AN ECONOMETRIC MODEL OF THE LAND MARKET STRESSING EFFECTS OF GOVERNMENT PROGRAMS ON LAND VALUES

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ON LAND VALUES

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CHAPTER I

STATEMENT OF THE PROBLEM

Historical Development of the Current Situation

Land has been an important instrument of U. S. agricultural policies for many decades. In early periods, public control and distribution of land resources were used to stimulate settlement of the frontier and to create a farming structure consistent with the Jeffersonian Ideal. Land grants to railroads encouraged building of a transportation network vital to a commercialized agriculture on the frontier. The Homestead Act and other legislation set the pattern for a farm structure that has persisted to the present.

Control of the land resource has been used in recent years as a public instrument to raise farm prices and incomes. Resulting output reductions, coupled with an inelastic demand for farm commodities, effectively raised farm income. Economic theory and observed behavior suggest that the monetary benefits of federal programs controlling land would be capitalized into land values over time. This tendency has been cited as one hypothesis explaining the rise of land values in recent periods of falling, stable or slowly rising farm commodity prices and net income.

The relative growth of farm real estate prices in the United States compared to prices of other farm inputs and prices received by farmers since 1950 is illustrated in Figure 1. From 1950 to 1963, farm real estate prices increased 91 percent while farm wage rates went up 59 percent, farm machinery prices rose 46 percent, fertilizer prices increased only six percent, and prices received by farmers decreased 7.5 percent.

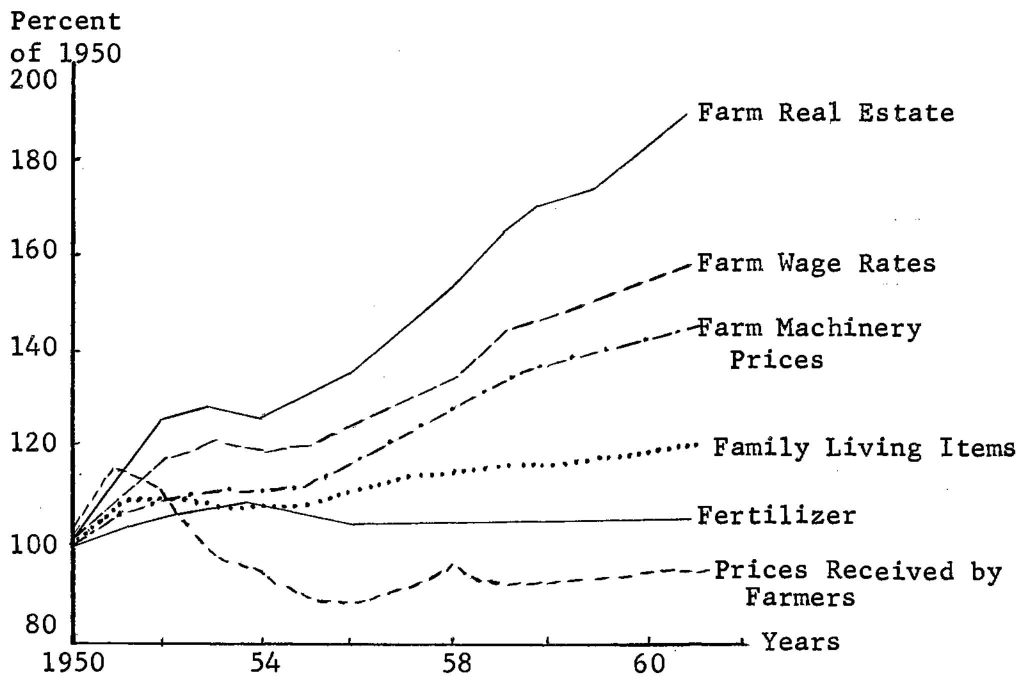

Figure 1. U. S. Farm Price Trends, 1950-1963 (1950 = 100).[a]

[a]U. S. Department of Agriculture, "Handbook of Agricultural Charts," Agricultural Handbook No. 258 (Washington, 1963), pp. 9-16.

