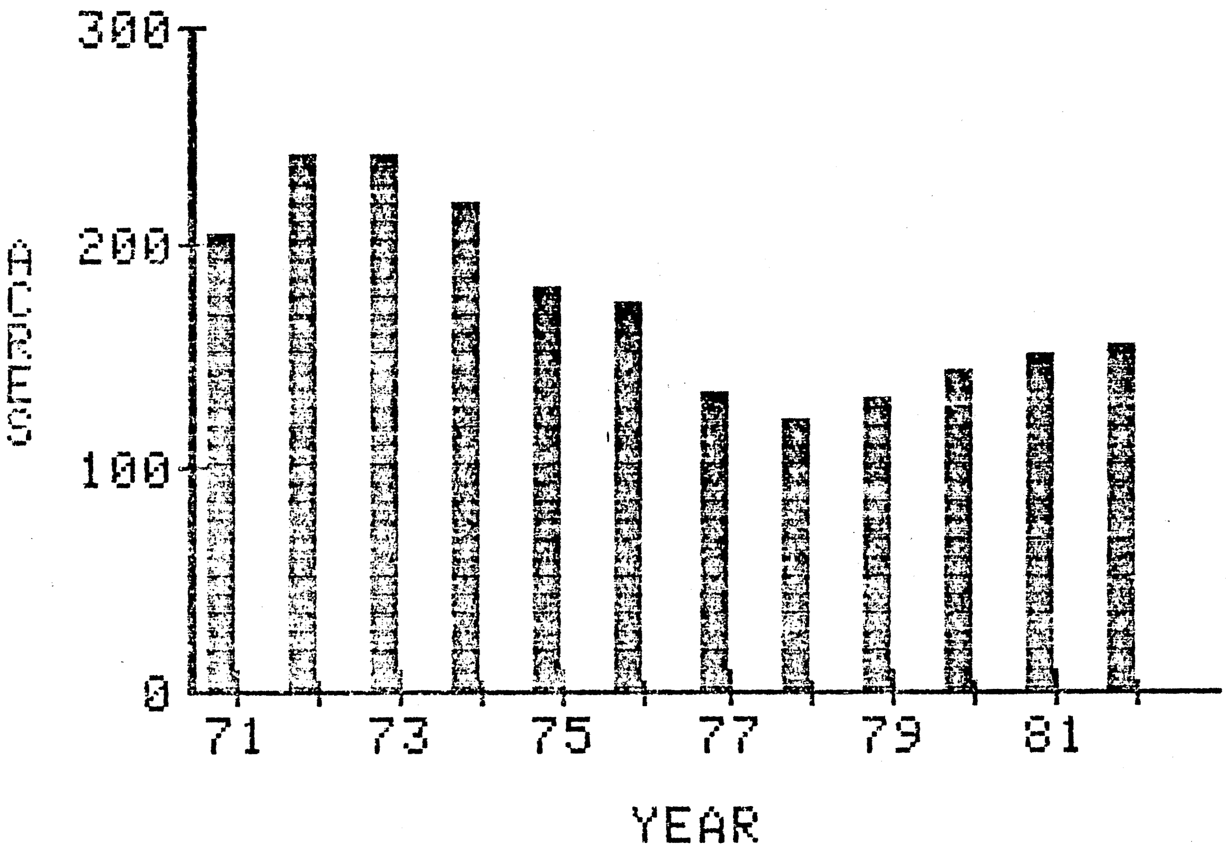


Figure 19. Tract Size of Farms Reported Sold in Oklahoma - 1971-1982

decreased from 1971 through 1982. From 1971 to 1974 the average size of tracts reported sold each year was over 200 acres. Average tract size has increased since 1978, perhaps in response to farmland purchasers growing accustomed to the higher per acre prices and larger expected total purchase prices of tracts.

The Central Crop Reporting District of Oklahoma reported smaller average tract size than all other districts for the years 1976 to 1982. The Panhandle reported the largest tracts sold for most years in the 1971 to 1982 period. This can almost certainly be explained by the fact that the central district is the most urban district in the state with high population density, while the Panhandle is the most rural, with very low population density.

Summary

From 1971 through 1981 the average price of farmland sold in Oklahoma increased from $281 per acre to $1248 per acre, an increase of 344 percent which is equivalent to an annual increase of 13 percent compounded. Farmland prices fell to $1038 per acre in 1982, down $210 per acre from 1981 levels, a decline of 16.8 percent. Cropland tracts sold for about 66 percent more than pastureland tracts. Farmland prices in constant value dollars based upon the Consumer Price Index increased 55 percent from 1971 through 1982, five percent per year for the eleven year period. Real farmland prices were higher in 1978 than for any other year from 1971 through 1982.

CHAPTER VI

ANALYSIS OF THE WESTERN OKLAHOMA LAND MARKET

In earlier chapters the many variables which have been shown to influence farmland values in Oklahoma and in other states have been discussed. Supplementary data show wide variability in the per acre sale price of farm and ranchland across all Oklahoma. The causes of this price variability are examined in this chapter.

In the following sections of this chapter the variables are briefly reviewed and the statistical procedures are discussed. Alternative models of farmland value are then presented.

Variables in the Full Model

The dependent variable in this analysis is the price of agricultural land per acre in dollar terms. Independent variables which were hypothesized to have an impact upon the per acre price of agricultural land are used in this analysis to account for the variation in the dependent variable across all observations in the study area. The dependent variable and the independent variables are discussed in Chapter II and listed below.

LDPRAC = land price per acre

BLDGAV = assessed value of buildings

TOTACRES = total acres in the tract

TSQ = TOTACRES^2

PTSPERAC = productivity points per acre

ADJPTS = adjusted productivity points per acre

INC = per capita income in county

POPDENS = county population density

RAIN = county average rainfall

MONTHS = time variable in months since 1-1-74

MSQ = MONTHS^2

VDENSTHO = assessed value per square mile

LDIST = distance to nearest large city (pop. > 100,000)

LPOP = population of nearest large city

MDIST = distance to nearest medium city (25,000 < pop. < 100,000)

MPOP = population of nearest medium city

SDIST = distance to nearest small city (10,000 < pop. < 25,000)

SPOP = population of nearest small city

RSDIST = distance to nearest town (5,000 < pop. < 10,000)

RSPOP = population of nearest town

TDIST = distance to nearest small town (1,000 < pop. < 5,000)

TPOP = population of nearest small town

ID = miles of interstate highway per 100 sq. miles in county

FD = miles of federal and state highway per 100 sq. miles in county

PD = miles of other paved highway per 100 sq. miles in county

GD = miles of gravel highway per 100 sq. miles in county

DD = miles of dirt road per 100 sq. miles in county

TD = miles of total roads per 100 sq. miles in county

TPD = miles of total paved roads (excluding interstate) per 100 sq. miles in county

CROPSHR = percent tract in cropland

RANGSHR = percent tract in rangeland

GONESHR = percent tract in good grasses

GTWOSHR = percent tract in sparser grasses

TREESHR = percent tract in trees with some grass but where trees are dominant

FORESHR = percent tract in dense trees

General Procedure

This research project represents an effort to determine the set of independent variables which, both theoretically and statistically, best explain the variation in the dependent variable, land price per acre. Correlation analysis of all independent variables and the dependent variable shows the degree of relationships between a variable and all others. A correlation matrix, included as Appendix B, shows the correlation coefficients between each independent variable and the dependent variable. Correlation among independent variables is also shown and noted. From this analysis the independent variables which are positively correlated or negatively correlated with the dependent variable were identified.

Once a set of variables were identified, these variables were analyzed in a stepwise multiple regression procedure to determine the extent to which the independent variables help to explain the variation in the dependent variable, price per acre. The stepwise procedure provides the first indication of the final model form and furnishes information on the effects of adding or deleting individual independent variables from the model. The overall appropriateness of the independent variables chosen in the analysis can be determined in part from stepwise regression procedures.

Specification of final models follows from the results of the stepwise and correlation procedures. Several trial models may be estimated to determine that model which best accounts for the variability in the observed dependent variable while including those variables which conform to economic and statistical theory. Some independent variables may have some non-linear relationship to the dependent variable. The effects of farm size on value have been shown to be a declining function. To examine these non-linear relationships quadratic or square root transformations of selected variables are analyzed in a stepwise regression procedure and in individual model trials. The contribution toward explaining the variability in the dependent variable can be increased by reviewing the different models' R^2 values (coefficients of determination) and by reviewing full model and single variable F test values.

Stepwise Regression Procedure

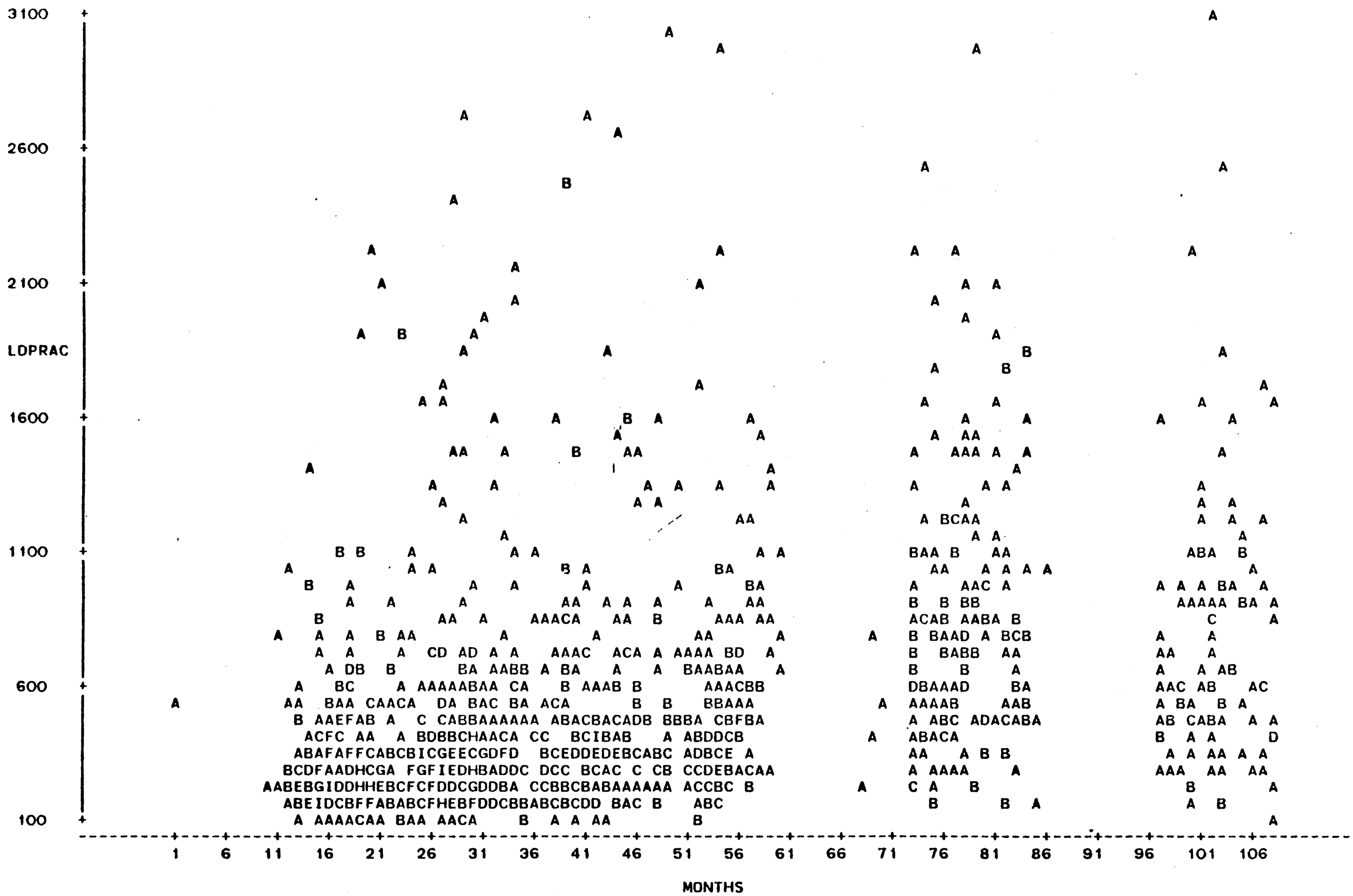
Stepwise regression procedures can be used to analyze the independent variables which contribute in a model toward explaining variation in the dependent variable. Combinations of variables are changed with nonsignificant variables removed in favor of significant ones. In attempts to maximize the coefficient of determination (R^2) the stepwise procedure can use R^2 values as one of the criteria for variable inclusion or exclusion.

Users of the stepwise regression procedure are cautioned to critically evaluate both the model forms and the individual variables included in any final model suggested by the stepwise procedure. Individual variable coefficients may have either magnitudes or signs which conflict with a priori knowledge of the relationship between the independent variable and the dependent variable. Stepwise regression can also result in the inclusion of certain variables which may contribute to explanation of variation in the dependent variable but should not be included in a final model because of low F values for the coefficient indicating low statistical significance. Problems of relationships between two independent variables, or multicolinearity, will be shown in the correlation matrix and in low F values for the problem variables. Stepwise procedures may suggest that several related variables be included in a final model; careful and thoughtful analysis might result in the ultimate exclusion of all but one of these variables.

The stepwise regression procedure combined with analysis of the correlation matrix was a beginning point in the overall analysis of the factors of land values. Independent variables which are listed above were regressed on the dependent variable, land price per acre, to determine the extent to which the variation in independent variables explained the variation in the dependent variable. Stepwise regression procedures yielded models which included numerous combinations of the independent variables. The final step in the procedure analyzed a twenty-five variable model with an R^2 value equal to 0.323. Most variables contributed little to explaining variation in the dependent variable. Analysis and careful scrutiny of interim stepwise models indicated that most dependent variable variation can be explained by six or seven independent variables. In any case the amount of variation in land prices is great. Figure 20 and Figure 21 are plots of the observations found in the data where land cover is analyzed and for all observation in the supplementary data set respectively. The independent variables considered in this analysis can at best account for less than forty-five percent of the total variation in the dependent variable, land price per acre.

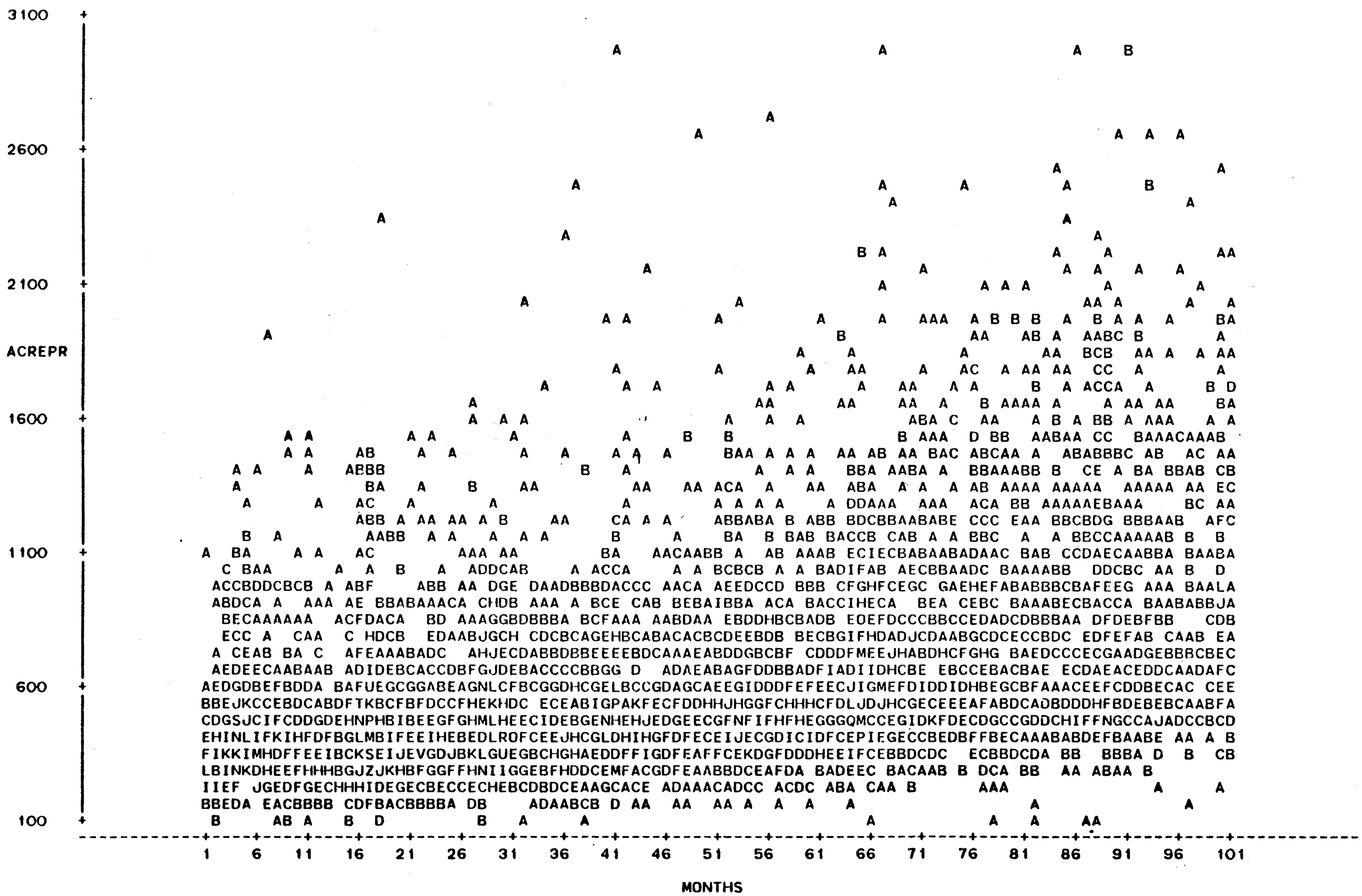
Initial Models of Farmland Value

Some initial models are shown in Table XII. The R^2 values shown have been corrected for sample size and model specifications. Additional variables included with these models resulted in slightly higher R^2 values but low F or t values for individual variables and negative or large intercept values. The selection of models to best explain the variation in the dependent variable and conform to a priori knowledge about the variable relationships yields models shown in Table XIII. In the second model, shown in Table XIII, all variable coefficients were accepted at the alpha = 0.10 level indicating that these coefficients are statistically significant from zero at least 90 percent of the time upon repeated sampling.



Legend: A = 1 OBS, B = 2 OBS, etc.

Figure 20. Oklahoma Tax Commission Data - Plot of Price Per Acre



Legend: A = 1 OBS, B = 2 OBS, etc.

Figure 21. Supplementary Data - Plot of Price Per Acre

TABLE XII

INITIAL MODELS OF FARMLAND VALUE

MODEL I R-Square[a] = 0.281 F = 33.47

PARAMETER	ESTIMATE	T FOR HO: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	233.87425835	1.90	0.0588	123.35688219
TOTACRES	-1.21589100	-3.66	0.0003	0.33201619
PTSPERAC	8.57408324	5.22	0.0001	1.64263526
MONTHS	5.42348618	7.49	0.0001	0.72375099
MDIST	-11.89495400	-2.42	0.0159	4.90690666

MODEL II R-Square = 0.295 F = 24.24

PARAMETER	ESTIMATE	T FOR HO: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	182.39200548	1.32	0.1891	138.60176684
TOTACRES	-2.97386003	-3.19	0.0015	0.93149414
PTSPERAC	8.67626482	5.28	0.0001	1.64284817
MONTHS	5.51878846	7.69	0.0001	0.71784682
MDIST	-9.91336367	-2.02	0.0446	4.91650879
TSQ	0.00685828	1.97	0.0498	0.00348308
TPOP	0.04751574	1.94	0.0532	0.02448507

MODEL III R-Square = 0.290 F = 28.07

PARAMETER	ESTIMATE	T FOR HO: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	111.94522107	0.83	0.4058	134.48520701
TOTACRES	-1.25809773	-3.80	0.0002	0.33064422
PTSPERAC	8.29062806	5.06	0.0001	1.63820576
MONTHS	5.52273178	7.66	0.0001	0.72095703
MDIST	-10.25207381	-2.08	0.0385	4.93480645
TPOP	0.05386204	2.21	0.0278	0.02437727

MODEL IV R-Square = 0.295 F = 24.25

PARAMETER	ESTIMATE	T FOR HO: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	67.93294902	0.65	0.5148	104.17474820
TOTACRES	-2.87061795	-3.07	0.0023	0.93512813
PTSPERAC	9.75336088	6.63	0.0001	1.47031822
MONTHS	5.58625093	7.75	0.0001	0.72068042
RSDIST	-12.30539793	-2.02	0.0439	6.08255298
TSQ	0.00642832	1.84	0.0669	0.00349680
TPOP	0.04626620	1.88	0.0607	0.02457906

MODEL V R-Square = 0.298 F = 21.21

PARAMETER	ESTIMATE	T FOR HO: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	211.18101433	1.51	0.1312	139.55572664
TOTACRES	-2.84305418	-3.05	0.0025	0.93336884
PTSPERAC	8.62725777	5.26	0.0001	1.63969463
MONTHS	5.62542224	7.82	0.0001	0.71964255
MDIST	-7.82817099	-1.54	0.1249	5.08787031
RSDIST	-9.74011018	-1.55	0.1227	6.29481198
TSQ	0.00637514	1.83	0.0686	0.00348975
TPOP	0.04237572	1.72	0.0866	0.02465829

[a]Corrected R^2 values are reported.

TABLE XIII

TWO MODELS OF FARMLAND VALUE

Variables	Model 1	Model 2
DEPENDENT VARIABLE	LDPRAC (land price per acre)	LDPRAC
INTERCEPT	211.1800 (1.51)[a]	316.040 (2.51)
TOTACRES (Size)	- 2.8430 (3.05)	- 2.986 (3.20)
PTSPERAC (Productivity)	8.6270 (5.26)	8.879 (5.42)
MONTHS (Time)	5.6250 (7.82)	5.566 (7.72)
MDIST (Distance to nearest city 25,000 pop 100,000)	- 7.8280 (1.54)	- 8.725 (1.72)
RSDIST (Distance to nearest town 5,000 pop 10,000)	- 9.7400 (1.55)	- 11.197 (1.79)
$TOTACRES^2$ ($Size^2$)	0.0064 (1.83)	0.0071(2.04)
TPOP (Population of nearest town 1,000 pop 5,000)	0.0424 (1.72)	-
R^2[b]	0.2980	0.294
F	21.2100	24.110

[a]The numbers in parentheses are t-values for the regression coefficients.

[b]Corrected R^2 values are reported.

The exclusion of land cover variables from these acceptable models indicates that for these samples the effects of land cover on variation in land value per acre are small. The coefficients for the land cover variables are statistically not significant and not different from zero.

Analysis of Individual Variables

Analyses leading to both models presented above selected explanatory independent variables on the basis of total model R^2, model significance as indicated by the F ratio value, individual variable significance, and a priori assumptions about the sign and magnitude of variable coefficients.