Since World War II, the average residual farm income to land has fallen from $6,389 million in 1945-49 to $4,528 million in 1955-59;[1] meanwhile, the value of land and service buildings rose from $56.5 billion in 1945-49 to $97.5 billion and the rate of return on farm

[1]U. S. Department of Agriculture, Farm Real Estate Market Developments, ERS (Washington, 1963), p. 21.

real estate investment dropped from 11.3 percent to 4.6 percent. In the 1960-62 period, the residual return to real estate was up slightly from the late 1950's and the rate of return averaged 5.1 percent.

Some Effects of Farm Real Estate Values

The effects of rising real estate values are brought more sharply into focus when reduced to the individual farm level. The average total net income per farm for the three year period, 1949-51, was $2,580. The comparable figure for 1959-61 was $3,077,[2] indicating a marked improvement. This figure is not adjusted for the opportunity cost of owned capital, however. It represents the residual income to farm owners and operators when production expenses have been deducted from gross farm sales.

Allowing five percent on real estate investment of $12,000 (the average farm value in 1950)[3], the return to labor, management, and non-real-estate capital would have been $1,980. Through farm consolidation and land value appreciation, the average value of real estate had risen to approximately $40,000 per farm by 1963.[4] Deduction of five percent on capital investment in real estate leaves less than $1,200 for labor, management and nonreal-estate capital based on the 1959-61 income figure, and only about $1,400 based on the 1963 average farm income. These

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[2] U. S. Department of Agriculture, The Farm Income Situation, ERS (Washington, 1963), p. 42.

[3] U. S. Department of Agriculture, Agriculture Handbook No. 258, p. 37.

[4] Ibid.

latter residuals to nonland factors are considerably below the residual of a decade earlier, even though net income uncorrected for real estate investment was higher in the recent years.

Addressing himself to this problem surrounding land prices and farm income, Benedict states:

> ...a major weakness in the farmer's argument is the continuing upward movement of land prices. Granted that there are many reasons for this, the fact remains that farmers are bidding more and more for the future returns from lands that are used for crop production. This raises serious question as to the adequacy of existing measures of the real content of agricultural income, a subject that is too complex for discussion here.[5]

Schultz's statement on the same problem at the same time is stronger:

> No one will contend that owners of farm land are in distress. On the contrary, farm real estate prices have been booming. This boom could burst but it continues presently. Last year alone, for example, it added virtually 7 billion dollars to the value of U. S. farm real estate, a tidy amount of capital appreciation for those who own this land. Two-fifths of it is owned by non-farm individuals and families. By some strange twist, that is inexplicable, many an agricultural economist and political "leader" recommends public action that would favor the owners of farm land above all else. Virtually none would appear to favor measures that would directly enhance the earnings of farm people that comes to them for the work they do in farming.
>
> ...Unwillingly, then, intellectual and moral support is given to this goal by a failure to examine the net income effects of the present farm programs which for a long time have been and continue to be substantially regressive.[6]

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[5] Murray R. Benedict, "The Supply, Price, and Income Dilemma," Journal of Farm Economics (May, 1959), p. 176.

[6] Theodore W. Schultz, "Agricultural Policy for What?" Journal of Farm Economics (May, 1959), p. 191.

Chryst and Timmons have described a "circle" involving farm programs and land values:

> ...since the programs themselves are usually tied to land, program benefits are in turn capitalized into land values, which may lead to a circle of more program benefits, higher land values and an increasing need for further layers of program benefits.
>
> This situation places agricultural programs in the position of supporting a system of land values which the programs helped to create.[7]

The following conclusion from Shepherd is based on three ingredients that are recognized as contributors to the problem of capitalization. Until (1) the excess of farm population problem is solved, most of the benefits of (2) technology and (3) production control programs will continue to be capitalized into land values and show up in the form of higher prices for farms rather than in higher incomes per farmer.[8]

When the income benefits of farm programs controlling the land input are capitalized into land values, a regressive income distribution takes place within agriculture. Owners of land at the time programs are initiated receive direct additions to their disposable net income from higher commodity prices or direct payments from the government.[9] Sale of the land brings further income gains as the

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[7] Walt E. Chryst and John F. Timmons, "The Economic Role of Land Resource Institutions in Agricultural Adjustment," Dynamics of Land Use: Needed Adjustment, The Iowa State University Center for Agricultural and Economic Adjustment, Iowa State University Press (Ames, 1961), p. 253.