In both models the unexplained variation in land price per acre was examined through residual analysis. No patterns in the residual were noted or discovered under statistical analysis. Both models had positive intercept values and the signs of the independent variable coefficients were as expected. The negative coefficient on the farm size variable indicates that the larger farms tended to sell for lower prices with all other factors remaining equal. Soil productivity is shown to have a positive relationship to price per acre. The variable accounting for time is shown to have a positive relationship with price per acre. Two variables measuring distance from the farm sold and the nearest medium city with population between 25,000 and 100,000 and to the nearest town with population between 5,000 and 10,000 were shown to be negatively correlated with price per acre. As these distances increase, the average price per acre, on average, decreases, with all other factors remaining equal.

The effect of the transformed variable TSQ, which is total acres squared, indicates a curvilinear relationship between land price per acre and the size of the farm sold. Over the range of observations on total acres in tracts sold and total relationship between size of farmland price per acre is still negative, all other factors remaining equal. We would expect size of farm sold to negatively relate to price per acre up to some level where the effect would diminish toward zero.

Other relationships between independent and dependent variables are shown to be linearly positive or negative throughout the range of observations. Multicollinearity, where two or more of the independent variables are approximately linearly related, does not appear to effect these models presented.

Analysis of all independent variables yielded the results presented above. It was earlier hypothesized that variables other than those found in these models would be helpful in explaining variation in the dependent variable, price per acre. None of the demographic variables were significantly correlated to land price per acre; none are included in these models. None of the road density variables were shown to consistently account for the variation in the dependent variable. The per acre assessed value of buildings found on farms sold was not shown to materially affect per acre prices in a consistent statistically significant manner. The degree of variation in land prices overwhelms these individual effects on price.

A somewhat surprising result of this analysis was the exclusion of all land cover variables from these models. These variables determined by remote sensing are expressed as percentages of the land in the various cover types. For this analysis six cover types were utilized: cropland, rangeland, higher quality pasture, lower quality pasture, light tree cover with some grass, and dense tree cover. These variables represent the characteristics of the farms sold, either showing individual farms to be cropland, pasture land or mixtures of the six cover types. Land cover provides some indication of current land use and the ultimate economic value of the land. It was expected that the tracts which had high cropland percentages would have higher average per acre prices. Statistical analysis of the land cover variables did not indicate a significant relationship between land cover type and farmland price per acre. The models developed included a soil productivity variable which may provide more information about a tract's quality and income producing capacity. If farmland is operated to its potential, then the productivity index for the individual farm (ACREPTS) provides better information about land quality than land cover data. Two tracts which are operated similarly, say as wheat land, may have quite different average soil productivity indexes. The analysis here indicates that farmland buyers are utilizing soil productivity index information rather than land cover information to decide bid prices for farms on the market.

A Land Value Model From Supplementary Data

Analysis of supplementary land sale data provides another view of the land market in the western Oklahoma study area. Bona fide land sales of strictly farm tracts from the period 1974 through 1982 in the thirty-seven county study area were available for analysis. Table XIV shows the variables available for each observation.

TABLE XIV

SUPPLEMENTARY DATA VARIABLES

MONTHS	=	month of sale
HOUSEVAL	=	house value
IMPRVAL	=	total value of improvements
TOTACRES	=	size of tract
PASTSHR	=	percent pasture
CROPSHR	=	percent cropland
IRRISHR	=	percent irrigated land
LANDPR	=	sale price of land only
ACREPR	=	per acre sale price of land only
INC	=	county per capita income
POPDENS	=	county population density per square mile
VDENSTHO	=	county assessed value per square mile (thousands)
RAIN	=	county rainfall in inches per year
IHD	=	miles of interstate highway per 100 square miles
SFD	=	miles of state and federal highway
PAVD	=	miles of other paved roads
GRD	=	miles of gravel roads
DTD	=	miles of dirt roads
TOTROADD	=	total miles of roads per 100 sqaure miles
PROADD	=	total miles of paved roads per 100 square miles
TSQ	=	$TOTACRES^2$
MSQ	=	$MONTHS^2$

The dependent variable in the analysis is ACREPR, the price per acre of the land only. As in the earlier analyses procedures, correlation analysis results aids in the identification of those independent variables which are correlated to the dependent variable. This correlation matrix is shown in Appendix C. Stepwise regression procedures further identify the combinations of variables which account for variation in the dependent variable. Examination of individual variables and transformations of individual variables in ordinary least squares regression models yields models which both account for the most variation in the dependent variable and also show relationships which conform to a priori knowledge about the correlation between dependent and independent variables.

The general form is as before:

$$Y = f(X_1, X_2, ..X_n)$$

where

Y is the dependent variable and

X_i are the n independent variables.

Application of the statistical procedures and direct analysis yields the model shown in Table XV. Corrected R^2 is shown on this table.

Price per acre is negatively correlated to size of farm sold (TOTACRES) and the percent of the tract in pasture (PASTSHR). Price per acre is positively correlated with other independent variables in the model. This model accounts for 41.8 percent of the variation in the dependent variable, land price per acre.

TABLE XV

A FARMLAND VALUE MODEL DEVELOPED FROM SUPPLEMENTARY DATA

ACREPR =	295.8500	INTERCEPT
	- 1.8440 (13.80)	TOTACRES (size of tract sold)
	+ 0.0034 (9.52)	IMPRVAL (value of all improvements)
	+ 2.465 (6.26)	CROPSHR (percent in cropland)
	- 1.125 (2.90)	PASTSHR (percent in pasture)
	+ 1.586 (4.61)	IRRISHR (percent irrigated)
	+ 1.781 (3.22)	MONTHS (months since 1-1-74)
	+ 0.444 (22.09)	VDENSTHO (county assessed value per square mile)
	+ 1.085 (7.10)	GRD (miles gravel roads per 100 square miles)
	+ 3.786 (21.13)	DTD (miles dirt roads per 100 square miles)
	+ 0.039 (7.25)	MSQ ($MONTHS^2$)
	+ 0.0023 (8.53)	TSQ ($TOTACRES^2$)
	+ e	

$R^2 = 0.418$ F = 396.15 ACREPR = 685.14

[a]The numbers in the parentheses are t-values for the regression coefficients.

Comparison of Models

Supplementary data models explained a greater proportion of the variation in land prices than did land cover data models. Both analysis procedures were begun and accomplished in similar fashion and yielded models consistent with a priori knowledge about the variables and their correlation.

Analysis of the land cover data led to the exclusion of the land cover variables as significant variables in accounting for variation in land prices. Cover data models benefitted from productivity information for each observation in the sample. Other data analyzed in this research project included information on each tract's current agricultural use but had no productivity measure. Land use variables in the supplementary data were statistically significant and the coefficients would be expected to differ from zero 95 times out of 100 in repeated sampling. Land cover variables determined through remote sensing techniques were not useful in this attempt to model the farmland market.

Other variables such as county assessed value per square mile, while not found useful in explaining land value in the cover data models, were included in the supplementary data land value model. The size of the tract sold represented by the variables TOTACRES in both analyses was included in both final models.

The following chapter includes a review of six designated land markets in western Oklahoma. Since the supplementary data models explain more variation in per acre farmland prices than the land cover data, these data form the basis for this market area evaluation.

CHAPTER VII

DISTINCT FARMLAND MARKETS IN WESTERN OKLAHOMA

Western Oklahoma and specifically the study area of this research project has considerable agricultural, geologic, and economic diversity. Any analysis of the market for farmland in an area of this size must address the existence of multiple land markets. Western Oklahoma land market areas were identified and designated using general soil characteristics, rainfall patterns, and the boundaries of a large multi-county SMSA (Standard Metropolitan Statistical Area) surrounding and including Oklahoma City. Figure 22 is a map showing the land market areas analyzed in this chapter. Table XVII includes general statistics for selected variables in each of the six designated market areas.

Information in Table XVI illustrates the diversity of the identified market areas in western Oklahoma. Area 1 has larger farm tract size among the reported sales, has the lowest average rainfall for the study area, and has by far the lowest population density among all areas. Reported sales in Area 1 are, on average, comprised of 40 percent cropland and 60 percent pasture.

Area 2 sales are, on average, comprised of about 65 percent cropland and 32 percent pasture. Area 2 has the lowest per capita income among the six market areas in western Oklahoma. Area 3 sales

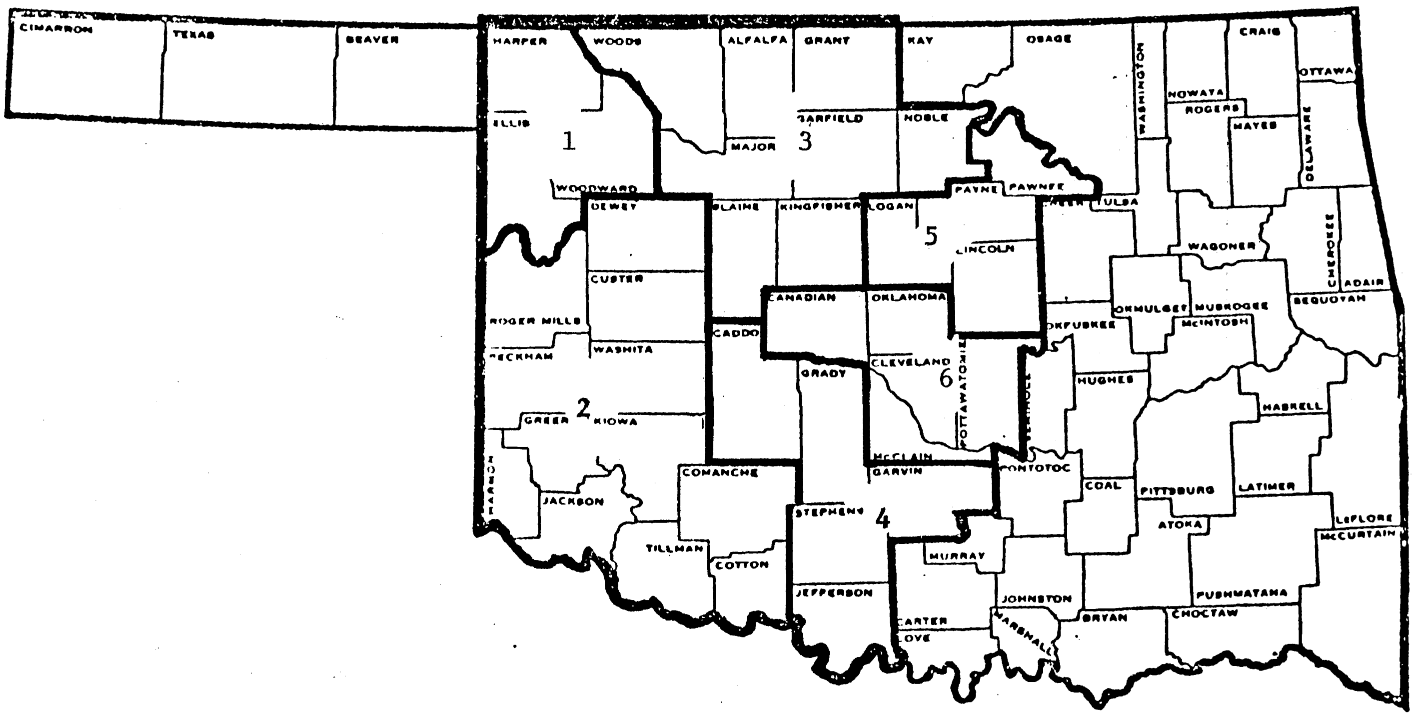


Figure 22. Farmland Markets in Western Oklahoma

TABLE XVI

GENERAL CHARACTERISTICS OF SIX FARMLAND MARKET AREAS IN WESTERN OKLAHOMA

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AREA=1									
ACREPR	344	388.1011255	216.3683303	100.0000000	2321.42857	11.6657985	133506.787	46815.3	55.751
TOTACRES	344	210.1947674	124.8707781	40.0000000	625.00000	6.7325811	72307.000	15592.7	59.407
CROPSHR	344	39.2065267	34.0618797	0.0000000	100.00000	1.8364935	13487.045	1160.2	86.878
PASTSHR	344	59.0565371	34.7726089	0.0000000	100.00000	1.8748134	20315.449	1209.1	58.880
IRRISHR	344	1.7836670	12.0449162	0.0000000	100.00000	0.6494184	613.581	145.1	675.290
PRICE	344	79679.9244186	64154.6976462	7750.0000000	650000.00000	3458.9894806	27409894.000	4115825230.1	80.516
IMPRVAL	344	2140.1162791	8119.1503087	0.0000000	85000.00000	437.7552469	736200.000	65920601.7	379.379
POPDENS	344	9.7093023	5.8680660	5.0000000	17.00000	0.3163849	3340.000	34.4	60.438
RAIN	344	24.3924419	0.4890055	24.0000000	25.00000	0.0263654	8391.000	0.2	2.005
VDENSTHO	344	43.3859738	20.3167207	24.2550000	68.37400	1.0954042	14924.775	412.8	46.828
INC	344	5373.9476744	259.1884906	5122.0000000	5694.00000	13.9745069	1848638.000	67178.7	4.823
AREA=2									
ACREPR	1967	610.8488261	340.8026107	85.1926978	3965.51724	7.6842367	1201539.64	116146.4	55.792
TOTACRES	1967	164.2104728	88.7585190	40.0000000	619.00000	2.0012801	323002.00	7878.1	54.052
CROPSHR	1967	64.6029598	31.6290315	0.0000000	100.00000	0.7131546	127074.02	1000.4	48.959
PASTSHR	1967	32.4136302	31.8031148	0.0000000	100.00000	0.7170798	63757.61	1011.4	98.116
IRRISHR	1967	3.7072188	16.6497956	0.0000000	100.00000	0.3754108	7292.10	277.2	449.118
PRICE	1967	95367.8078292	64515.4190337	8000.0000000	585000.00000	1454.6594828	187588478.00	4162239293.1	67.649
IMPRVAL	1967	1843.4926284	7816.8724739	0.0000000	100000.00000	176.2506985	3626150.00	61103495.3	424.025
POPDENS	1967	22.0752415	23.1753112	4.0000000	103.00000	0.5225446	43422.00	537.1	104.983
RAIN	1967	27.6792069	1.5140205	25.0000000	31.00000	0.0341373	54445.00	2.3	5.470
VDENSTHO	1967	53.5356558	30.5261315	26.1260000	142.75700	0.6882870	105304.63	931.8	57.020
INC	1967	4084.5388917	1019.2320720	471.0000000	5430.00000	22.9811047	8034288.00	1038834.0	24.953
AREA=3									
ACREPR	1790	848.707658	416.6593981	100.0000000	3354.43038	9.8481503	1519186.71	173605.1	49.093
TOTACRES	1790	151.766480	76.1373916	40.0000000	635.00000	1.7995813	271662.00	5796.9	50.167
CROPSHR	1790	57.624836	33.8656875	0.0000000	100.00000	0.8004485	103148.46	1146.9	58.769
PASTSHR	1790	40.050098	33.8728731	0.0000000	100.00000	0.8006183	71689.67	1147.4	84.576
IRRISHR	1790	0.096369	2.8870581	0.0000000	91.25000	0.0682384	172.50	8.3	2995.846
PRICE	1790	123695.153631	75433.7161306	8000.0000000	676000.00000	1782.9492749	221414325.00	5690245529.3	60.984
IMPRVAL	1790	1887.332961	7778.9771210	0.0000000	107400.00000	183.8636929	3378326.00	60512485.0	412.168
POPDENS	1790	20.726257	19.7954869	6.0000000	60.00000	0.4678856	37100.00	391.9	95.509
RAIN	1790	30.539665	2.3122252	26.0000000	34.00000	0.0546517	54666.00	5.3	7.571
VDENSTHO	1790	98.981763	62.3342442	35.1320000	207.10200	1.4733305	177177.36	3885.6	62.975
INC	1790	5442.018994	760.8529544	4473.0000000	7077.00000	17.9834999	9741214.00	578897.2	13.981

TABLE XVI (Continued)

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AREA=4									
ACREPR	825	610.0414129	355.8565199	82.1538462	3000.00000	12.3893338	503284.166	126633.9	58.333
TOTACRES	825	149.7781818	99.2892974	40.0000000	630.00000	3.4568096	123567.000	9858.4	66.291
CROPSHR	825	31.1976974	34.8064155	0.0000000	100.00000	1.2118038	25738.100	1211.5	111.567
PASTSHR	825	65.8892872	36.0310311	0.0000000	100.00000	1.2544395	54358.662	1298.2	54.684
IRRISHR	825	2.4178304	13.6112960	0.0000000	100.00000	0.4738845	1994.710	185.3	562.955
PRICE	825	90259.5842424	69472.3954168	9810.0000000	775000.00000	2418.7183496	74464157.000	4826413725.0	76.970
IMPRVAL	825	5205.2121212	12426.5156812	0.0000000	85000.00000	432.6357443	4294300.000	154418292.0	238.732
POPDENS	825	32.4363636	10.7307577	10.0000000	49.00000	0.3735970	26760.000	115.1	33.082
RAIN	825	32.2339394	1.7708021	30.0000000	35.00000	0.0616514	26593.000	3.1	5.494
VDENSTHO	825	77.1493212	19.8428093	25.2270000	104.62000	0.6908379	63648.190	393.7	25.720
INC	825	4631.1224242	602.4601613	3713.0000000	5464.00000	20.9749705	3820676.000	362958.2	13.009
AREA=5									
ACREPR	683	565.6744894	316.7679965	57.726465	3000.00000	12.1207905	386355.676	100342.0	55.998
TOTACRES	683	133.8682284	90.6882946	40.000000	563.00000	3.4700912	91432.000	8224.4	67.744
CROPSHR	683	15.8257900	24.2703053	0.000000	100.00000	0.9286774	10809.015	589.0	153.359
PASTSHR	683	82.5909832	24.9985642	0.000000	100.00000	0.9565435	56409.642	624.9	30.268
IRRISHR	683	0.1125549	2.9415401	0.000000	76.87500	0.1125549	76.875	8.7	2613.427
PRICE	683	77788.4831625	69751.3860571	11500.000000	714000.00000	2668.9626131	53129534.000	4865255856.9	89.668
IMPRVAL	683	5439.8901903	14425.6198206	0.000000	147500.00000	551.9810021	3715445.000	208098507.2	265.182
POPDENS	683	44.7203514	26.1733895	26.000000	89.00000	1.0014969	30544.000	685.0	58.527
RAIN	683	34.0819912	1.3206062	32.000000	36.00000	0.0505316	23278.000	1.7	3.875
VDENSTHO	683	95.4435066	43.3043065	57.493000	165.17000	1.6569932	65187.915	1875.3	45.372
INC	683	4619.1786237	276.8116127	4311.000000	5166.00000	10.5919020	3154899.000	76624.7	5.993
AREA=6									
ACREPR	596	795.737229	463.2755968	112.7272727	3500.00000	18.9765078	474259.388	214624.3	58.220
TOTACRES	596	132.248322	87.2774312	40.0000000	585.00000	3.5750229	78820.000	7617.3	65.995
CROPSHR	596	31.796726	35.9889503	0.0000000	100.00000	1.4741648	18950.849	1295.2	113.184
PASTSHR	596	64.530961	37.6643586	0.0000000	100.00000	1.5427922	38460.453	1418.6	58.366
IRRISHR	596	0.160445	3.9169526	0.0000000	95.62500	0.1604446	95.625	15.3	2441.311
PRICE	596	104818.659396	76577.3390861	6200.0000000	600000.00000	3136.7300284	62471921.000	5864088861.5	73.057
IMPRVAL	596	7688.258389	18666.8494192	0.0000000	165000.00000	764.6239450	4582202.000	348451267.2	242.797
POPDENS	596	146.439597	213.6233583	35.0000000	801.00000	8.7503537	87278.000	45634.9	145.878
RAIN	596	32.942953	2.0341870	30.0000000	35.00000	0.0833235	19634.000	4.1	6.175
VDENSTHO	596	378.374844	584.4639427	85.8760000	2195.96700	23.9405759	225511.407	341598.1	154.467
INC	596	4916.385906	538.9523969	4320.0000000	6250.00000	22.0763504	2930166.000	290469.7	10.962

consist of 58 percent cropland and 40 percent pasture. The average size of tract reported sold in Areas 2, 3, and 4 ranges from 150 to 165 acres.

The size of tract sold in Areas 5 and 6 averages 134 and 132 acres respectively. Area 5 has the highest average share of pastureland among its reported sales, 83 percent. Rainfall is also highest for Area 5. The highest population density based upon county averages occurs in Area 6, the Oklahoma City SMSA. This area also has the highest assessed valuation per square mile and the highest improvement value for all reported sales.

Analysis Procedure

After preliminary market areas were identified and designated using area characteristics, each area's farmland sales reported in the supplementary data were analyzed using the steps employed earlier. Stepwise regressions were used to identify the combinations of variables which, when regressed against the dependent variable, accounted for the greatest proportion of variation in farmland prices.

Initial models and variables considered in the stepwise procedure were further analyzed using an ordinary least squares technique. The six models resulting from statistical analysis and direct inspection are shown in Table XVII. These are the models which best account for variability in farmland prices in each area and contain variable coefficients which are statistically significant and consistent with economic theory. The R^2 values are corrected for sample size and degrees of freedom.

TABLE XVII

LAND VALUE MODELS FOR SIX FARMLAND MARKET AREAS IN WESTERN OKLAHOMA

Variable	Area 1	Area 2[b]	Area 2	Area 3	Area 4	Area 5	Area 6
INTERCEPT	211.2000 (4.46)[a]	545.460 (17.03)	496.460 (6.48)	657.220 (6.31)	576.390 (8.53)	496.140 (13.32)	966.660 (17.51)
TOTACRES (size)	- 0.8380 (2.78)	- 1.173 (5.41)	- 1.180 (5.43)	- 1.379 (6.06)	- 1.353 (4.68)	- 1.312 (3.74)	- 2.408 (4.88)
IMPRVAL (value of improvements)	0.0040 (3.07)	0.002 (2.54)	0.002 (2.59)	-	0.003 (3.68)	0.003 (4.74)	0.002 (3.30)
CROPSHR (cropland percentage)	1.1770 (4.05)	-	0.519 (0.70)[c]	2.745 (2.72)	3.096 (4.67)	3.226 (7.30)	4.255 (10.49)
PASTSHR (pasture percentage)	-	- 3.908 (20.11)	- 3.412 (4.66)	- 1.854 (1.84)	- 1.554 (2.43)	-	-
IRRISHR (irrigated percentage)	2.5590 (3.13)	2.375 (6.63)	2.362 (6.59)	-	2.879 (4.11)	7.325 (2.05)	-
VDENSTHO (county assessed value per square mile)	3.3340 (6.96)	1.523 (7.71)	1.530 (7.73)	0.604 (5.00)	-	-	-
MONTHS (time)	-	3.663 (4.62)	3.642 (4.59)	1.757 (1.65)	-	-	-
MSQ ($time^2$)	0.0247 (7.17)	0.021 (2.73)	0.021 (2.75)	0.054 (5.38)	0.053 (16.02)	0.043 (11.60)	0.064 (11.79)
TSQ ($size^2$)	0.0010 (2.33)	0.001 (2.96)	0.001 (2.99)	0.002 (3.44)	0.001 (2.61)	0.002 (2.73)	0.003 (3.11)
GRD (miles of gravel road per 100 square miles)	-	-	-	-	-	-	- 6.171 (10.42)
MODEL R^2[d]	0.3220	0.427	0.427	0.427	0.441	0.248	0.433
F	24.0600	183.90	163.480	191.480	93.67	38.44	76.560

[a]The numbers in parentheses are t-values for the regression coefficients.