[8] Geoffrey Shepherd, Appraisal of the Federal Feed-Grains Programs, Iowa State University of Science and Technology Research Bulletin 501 (Ames, 1962), p. 374.

[9] For our purposes, disposable income is defined as the income remaining to pay operating and living expenses after paying fixed mortgage obligations and taxes.

discounted value of future earnings from allotments are capitalized into the selling price. But the new owner must pay interest and principal on the appreciated selling price, and his disposable income is reduced accordingly. The distribution is regressive when the seller who receives the capital gain has a more favorable income and asset position than the buyer.

The redistribution of income due to capital gains does not occur until land is exchanged; hence, in the early stages of a farm program, the income benefits accrue largely as disposable income. But as more farms change hands, and more farmers must pay the interest and principal on inflated land value, a given program becomes less efficient in raising disposable farm income.

Once a contractual obligation for the purchase or rental of land has been consummated, the operator has given first legal claim on his future income to the contract. Family consumption must be second claimant on future income from the farm business; second to the mortgage which must be paid if the family business is to survive.[10]

The tenant is also quite well insulated over short periods of time from the effects of changes in land values by the institutionalized leasing arrangements found in American agriculture. Both cash and share

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[10]The solemnity of the contractual obligation involving land has long been recognized in law. Many states require special treatment of land sales in the form of written contracts under seal. While other contracts with minors and incompetents are voidable, contracts for the sale and purchase of land with such persons are, by statute of frauds, void. See Len Young Smith and G. Gale Roberson, Business Law, Vol. I (St. Paul, 1958), p. 191. But in the main, society has had no other interest than as referee and to provide an atmosphere in which orderly transactions could take place.

rental rates are "sticky" from year-to-year. Many owners are reluctant to make material changes in rates until a change in tenants permits revision without controversy.

So long as land values continue to appreciate, the current buyer can sell later to realize capital gains. But if the land values do not continue an inflationary trend, the result can be serious economic and social problems.

A major goal of farm commodity programs is to maintain or increase farm income. The effectiveness of particular programs to raise farm disposable income depends on the capitalization of benefits into the value of fixed assets such as land.

If benefits are quickly and completely capitalized and ownership turnover is rapid, intended benefits of farm programs go to initial owners and are lost to future owners. Research findings pointing to this tendency might suggest revision of current farm policies. One purpose of this study is to examine the factors influencing land values and to estimate the role of national farm programs in recent land price trends.

The annual contribution of commodity programs to farm income, estimated at approximately three billion dollars annually, capitalized at five percent in perpetuity would add $60 billion to farm real estate values.[11] The total value of real estate increased $62 billion between 1950 and 1962, approximately the capitalized value of commodity

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[11]Under specified assumptions, net farm income would fall over 40 percent or nearly $5 billion in the absence of commodity programs. However, because certain adjustments would occur, farm income might optimistically rise to a level 25 percent or $3 billion less than current levels. See Luther G. Tweeten, et al., Farm Program Alternatives, Oklahoma State Journal No. 911 and CAED Report No. 18 (Ames, 1963).

program benefits. The extent to which this increased real estate value was due to national farm programs and to other factors involved are questions of major concern to this investigation.

If farm benefits of commodity programs are soon lost through land value appreciation, then inflated land values are indirectly maintained through higher consumer food bills or taxes---funds that consumers and taxpayers might prefer to use elsewhere.[12]

Other features of the income capitalization process are important from the standpoint of economic efficiency. Land value appreciation provides an equity base for purchase of technologically improved inputs or additional land needed to achieve scale economies. Sale of land at inflated prices may provide incentive for retirement, allowing a buyer to consolidate units, and realize scale economies.