[b]A second model for AREA 2 is shown.

[c]This is a low t-value and indicates that this coefficient may not differ from zero.

[d]Corrected R^2 values are reported.

Evaluation of the Market Area Models

Table XVII shows all six models and permits comparison of these different models. The signs of the coefficients support earlier study findings and theoretical foundations of land value.

In all models the tract size is negatively correlated to per acre prices. As tract size increases, per acre prices tend to decrease, all other factors being equal. Tract size has the least impact in Area 1, where the largest tracts were reported sold, and the greatest impact on Area 6, the Oklahoma City SMSA counties.

The value of improvements is positively related to the dependent variable, price per acre, in five of six market areas. Only in Area 3 was the improvement value variable eliminated from the model. Cropland is a determinant of value on all acres, however in Area 2 the coefficient on the CROPSHR variable would be statistically significant at the fifty percent probability level. Area 2 models which explains an equal proportion of the variation in the dependent variable were obtainable with or without the variable CROPSHR. Both models for Area 2 are shown on Table XVII .

Road system variables were important to only one market area model. This is the case for Area 6, the Oklahoma City SMSA, which has a more highly developed road system than other market areas in the western Oklahoma study area. The miles of gravel road per 100 square miles in the Area 6 counties was negatively correlated to land price per acre. Those counties in Area 6 with higher proportions of gravel roads tended to have lower per acre sale prices for the farmland tracts reported sold.

Summary

In this chapter six distinct farmland market areas were identified and designated using general soil and demographic data. Analysis of farmland sales in these designated areas resulted in six models of land value for the western Oklahoma study area. The models developed illustrate the diversity in farmland and in farmland sales across the study area.

CHAPTER VIII

SUMMARY AND CONCLUSIONS

Land is the single largest factor of production in agriculture and represents the bulk of the capital devoted to agriculture. The market for agricultural land is diverse and involves individuals and corporations who may or may not be directly involved in agricultural production. Since land is the principle asset in agriculture, there is much interest in determining the value of land as a balance sheet item and as security for credit.

The general objective of this study was to evaluate recent reported sales of farmland tracts across the state of Oklahoma, reporting the trends in farmland prices for the state and in a number of regions of the state. Additional specific information was gathered for a sample of reported farmland sales in western Oklahoma in order to evaluate the factors which affect the selling price and value of farmland tracts. The current use of the land resource is indicated by the type of cover on the land. Land cover information in the form of satellite imagery provided detailed information on the use of land recently reported sold in the study area. Land cover factors, such as the proportion of the tract in cropland, pasture, or rangeland, were evaluated along with general demographic factors to determine the extent to which each of these factors account for the variation in farmland prices.

Sales of agricultural land, recorded in the offices of the County Clerks, were obtained for a thirty-seven county study area in western Oklahoma. The legal description of each tract provides a means to determine tract size and tract location and to evaluate the current cover of the land in the tract. Each reported sale, the value of descriptive variables of the tract, and general demographic variables for the county in which the tract is located comprised an observation in a data set to be statistically analyzed using multiple regression techniques.

The western Oklahoma study area included thirty-seven counties and represented a diverse agricultural and geographical community. Six district agricultural land market areas were identified in the study area. Utilizing supplementary farm sales reports each of these market areas were evaluated to develop models of farmland value for each area.

Farmland Price Trends

For the period 1971 through 1982 statewide average farmland prices increased from $281 per acre in 1971 to $1038 per acre in 1982. Prices actually declined in 1982 from a 1981 average of $1248 per acre. Not surprisingly, the higher quality land which was in the production of crops sold for about 66 percent more than pastureland.

When comparing nominal farmland price changes with the consumer price index for the same period, real farmland prices were found to be highest during 1978, increasing up to that time and decreasing through 1982.

The average size of farms reported sold during the years 1971 through 1982 declined for the years 1971 through 1978. Statewide average tract size and real per acre price showed a negative relationship. As real prices increased, the average tract size decreased; when real prices declined the average tract size increased.

Development of the Land Cover Data

Land cover has been used to determine the current use of land. It was hypothesized that land use would be a determinant of value for the reported farmland sales evaluated in this study. An efficient method to determine land use was needed to complete this analysis. Remote sensing imagery, in the form of digital reflectance data, was acquired for the western Oklahoma study area. Processing of this digital data into nine cover classes transformed it into a usable set of data. Land cover data provide a description of the study area with respect to the current use of the land surface. Known points of location are designated within the land cover data matrix; this allows evaluation of land cover for specific tracts of land based upon their legal land descriptions. Cover data are organized in map form with each cell of data having an unique location consisting of X and Y coordinates. The land cover associated with each cell is a number code. Legal descriptions of tracts of land were converted to combinations of X and Y values, and a numeric count of each cell's land cover code is then translated into an inventory of the land cover for a specific tract. Land cover percentages, such as percent of the tract in cropland, were calculated for each farm, and these cover variables were subsequently analyzed with other variables to accomplish the objectives of the research project.

The nine cover classes used in this study were: cropland, bare soil, rangeland, high quality grassland, poorer quality grassland, trees, forest, water, and cloud cover, or missing data. The system of legal land description found in Oklahoma and many other states and Canada made possible the matching of the farm locations with the correctly processed LANDSAT cover data.

Evaluation of the Land Value Models

Correlation analysis and multiple regression analysis of the independent variables and the dependent variable, farmland price per acre, allowed the development of models of value for farmland. Variables were included in the model based upon three criteria: (1) the economic theory which suggested inclusion of the variable, (2) the amount of variation in the dependent variable accounted for by including the variable in the model, and (3) the statistical significance of the model equation and the individual explanatory variables in the model.

Models developed for the entire western Oklahoma study area showed a negative correlation between per acre price and tract size. Proximity of the tract sold to medium sized cities with populations between 25,000 and 100,000 and to towns with populations between 5,000 and 10,000 was negatively correlated to price per acre. The greater the distance to these population centers the lower the average price per acre.

Time and soil productivity as measured by a productivity index were positively correlated with price per acre. Demographic variables like per capita income and average assessed valuation for the county were not statistically significant and were not included in the models developed.

Land cover variables measuring the use of the land for the farms reported sold were not significant determinants of value; their inclusion in the value models did not materially increase the amount of explained variation in the dependent variable. The coefficients for these cover variables were not statistically significant and could not be expected to be different from zero in repeated sampling.

Farmland Market Areas

Evaluation of the resource areas and farming practices in Oklahoma led to the identification of six distinct farmland market areas in the western Oklahoma study area. Reported farmland sales in each of these areas were analyzed using correlation and multiple regression techniques to build a model of farmland value for each area. Area models differed in both the combination of explanatory variables and in the coefficients of the variables.

For all market areas there was much price variability among the reported sales. Models utilizing the available explanatory variables which had economic relevance and statistical significance accounted for between 25 and 45 percent of the variation in the dependent variable, farmland price per acre.

Limitation and Conclusions

Earlier attempts to model the farmland market have reported a number of problems which are difficult to solve. This research showed a high degree of variability in farmland prices; models of value and price accounted for less than half of all variability in per acre prices of farmland in the study area. More descriptive information relative to the individual farm tracts sold and to both the sellers and buyers would be needed to account for a greater proportion of land price variability.

Other studies referenced here have utilized buyer and seller characteristics to improve the performance of their models in explaining the farmland market. Personal information on buyers and sellers may help explain specific prices, but they are of little value in explaining the general land market. Buyer or seller characteristics can show the effects of financing arrangements and the tax consequences of a major purchase. These studies have benefitted from more detailed secondary data or have acquired the desired detail from a primary data gathering effort. The relative value of primary data, whose integrity and reliability are better known, must be weighed against the cost of data acquisition. This study relied upon secondary data which provided tract legal descriptions specifically necessary to determine land cover. These data did not include buyer or seller characteristics or any measure of the mineral rights component of the real estate, an important consideration in the study area.

The farmland sales analyzed in this research do not constitute a random sampling of all sales of farmland in the western Oklahoma study area. They are believed to be representative of farms in the area. Some sales of farms are no doubt not included in these data. The results of this research refer only to the sales actually reported and analyzed, and due care should be taken to limit the extent of generalizations about the farmland market in the study area and beyond.

This research analyzed the farmland market in western Oklahoma and identified from the available data the factors which explain a proportion of land price variability. Soil productivity information, when available, is an important factor of value. Land cover factors were not shown to be useful in explaining the variation in per acre farmland prices when combined with soil productivity information.

Analysis of additional farmland sale data provided sufficient information to identify six distinct land markets in the western Oklahoma study area. Models for these market areas accounted for a greater proportion of the land price variability.

The models developed here can be used by interested persons as starting points in estimating values of specific land parcels. Additional information will enable users to amplify these models and to demonstrate how different tracts are separately appraised. Persons interested in the general trends in land values can use these results directly. Bankers, other lenders, tax assessors, and farmers can utilize trend information as well as the general model forms to help make decisions regarding the value of farmland.

The land cover data developed from LANDSAT digital data sources can be utilized in other resource based research efforts. This research has demonstrated techniques of matching known land tracts with remotely sensed cover data through the use of legal land descriptions. Further research dealing with land resources and requiring detailed land cover inventories for known locations may be able to use these data handling techniques.

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APPENDIXES

APPENDIX A

CITIES AND TOWNS WITH THEIR RESPECTIVE POPULATIONS FOR EACH CITY AND TOWN CLASS IN THE WESTERN OKLAHOMA STUDY AREA

	Name	Population
Major City (Population > 100,000)		
	Oklahoma City	403,000
	Tulsa	361,000
Medium City (25,000 < pop. < 100,000)		
	Lawton	80,954
	Enid	50,363
	Del City	28,523
	Edmond	34,637
	Midwest City	49,559
	Stillwater	38,268
	Moore	35,063
	Norman	68,020
	Shawnee	26,506
Average City (10,000 < pop. < 25,000)		
	El Reno	15,486
	Ardmore	23,689
	Ft. Sill	15,924
	Chickasha	15,828
	Altus	23,101
	Guthrie	10,312
	Bethany	22,130
	Village	11,049
	Woodward	13,610
	Yukon	17,112
Small City (5,000 < pop. < 10,000)		
	Elk City	9,579
	Anadarko	6,378
	Mustang	7,496
	Clinton	8,796
	Weatherford	9,640
	Pauls Valley	5,664
	Perry	5,796
	Choctaw	7,520
	Warr Acres	9,940
	Cushing	7,720
	Marlow	5,017
	Tecumseh	5,123
	Alva	6,416
	Frederick	6,153

APPENDIX A (Continued)

Town (1000 < pop. < 5,000)	Name	Population
	Cherokee	2,105
	Erick	1,375
	Sayre	3,177
	Geary	1,557
	Okeene	1,601
	Watonga	4,139
	Apache	1,560
	Carnegie	2,016
	Cyril	1,220
	Hinton	1,432
	Piedmont	2,006
	Healdton	3,769
	Lone Grove	3,369
	Wilson	1,585
	Cache	1,661
	Elgin	1,003
	Fletcher	1,074
	Temple	1,339
	Walters	2,778
	Thomas	1,515
	Seiling	1,103
	Shattuck	1,759
	Garber	1,215
	Waukomis	1,551
	Maysville	1,396
	Stratford	1,459
	Wannewood	2,615
	East Ninnekah	1,085
	Minco	1,485
	Rush Springs	1,451
	Tuttle	3,051
	Granite	1,617
	Mangum	3,833
	Hollis	2,958
	Buffalo	1,381
	Laverne	1,563
	Blair	1,092
	Ringling	1,561
	Ryan	1,083
	Waurika	2,258
	Hennessey	2,287
	Kingfisher	4,745
	Hobart	4,735
	Mountain View	1,189
	Snyder	1,848
	Chandler	2,926
	Meeker	1,032
	Prague	2,208
	Stroud	3,139
	Crescent	1,651