High land values have been an economic barrier to entry into farming. The average farm in 1940 required a $4,394 investment in real estate;[13] in 1963 a $40,216 investment.[14] Many young farmers have been "encouraged" to learn new skills and obtain nonfarm jobs because of high "entrance" requirements in farming---a decision they may not have regretted and would have eventually made even at lower land prices but only after an unsuccessful tenure on an inadequate farming unit.

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[12]National farm programs remove some of the instability in farm prices and incomes, hence, may be of value to farmers even after initial program benefits have been lost in the long-run through real estate payments to former owners at inflated prices.

[13]U. S. Department of Agriculture, Balance Sheet of Agriculture, ARS, Agricultural Information Bulletin No. 232 (Washington, 1960), p. 19.

[14]U. S. Department of Agriculture, Agriculture Handbook No. 258, p. 37.

Objectives

The specific objectives of this study are:

1. To develop an economic model of the land market, including as hypotheses the structural variables and relationships in the system.
2. To estimate statistically the parameters of the land market model.
3. To "determine" the short and long-run influences of agricultural policies on land prices and other land market variables; and
4. To explore the ramifications of agricultural policies on farm family income through capitalization of benefits into land values.

In addition to capitalization of commodity program benefits, other hypotheses which have been advanced as possible sources of recent advances in land values are defined in Chapter II. Certain classical and more recent models of land price determination are presented in Chapter III as background for formulation of an empirical model of land price determination. An economic model of the land market provides the basic framework for statistical estimates of parameters determining land prices and other related variables with aggregate U. S. data in Chapter IV. Similar models are applied regionally in Chapter V to measure regional differences in parameters. The empirical land market model, estimated recursively, provides the basis for estimating the "sources" of current real estate prices in Chapter VI. The estimates in Chapters IV, V, and VI give one measure of the rate and extent to which farm commodity program benefits and other factors are capitalized into current land values.

CHAPTER II

HYPOTHESES EXPLAINING RECENT LAND PRICE TRENDS

Several hypotheses, in addition to capitalization of farm commodity program benefits, attempt to explain the recent divergent trends of farm incomes and farm land prices. Here we review certain of these hypotheses.

Farm Consolidation

Farm consolidation has taken place rapidly during the recent period of real estate price increases, suggesting a relationship between the two phenomena. This theory is sometimes referred to as a "marginal costing" approach by farmers. The farmer investing in labor-saving equipment usually buys a larger or more efficient machine than owned previously and eventually finds that he owns excess machine capacity for the land he operates and the labor supply provided by the family. Already owning the machinery and controlling the labor, he budgets the buying price he can afford to pay for additional land at a higher rate than the "whole-farm" buyer who does not have an existing unit to absorb the fixed costs of equipment and labor.

A Montana study concludes: "One of the reasons why land values increase is because of economies of scale. As more land is farmed, average costs per acre decline. This has the effect of increasing net income per acre, and when net income is capitalized, a higher value per acre results."[1]

The proportion of all farm purchases made for farm enlargement varies among regions, but has consistently increased in all regions of the U. S. in recent years. This proportion has nearly doubled over the past ten years from 26 percent in 1950-60 to 46 percent in 1960 for the 48 contiguous states. In the wheat areas the increase was from 48 to 71 percent in the same period of time.[2]

Excess Labor in Agriculture

Excess labor in agriculture provides a second hypothesis to explain rising land values. This theory comes from land scarcity relative to the number of people who want to farm. Accumulation of excess labor and consequent competition for available farming units forces those who remain to pay more and more for control of land and therefore to accept lower residual returns to their labor and management. Excess labor constitutes perhaps 50 percent of the farm work force.[3] If all recent farm transfers were made to farm males born on farms and reaching age 20, these youths would not find sufficient farming opportunities (Table I). Transfers for consolidation do not represent opportunities for new starts in farming. Table I also shows that the

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[1]John D. Lawrence, "The Effect of Increasing Farm Size on Land Values" (unpub. M.S. Thesis, Montana State College, 1958), p. 63.