APPENDIX A (Continued)

Town (1000 < pop. < 5,000)	Name	Population
	Blanchard	1,658
	Newcastle	3,076
	Purcell	4,638
	Fairview	3,370
	Forest Park	1,148
	Harrah	2,897
	Jones	2,270
	Luther	1,159
	Nichols Hills	4,171
	Nicoma Park	2,588
	Spencer	4,046
	Cleveland	2,792
	Pawnee	1,688
	Perkins	1,762
	Yale	1,652
	Cheyenne	1,207
	Comanche	1,937
	Grandfield	1,445
	Tipton	1,475
	Burns Flat	2,431
	Cordell	3,301
	Sentinel	1,016
	Mooreland	1,383
	Lexington	1,731
	Noble	3,479
	Slaughterville	1,953
	Bethel Acres	2,314
	McCloud	4,061
	Medford	1,419
	Waynoka	1,377

APPENDIX B

CORRELATION MATRIX FOR THE COVER DATA

CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / N = 337

	LDPRAC	BLDGAV	TOTACRES	PTSPERAC	ADJPTS	INC	POPDENS	RAIN	MONTHS	VDENSTHO	LDIST	MDIST	SDIST
LDPRAC	1.00000	0.11214	-0.15774	0.37597	0.13560	0.05094	-0.02133	0.20413	0.34719	0.01873	-0.28664	-0.26245	0.15036
	0.0000	0.0396	0.0037	0.0001	0.0127	0.3512	0.6964	0.0002	0.0001	0.7319	0.0001	0.0001	0.0057
BLDGAV	0.11214	1.00000	-0.11653	0.03137	0.13505	-0.05302	-0.03784	0.03136	0.02676	-0.06046	0.08369	0.03511	0.04920
	0.0396	0.0000	0.0325	0.5661	0.0131	0.3319	0.4887	0.5662	0.6245	0.2683	0.1252	0.5207	0.3679
TOTACRES	-0.15774	-0.11653	1.00000	-0.06394	-0.35650	-0.02482	-0.08147	-0.02245	0.11161	-0.07340	0.04867	0.06157	0.09626
	0.0037	0.0325	0.0000	0.2417	0.0001	0.6499	0.1356	0.6813	0.0406	0.1789	0.3731	0.2597	0.0776
PTSPERAC	0.37597	0.03137	-0.06394	1.00000	0.33524	-0.01671	0.19026	0.44256	0.06933	0.23497	-0.43919	-0.48490	0.01972
	0.0001	0.5661	0.2417	0.0000	0.0001	0.7599	0.0004	0.0001	0.2042	0.0001	0.0001	0.0001	0.7184
ADJPTS	0.13560	0.13505	-0.35650	0.33524	1.00000	-0.00127	-0.00576	0.02569	-0.06876	0.01053	0.00876	0.00017	-0.08184
	0.0127	0.0131	0.0001	0.0001	0.0000	0.9815	0.9162	0.6384	0.2080	0.8473	0.8728	0.9975	0.1338
INC	0.05094	-0.05302	-0.02482	-0.01671	-0.00127	1.00000	-0.28557	-0.37660	0.06381	-0.21721	0.09730	0.11376	0.13042
	0.3512	0.3319	0.6499	0.7599	0.9815	0.0000	0.0001	0.0001	0.2427	0.0001	0.0744	0.0369	0.0166
POPDENS	-0.02133	-0.03784	-0.08147	0.19026	-0.00576	-0.28557	1.00000	0.46802	-0.27026	0.97311	-0.13329	-0.36947	-0.21930
	0.6964	0.4887	0.1356	0.0004	0.9162	0.0001	0.0000	0.0001	0.0001	0.0001	0.0143	0.0001	0.0001
RAIN	0.20413	0.03136	-0.02245	0.44256	0.02569	-0.37660	0.46802	1.00000	-0.03669	0.49996	-0.56762	-0.77318	0.13905
	0.0002	0.5662	0.6813	0.0001	0.6384	0.0001	0.0001	0.0000	0.5020	0.0001	0.0001	0.0001	0.0106
MONTHS	0.34719	0.02676	0.11161	0.06933	-0.06876	0.06381	-0.27026	-0.03669	1.00000	-0.23850	-0.10825	0.03367	0.15369
	0.0001	0.6245	0.0406	0.2042	0.2080	0.2427	0.0001	0.5020	0.0000	0.0001	0.0471	0.5379	0.0047
VDENSTHO	0.01873	-0.06046	-0.07340	0.23497	0.01053	-0.21721	0.97311	0.49996	-0.23850	1.00000	-0.22489	-0.42099	-0.17854
	0.7319	0.2683	0.1789	0.0001	0.8473	0.0001	0.0001	0.0001	0.0001	0.0000	0.0001	0.0001	0.0010
LDIST	-0.28664	0.08369	0.04867	-0.43919	0.00876	0.09730	-0.13329	-0.56762	-0.10825	-0.22489	1.00000	0.84630	0.09492
	0.0001	0.1252	0.3731	0.0001	0.8728	0.0744	0.0143	0.0001	0.0471	0.0001	0.0000	0.0001	0.0819
MDIST	-0.26245	0.03511	0.06157	-0.48490	0.00017	0.11376	-0.36947	-0.77318	0.03367	-0.42099	0.84630	1.00000	0.10654
	0.0001	0.5207	0.2597	0.0001	0.9975	0.0369	0.0001	0.0001	0.5379	0.0001	0.0001	0.0000	0.0507
SDIST	0.15036	0.04920	0.09626	0.01972	-0.08184	0.13042	-0.21930	0.13905	0.15369	-0.17854	0.09492	0.10654	1.00000
	0.0057	0.3679	0.0776	0.7184	0.1338	0.0166	0.0001	0.0106	0.0047	0.0010	0.0819	0.0507	0.0000
RSDIST	-0.14708	-0.05222	0.04241	-0.17145	-0.01278	0.21913	-0.39791	-0.54208	0.10897	-0.35307	0.11173	0.33575	-0.39927
	0.0068	0.3392	0.4377	0.0016	0.8152	0.0001	0.0001	0.0001	0.0456	0.0001	0.0404	0.0001	0.0001
TDIST	-0.08791	-0.05372	0.01841	-0.25617	-0.04015	0.23420	-0.22604	-0.35982	0.09080	-0.25474	0.13732	0.29739	-0.04136
	0.1072	0.3255	0.7364	0.0001	0.4626	0.0001	0.0001	0.0001	0.0961	0.0001	0.0116	0.0001	0.4492

APPENDIX B (Continued)

	LDPRAC	BLDGAV	TOTACRES	PTSPERAC	ADJPTS	INC	POPDENS	RAIN	MONTHS	VDENSTHD	LDIST	MDIST	SDIST
ID	-0.11838	0.01742	0.00542	-0.07970	-0.03901	-0.29226	0.61326	0.10598	-0.27804	0.53616	0.37003	0.12995	0.22321
	0.0298	0.7500	0.9211	0.1443	0.4754	0.0001	0.0001	0.0519	0.0001	0.0001	0.0001	0.0170	0.0001
FD	0.05189	0.01532	0.06926	0.16650	0.06671	-0.50911	0.09121	0.52613	-0.17168	0.09479	-0.11379	-0.26254	0.18498
	0.3423	0.7766	0.2047	0.0022	0.2219	0.0001	0.0946	0.0001	0.0016	0.0823	0.0368	0.0001	0.0006
PD	-0.00492	0.08517	-0.08915	0.11104	0.06851	-0.56681	0.50668	0.48371	-0.29332	0.39343	0.02804	-0.22908	0.12714
	0.9283	0.1136	0.1023	0.0416	0.2097	0.0001	0.0001	0.0001	0.0001	0.0001	0.6079	0.0001	0.0196
GD	-0.02552	-0.06783	-0.03594	-0.06808	0.10456	0.29963	-0.27006	-0.39261	0.05761	-0.31499	0.09639	0.22872	-0.41138
	0.6406	0.2142	0.5108	0.2125	0.0552	0.0001	0.0001	0.0001	0.2916	0.0001	0.0772	0.0001	0.0001
DD	0.16303	0.06535	0.02463	0.28366	-0.05199	-0.24046	0.18391	0.68888	-0.05785	0.22767	-0.34052	-0.51509	0.38239
	0.0027	0.2315	0.6524	0.0001	0.3413	0.0001	0.0007	0.0001	0.2897	0.0001	0.0001	0.0001	0.0001
TD	0.13730	0.06436	-0.02930	0.29700	0.04855	-0.39295	0.29902	0.71939	-0.19418	0.25830	-0.24585	-0.48598	0.21888
	0.0116	0.2386	0.5920	0.0001	0.3742	0.0001	0.0001	0.0001	0.0003	0.0001	0.0001	0.0001	0.0001
TPD	0.00785	0.07756	-0.06120	0.13528	0.07505	-0.61092	0.46111	0.54276	-0.29470	0.36364	-0.00224	-0.26017	0.15357
	0.8859	0.1554	0.2625	0.0129	0.1693	0.0001	0.0001	0.0001	0.0001	0.0001	0.9674	0.0001	0.0047
CROPSHR	-0.02803	0.08632	-0.04096	-0.01213	0.00458	0.02164	0.02227	-0.28042	-0.08258	-0.02017	0.23832	0.26444	-0.01839
	0.6081	0.1137	0.4535	0.8244	0.9333	0.6922	0.6837	0.0001	0.1303	0.7122	0.0001	0.0001	0.7365
RANGSHR	-0.08831	0.00622	0.06703	-0.07406	-0.04313	-0.03698	-0.03394	-0.05210	0.00267	-0.08429	0.02395	0.04401	-0.12489
	0.1056	0.9095	0.2197	0.1750	0.4300	0.4987	0.5347	0.3403	0.9610	0.1225	0.6613	0.4206	0.0218
GONESHR	-0.00024	-0.06315	0.01254	0.02407	-0.03717	-0.02730	-0.06085	0.16343	0.04584	-0.01049	-0.15605	-0.17461	0.05696
	0.9964	0.2476	0.8186	0.6597	0.4965	0.6175	0.2653	0.0026	0.4016	0.8479	0.0041	0.0013	0.2972
GTWOSHR	-0.02936	-0.05162	0.01086	-0.07042	0.13809	0.03997	0.01989	0.06625	0.08624	0.03029	-0.06076	-0.03848	0.05955
	0.5912	0.3448	0.8425	0.1972	0.0112	0.4646	0.7161	0.2251	0.1141	0.5795	0.2660	0.4814	0.2757
TREESHR	0.13822	-0.04260	0.03121	0.04907	-0.03488	-0.12742	0.09115	0.27005	0.00045	0.13258	-0.20470	-0.23603	-0.02755
	0.0111	0.4357	0.5681	0.3692	0.5234	0.0193	0.0948	0.0001	0.9935	0.0149	0.0002	0.0001	0.6143
FORESHR	0.13206	-0.04074	-0.03473	0.14514	-0.02467	0.08375	0.00222	0.28706	0.03369	0.05438	-0.20053	-0.27189	0.06353
	0.0153	0.4561	0.5252	0.0076	0.6518	0.1249	0.9676	0.0001	0.5377	0.3196	0.0002	0.0001	0.2448

APPENDIX B (Continued)