[2]U. S. Department of Agriculture, Farm Real Estate Market Developments (April, 1963), p. 9.

[3]Luther G. Tweeten, "Should We Put on the Brakes?" Better Farming Methods (November, 1963), p. 10.

ratio of potential farm operators to transfers has risen in recent years, accelerating competition for available units. Farming opportunities have been so limited in relation to the potential number of workers that farm labor outmigration averaged about three percent per year in the past decade.[4]

TABLE I

FARM TRANSFERS AND POTENTIAL DEMAND FOR FARMS, 1955-63

Year	All Farm Transfers (Thousands)	Potential Demand for Farms[a] (Thousands)
1955	201.0	354
1956	205.6	352
1957	188.9	352
1958	180.9	355
1959	172.5	355
1960	163.5	331
1961	148.9	338
1962	148.5	350
1963	140.5	322

[a]Estimated demand for farms based on all farm males born on farms "demanding" a farm at 20 years of age.

Source: U. S. Department of Agriculture, Farm Real Estate Market Developments, (August, 1963), p. 17; and Farm Population, ERS-130 (October, 1963), p. 23.

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[4]U. S. Department of Agriculture, Farm Employment, Statistical Reporting Service, Statistical Bulletin No. 334 (Washington, 1963), p. 7.

Population Pressure

A growing population expands demand for land indirectly through increased food requirements and directly through conversion of farmland to suburban housing, airports, roads, etc. Population growth at the rate of 1.7 percent annually can be expected to increase food requirements at a similar rate. Other things equal, greater food requirements would be expected to increase farm income and farm real estate values.

The absolute quantity of land directly required as space for an expanding population is impressive indeed. A comprehensive study of land resources and anticipated needs has predicted that 15.8 million acres will be shifted to urban and built-up uses between 1958 and 1975.[5] This is equal to more than the combined area of Rhode Island, Delaware, Hawaii, Maryland, and New Jersey.

A comparison of changes in population and changes in farm real estate prices suggests to some that total population of an area greatly influences land prices. Figure 2 compares percentage change in population in the states with percentage change in land price.[6] It indicates that where population is expanding rapidly, real estate prices have shown a marked advance. This cause-effect relationship does not hold completely, however. Nevada exhibits a large increase

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[5] U. S. Department of Agriculture, Basic Statistics of the National Inventory of Soil and Water Conservation Needs, Conservation Needs Inventory Committee, Statistical Bulletin 317 (Washington, 1962), p. 25.

[6] Population changes are from 1950 to 1960 from The Statistical Abstract of the U. S. (1962), p. 11. Farm land price changes are from 1950 to 1963 computed from Farm Real Estate Market Developments (August, 1963), p. 38.