	RSDIST	TDIST	ID	FD	PD	GD	DD	TD	TPD	CROPSHR	RANGSHR	GONESHR	GTWOSHR
LDPRAC	-0.14708	-0.08791	-0.11838	0.05189	-0.00492	-0.02552	0.16303	0.13730	0.00785	-0.02803	-0.08831	-0.00024	-0.02936
	0.0068	0.1072	0.0298	0.3423	0.9283	0.6406	0.0027	0.0116	0.8859	0.6081	0.1056	0.9964	0.5912
BLDGAV	-0.05222	-0.05372	0.01742	0.01552	0.08517	-0.06783	0.06535	0.06436	0.07756	0.08632	0.00622	-0.06315	-0.05162
	0.3392	0.3255	0.7500	0.7766	0.1186	0.2142	0.2315	0.2386	0.1554	0.1137	0.9095	0.2476	0.3448
TOTACRES	0.04241	0.01841	0.00542	0.06926	-0.08915	-0.03594	0.02463	-0.02930	-0.06120	-0.04096	0.06703	0.01254	0.01086
	0.4377	0.7364	0.9211	0.2047	0.1023	0.5108	0.6524	0.5920	0.2625	0.4535	0.2197	0.8186	0.8425
PTSPERAC	-0.17145	-0.25617	-0.07970	0.16650	0.11104	-0.06808	0.28366	0.29700	0.13528	-0.01213	-0.07406	0.02407	-0.07042
	0.0016	0.0001	0.1443	0.0022	0.0416	0.2125	0.0001	0.0001	0.0129	0.8244	0.1750	0.6597	0.1972
ADJPTS	-0.01278	-0.04015	-0.03901	0.06671	0.06851	0.10456	-0.05199	0.04855	0.07505	0.00458	-0.04313	-0.03717	0.13809
	0.8152	0.4626	0.4754	0.2219	0.2097	0.0552	0.3413	0.3742	0.1693	0.9333	0.4300	0.4965	0.0112
INC	0.21913	0.23420	-0.29226	-0.50911	-0.56681	0.29963	-0.24046	-0.39295	-0.61092	0.02164	-0.03698	-0.02730	0.03997
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.6922	0.4987	0.6175	0.4646
POPDENS	-0.39791	-0.22604	0.61326	0.09121	0.50668	-0.27006	0.18391	0.29902	0.46111	0.02227	-0.03394	-0.06085	0.01989
	0.0001	0.0001	0.0001	0.0946	0.0001	0.0001	0.0007	0.0001	0.0001	0.6837	0.5347	0.2653	0.7161
RAIN	-0.54208	-0.35982	0.10598	0.52613	0.48371	-0.39261	0.68888	0.71939	0.54276	-0.28042	-0.05210	0.16343	0.06625
	0.0001	0.0001	0.0519	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.3403	0.0026	0.2251
MONTHS	0.10897	0.09080	-0.27804	-0.17168	-0.29332	0.05761	-0.05785	-0.19418	-0.29470	-0.08258	0.00267	0.04584	0.08624
	0.0456	0.0961	0.0001	0.0016	0.0001	0.2916	0.2897	0.0003	0.0001	0.1303	0.9610	0.4016	0.1141
VDENSTHO	-0.35307	-0.25474	0.53616	0.09479	0.39343	-0.31499	0.22767	0.25830	0.36364	-0.02017	-0.08429	-0.01049	0.03029
	0.0001	0.0001	0.0001	0.0823	0.0001	0.0001	0.0001	0.0001	0.0001	0.7122	0.1225	0.8479	0.5795
LDIST	0.11173	0.13732	0.37003	-0.11379	0.02804	0.09639	-0.34052	-0.24585	-0.00224	0.23832	0.02395	-0.15605	-0.06076
	0.0404	0.0116	0.0001	0.0368	0.6079	0.0772	0.0001	0.0001	0.9674	0.0001	0.6613	0.0041	0.2660
MDIST	0.33575	0.29739	0.12995	-0.26254	-0.22908	0.22872	-0.51509	-0.48598	-0.26017	0.26444	0.04401	-0.17461	-0.03848
	0.0001	0.0001	0.0170	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.4206	0.0013	0.4814
SDIST	-0.39927	-0.04136	0.22321	0.18498	0.12714	-0.41138	0.38239	0.21888	0.15357	-0.01839	-0.12489	0.05696	0.05955
	0.0001	0.4492	0.0001	0.0006	0.0196	0.0001	0.0001	0.0001	0.0047	0.7365	0.0218	0.2972	0.2757
RSDIST	1.00000	0.11321	-0.51954	-0.26918	-0.64487	0.42102	-0.47446	-0.56661	-0.62263	0.00373	0.10274	0.01278	-0.09135
	0.0000	0.0378	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.9456	0.0596	0.8152	0.0941
TDIST	0.11321	1.00000	-0.14364	-0.36848	-0.26273	0.24094	-0.32747	-0.34554	-0.31412	0.09481	0.03851	-0.05259	0.01702
	0.0378	0.0000	0.0083	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0822	0.4811	0.3358	0.7556
ID	-0.51954	-0.14364	1.00000	0.37413	0.61241	-0.53375	0.33955	0.40093	0.61897	0.17130	-0.05451	-0.12221	-0.02459
	0.0001	0.0083	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0016	0.3184	0.0249	0.6528

APPENDIX B (Continued)

	RSDIST	TDIST	ID	FD	PD	GD	DD	TD	TPD	CROPSHR	RANGSHR	GONESHR	GTWOSHR
FD	-0.26918	-0.36848	0.37413	1.00000	0.47349	-0.47426	0.74191	0.79312	0.64458	-0.16422	-0.02814	0.11653	-0.02515
	0.0001	0.0001	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0025	0.6067	0.0325	0.6455
PD	-0.64487	-0.26273	0.61241	0.47349	1.00000	-0.30165	0.41198	0.76971	0.97861	0.06123	-0.00384	-0.03408	-0.01487
	0.0001	0.0001	0.0001	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001	0.2623	0.9441	0.5330	0.7857
GD	0.42102	0.24094	-0.53375	-0.47426	-0.30165	1.00000	-0.78798	-0.39562	-0.37261	0.03719	0.12884	-0.07116	-0.01506
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0001	0.0001	0.0001	0.4963	0.0180	0.1926	0.7830
DD	-0.47446	-0.32747	0.33955	0.74191	0.41198	-0.78798	1.00000	0.79353	0.53090	-0.18307	-0.10114	0.14501	0.03344
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0001	0.0001	0.0007	0.0637	0.0077	0.5407
TD	-0.56661	-0.34554	0.40093	0.79312	0.76971	-0.39562	0.79353	1.00000	0.85338	-0.13425	-0.02970	0.08756	0.01167
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0001	0.0136	0.5869	0.1086	0.8309
TPD	-0.62263	-0.31412	0.61897	0.64458	0.97861	-0.37261	0.53090	0.85338	1.00000	0.01479	-0.00990	-0.00236	-0.01878
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.7868	0.8563	0.9656	0.7312
CROPSHR	0.00373	0.09481	0.17130	-0.16422	0.06123	0.03719	-0.18307	-0.13425	0.01479	1.00000	-0.37851	-0.64077	-0.40514
	0.9456	0.0822	0.0016	0.0025	0.2623	0.4963	0.0007	0.0136	0.7868	0.0000	0.0001	0.0001	0.0001
RANGSHR	0.10274	0.03851	-0.05451	-0.02814	-0.00384	0.12884	-0.10114	-0.02970	-0.00990	-0.37851	1.00000	-0.02092	-0.03878
	0.0596	0.4811	0.3184	0.6067	0.9441	0.0180	0.0637	0.5869	0.8563	0.0001	0.0000	0.7019	0.4780
GONESHR	0.01278	-0.05259	-0.12221	0.11653	-0.03408	-0.07116	0.14501	0.08756	-0.00236	-0.64077	-0.02092	1.00000	-0.04830
	0.8152	0.3358	0.0249	0.0325	0.5330	0.1926	0.0077	0.1086	0.9656	0.0001	0.7019	0.0000	0.3768
GTWOSHR	-0.09135	0.01702	-0.02459	-0.02515	-0.01487	-0.01506	0.03344	0.01167	-0.01878	-0.40514	-0.03878	-0.04830	1.00000
	0.0941	0.7556	0.6528	0.6455	0.7857	0.7830	0.5407	0.8309	0.7312	0.0001	0.4780	0.3768	0.0000
TREESHR	-0.05223	-0.03703	-0.08049	0.12565	-0.01222	-0.09062	0.14576	0.09063	0.01874	-0.40751	-0.11513	0.12031	0.08813
	0.3391	0.4981	0.1403	0.0210	0.8231	0.0968	0.0074	0.0967	0.7317	0.0001	0.0346	0.0272	0.1063
FORESHR	-0.02631	-0.21620	-0.10301	0.22505	-0.07602	-0.05846	0.23750	0.17906	-0.01341	-0.36019	-0.08920	-0.01117	0.00055
	0.6304	0.0001	0.0589	0.0001	0.1638	0.2846	0.0001	0.0010	0.8062	0.0001	0.1021	0.8381	0.9919

	TREESHR	FORESHR
LDPRAC	0.13822	0.13206
	0.0111	0.0153
BLDGAV	-0.04260	-0.04074
	0.4357	0.4561
TOTACRES	0.03121	-0.03473
	0.5681	0.5252
PTSPERAC	0.04907	0.14514
	0.3692	0.0076

APPENDIX B (Continued)

	TREESHR	FORESHR
ADJPTS	-0.03488	-0.02467
	0.5234	0.6518
INC	-0.12742	0.08375
	0.0193	0.1249
POPDENS	0.09115	0.00222
	0.0948	0.9676
RAIN	0.27005	0.28706
	0.0001	0.0001
MONTHS	0.00045	0.03369
	0.9935	0.5377
VDENSTHD	0.13258	0.05438
	0.0149	0.3196
LDIST	-0.20470	-0.20053
	0.0002	0.0002
MDIST	-0.23603	-0.27189
	0.0001	0.0001
SDIST	-0.02755	0.06353
	0.6143	0.2448
RSDIST	-0.05223	-0.02631
	0.3391	0.6304
TDIST	-0.03703	-0.21620
	0.4981	0.0001
ID	-0.08049	-0.10301
	0.1403	0.0589
FD	0.12565	0.22505
	0.0210	0.0001
PD	-0.01222	-0.07602
	0.8231	0.1638
GD	-0.09062	-0.05846
	0.0968	0.2846
DD	0.14576	0.23[illegible]50
	0.0074	0.0001

APPENDIX B (Continued)

	TREESHR	FORESHR
TD	0.09063 0.0967	0.17906 0.0010
TPD	0.01874 0.7317	-0.01341 0.8062
CROPSHR	-0.40751 0.0001	-0.36019 0.0001
RANGSHR	-0.11513 0.0346	-0.08920 0.1021
GONESHR	0.12031 0.0272	-0.01117 0.8381
GTWOSHR	0.08813 0.1063	0.00055 0.9919
TREESHR	1.00000 0.0000	0.22827 0.0001
FORESHR	0.22827 0.0001	1.00000 0.0000

APPENDIX C

CORRELATION MATRIX OF THE SUPPLEMENTARY DATA VARIABLES

CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / NUMBER OF OBSERVATIONS

	ACREPR	TOTACRES	IMPRVAL	CROPSHR	PASTSHR	IRRISHR	MONTHS	RAIN	POPDENS	VDENSTHO	SFD	PAVD	GRD
ACREPR	1.00000	-0.21102	0.10224	0.33678	-0.32893	0.07784	0.40475	0.08329	0.10183	0.13428	-0.11779	-0.06404	-0.05275
	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	6205	6205	6205	6205	6205	6205	6205	6205	6205	6205	6055	6055	6055
TOTACRES	-0.21102	1.00000	-0.01861	-0.03758	0.03738	-0.00740	-0.02253	-0.19847	-0.08958	-0.07930	-0.03434	-0.03542	-0.06504
	0.0001	0.0000	0.1427	0.0031	0.0032	0.5602	0.0759	0.0001	0.0001	0.0001	0.0075	0.0058	0.0001
	6205	6205	6205	6205	6205	6205	6205	6205	6205	6205	6055	6055	6055
IMPRVAL	0.10224	-0.01861	1.00000	-0.11210	0.10414	0.00077	0.10518	0.15373	0.11266	0.09148	0.02877	0.05030	-0.00228
	0.0001	0.1427	0.0000	0.0001	0.0001	0.9519	0.0001	0.0001	0.0001	0.0001	0.0252	0.0001	0.8592
	6205	6205	6205	6205	6205	6205	6205	6205	6205	6205	6055	6055	6055
CROPSHR	0.33678	-0.03758	-0.11210	1.00000	-0.96369	0.15356	-0.03260	-0.34894	-0.16908	-0.12901	-0.12239	-0.00120	-0.04744
	0.0001	0.0031	0.0001	0.0000	0.0001	0.0001	0.0102	0.0001	0.0001	0.0001	0.0001	0.9259	0.0002
	6205	6205	6205	6205	6205	6205	6205	6205	6205	6205	6055	6055	6055
PASTSHR	-0.32893	0.03738	0.10414	-0.96369	1.00000	-0.14952	0.05118	0.34467	0.16006	0.12324	0.12620	-0.00344	0.06007
	0.0001	0.0032	0.0001	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.7889	0.0001
	6205	6205	6205	6205	6205	6205	6205	6205	6205	6205	6055	6055	6055
IRRISHR	0.07784	-0.00740	0.00077	0.15356	-0.14952	1.00000	-0.02038	-0.11665	-0.02267	-0.03490	-0.02072	0.10907	-0.00956
	0.0001	0.5602	0.9519	0.0001	0.0001	0.0000	0.1085	0.0001	0.0741	0.0060	0.1070	0.0001	0.4570
	6205	6205	6205	6205	6205	6205	6205	6205	6205	6205	6055	6055	6055
MONTHS	0.40475	-0.02253	0.10518	-0.03260	0.05118	-0.02038	1.00000	0.00875	-0.02102	-0.02057	0.01355	0.00016	0.01971
	0.0001	0.0759	0.0001	0.0102	0.0001	0.1085	0.0000	0.4909	0.0978	0.1053	0.2917	0.9899	0.1251
	6205	6205	6205	6205	6205	6205	6205	6205	6205	6205	6055	6055	6055
RAIN	0.08329	-0.19847	0.15373	-0.34894	0.34467	-0.11665	0.00875	1.00000	0.23488	0.20170	0.39766	-0.06032	0.44267
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.4909	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001
	6205	6205	6205	6205	6205	6205	6205	6205	6205	6205	6055	6055	6055
POPDENS	0.10183	-0.08958	0.11266	-0.16908	0.16006	-0.02267	-0.02102	0.23488	1.00000	0.97964	-0.32978	0.17397	-0.17472
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0741	0.0978	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001
	6205	6205	6205	6205	6205	6205	6205	6205	6205	6205	6055	6055	6055
VDENSTHO	0.13428	-0.07930	0.09148	-0.12901	0.12324	-0.03490	-0.02057	0.20170	0.97964	1.00000	-0.34869	0.11580	-0.17088
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0060	0.1053	0.0001	0.0001	0.0000	0.0001	0.0001	0.0001
	6205	6205	6205	6205	6205	6205	6205	6205	6205	6205	6055	6055	6055
SFD	-0.11779	-0.03434	0.02877	-0.12239	0.12620	-0.02072	0.01355	0.39766	-0.32978	-0.34869	1.00000	-0.16417	0.31048
	0.0001	0.0075	0.0252	0.0001	0.0001	0.1070	0.2917	0.0001	0.0001	0.0001	0.0000	0.0001	0.0001
	6055	6055	6055	6055	6055	6055	6055	6055	6055	6055	6055	6055	6055

	ACREPR	TOTACRES	IMPRVAL	CROPSHR	PASTSHR	IRRISHR	MONTHS	RAIN	POPDENS	VDENSTHO	SFD	PAVD	GRD
PAVD	-0.06404	-0.03542	0.05030	-0.00120	-0.00344	0.10907	0.00016	-0.06032	0.17397	0.11580	-0.16417	1.00000	-0.30349
	0.0001	0.0058	0.0001	0.9259	0.7889	0.0001	0.9899	0.0001	0.0001	0.0001	0.0001	0.0000	0.0001
	6055	6055	6055	6055	6055	6055	6055	6055	6055	6055	6055	6055	6055
GRD	-0.05275	-0.06504	-0.00228	-0.04744	0.06007	-0.00956	0.01971	0.44267	-0.17472	-0.17088	0.31048	-0.30349	1.00000
	0.0001	0.0001	0.8592	0.0002	0.0001	0.4570	0.1251	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000
	6055	6055	6055	6055	6055	6055	6055	6055	6055	6055	6055	6055	6055
DTD	0.22771	0.03519	-0.13432	0.27837	-0.28143	-0.02082	-0.00297	-0.35560	-0.31922	-0.24502	-0.07176	-0.30701	-0.36442
	0.0001	0.0062	0.0001	0.0001	0.0001	0.1052	0.8174	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	6055	6055	6055	6055	6055	6055	6055	6055	6055	6055	6055	6055	6055
TOTROADD	0.10460	-0.06732	-0.09099	0.18085	-0.17242	0.02593	0.02165	0.18855	-0.44043	-0.40099	0.35158	-0.07154	0.60278
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0436	0.0922	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	6055	6055	6055	6055	6055	6055	6055	6055	6055	6055	6055	6055	6055
PROADD	-0.09900	-0.05565	0.06901	-0.06028	0.05676	0.09731	0.00624	0.10253	0.08613	0.02442	0.15839	0.94488	-0.18966
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.6272	0.0001	0.0001	0.0574	0.0001	0.0001	0.0001
	6055	6055	6055	6055	6055	6055	6055	6055	6055	6055	6055	6055	6055
INC	0.16116	-0.01741	-0.00223	-0.07467	0.07309	-0.12138	-0.03031	0.04022	0.17799	0.23020	-0.39963	-0.09082	-0.20509
	0.0001	0.1703	0.8608	0.0001	0.0001	0.0001	0.0170	0.0015	0.0001	0.0001	0.0001	0.0001	0.0001
	6205	6205	6205	6205	6205	6205	6205	6205	6205	6205	6055	6055	6055
MSQ	0.41135	-0.01203	0.10384	-0.02620	0.03801	-0.02212	0.96769	0.00245	-0.02710	-0.02597	0.01558	-0.00740	0.01066
	0.0001	0.3436	0.0001	0.0390	0.0027	0.0815	0.0001	0.8471	0.0328	0.0408	0.2254	0.5647	0.4071
	6205	6205	6205	6205	6205	6205	6205	6205	6205	6205	6055	6055	6055
TSQ	-0.18729	0.94575	0.01177	-0.08694	0.08433	-0.00478	-0.01071	-0.15098	-0.05918	-0.05703	-0.02759	-0.01808	-0.06198
	0.0001	0.0001	0.3539	0.0001	0.0001	0.7066	0.3991	0.0001	0.0001	0.0001	0.0318	0.1594	0.0001
	6205	6205	6205	6205	6205	6205	6205	6205	6205	6205	6055	6055	6055

	DTD	TOTROADD	PROADD	INC	MSQ	TSQ
ACREPR	0.22771	0.10460	-0.09900	0.16116	0.41135	-0.18729
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	6055	6055	6055	6205	6205	6205
TOTACRES	0.03519	-0.06732	-0.05565	-0.01741	-0.01203	0.94575
	0.0062	0.0001	0.0001	0.1703	0.3436	0.0001
	6055	6055	6055	6205	6205	6205
IMPRVAL	-0.13432	-0.09099	0.06901	-0.00223	0.10384	0.01177
	0.0001	0.0001	0.0001	0.8608	0.0001	0.3539
	6055	6055	6055	6205	6205	6205
CROPSHR	0.27837	0.18085	-0.06028	-0.07467	-0.02620	-0.08694
	0.0001	0.0001	0.0001	0.0001	0.0390	0.0001
	6055	6055	6055	6205	6205	6205

APPENDIX C (Continued)

	DTD	TOTROADD	PROADD	INC	MSQ	TSQ
PASTSHR	-0.28143	-0.17242	0.05676	0.07309	0.03801	0.08433
	0.0001	0.0001	0.0001	0.0001	0.0027	0.0001
	6055	6055	6055	6205	6205	6205
IRRISHR	-0.02082	0.02593	0.09731	-0.12139	-0.02212	-0.00478
	0.1052	0.0436	0.0001	0.0001	0.0815	0.7066
	6055	6055	6055	6205	6205	6205
MONTHS	-0.00297	0.02165	0.00624	-0.03091	0.96769	-0.01071
	0.8174	0.0922	0.6272	0.0170	0.0001	0.3991
	6055	6055	6055	6205	6205	6205
RAIN	-0.35560	0.18855	0.10253	0.04022	0.00245	-0.15098
	0.0001	0.0001	0.0001	0.0015	0.8471	0.0001
	6055	6055	6055	6205	6205	6205
POPDENS	-0.31922	-0.44043	0.08613	0.17799	-0.02710	-0.05918
	0.0001	0.0001	0.0001	0.0001	0.0328	0.0001
	6055	6055	6055	6205	6205	6205
VDENSTHO	-0.24502	-0.40099	0.02442	0.23020	-0.02597	-0.05703
	0.0001	0.0001	0.0574	0.0001	0.0408	0.0001
	6055	6055	6055	6205	6205	6205
SFD	-0.07176	0.35158	0.15839	-0.39963	0.01558	-0.02759
	0.0001	0.0001	0.0001	0.0001	0.2254	0.0318
	6055	6055	6055	6055	6055	6055
PAVD	-0.30701	-0.07154	0.94488	-0.09082	-0.00740	-0.01808
	0.0001	0.0001	0.0001	0.0001	0.5647	0.1594
	6055	6055	6055	6055	6055	6055
GRD	-0.36442	0.60278	-0.18966	-0.20509	0.01066	-0.06198
	0.0001	0.0001	0.0001	0.0001	0.4071	0.0001
	6055	6055	6055	6055	6055	6055
DTD	1.00000	0.36087	-0.36131	0.17709	0.01296	-0.00714
	0.0000	0.0001	0.0001	0.0001	0.3134	0.5783
	6055	6055	6055	6055	6055	6055
TOTROADD	0.36087	1.00000	0.02895	-0.16731	0.02285	-0.09155
	0.0001	0.0000	0.0243	0.0001	0.0755	0.0001
	6055	6055	6055	6055	6055	6055

APPENDIX C (Continued)

	DTD	TOTROADD	PROADD	INC	MSQ	TSQ
PROADD	-0.36131 0.0001 6055	0.02895 0.0243 6055	1.00000 0.0000 6055	-0.20709 0.0001 6055	-0.00142 0.9118 6055	-0.03313 0.0099 6055
INC	0.17709 0.0001 6055	-0.16731 0.0001 6055	-0.20709 0.0001 6055	1.00000 0.0000 6205	-0.02632 0.0381 6205	-0.00110 0.9311 6205
MSQ	0.01296 0.3134 6055	0.02285 0.0755 6055	-0.00142 0.9118 6055	-0.02632 0.0381 6205	1.00000 0.0000 6205	-0.00302 0.8123 6205
TSQ	-0.00714 0.5783 6055	-0.09155 0.0001 6055	-0.03313 0.0099 6055	-0.00110 0.9311 6205	-0.00302 0.8123 6205	1.00000 0.0000 6205

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VITA

Gerald William Warmann

Candidate for the Degree of

Doctor of Philosophy

Thesis: AN ECONOMIC ANALYSIS OF FARMLAND MARKETS IN WESTERN OKLAHOMA

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