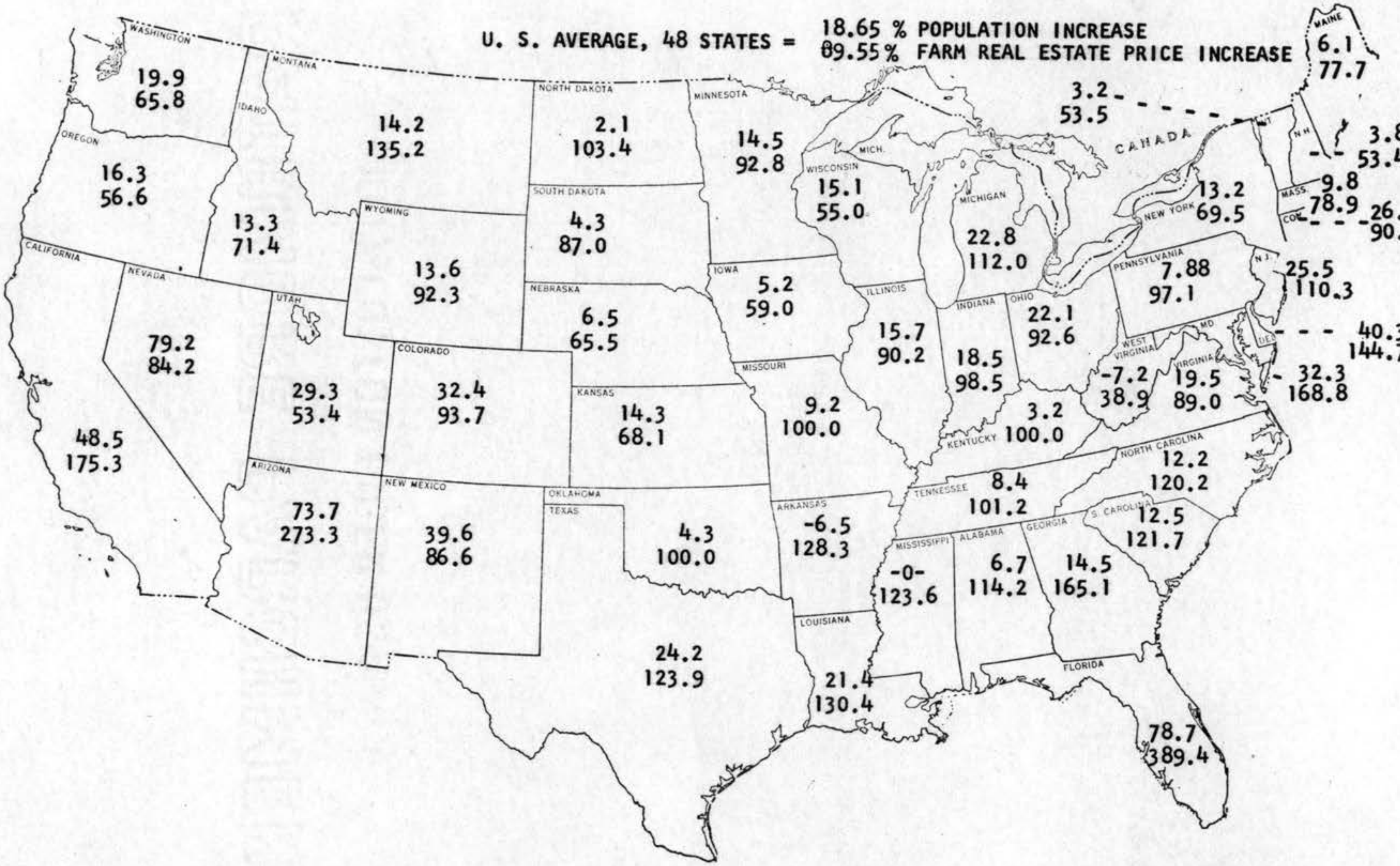

Figure 2. Percentage Change in Total Population 1950-1960 and in Farm Real Estate Prices 1950-1963, U.S.

in population with a modest increase in land price, while Arkansas experienced a large land price increase with a 6.5 percent net loss in population. There can be little doubt that mushrooming population in a limited area must have a pronounced effect on real estate prices, however. It is also quite evident that other important factors are at work in areas experiencing population adjustments.

Direct and indirect population pressures for more farmland and higher land prices are offset by substitution of fertilizer, irrigation and other capital inputs for land. Assuming each ton of the 8.4 million tons of fertilizer nutrients applied in 1962 added production equivalent to that on 15 unimproved cropland acres, then fertilizer broadly "added" 126 million cropland acres.[7]

The tendency for capital inputs to substitute for land is one factor responsible for a projection that by 1975 cropland will be reduced by about 2.5 percent, pasture-range will increase by about 2.5 percent, forest-woodland will decrease 2.25 percent and urban built-up area will increase by 31.2 percent.[8] Total agricultural and forestry use is predicted to change less than one percent.

Nonfarm Investors

One family of theories cites the nonfarm investor as a prime factor in the rising farm real estate price structure. Nonfarmers become owners of farm real estate through inheritance, gift, purchase,

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[7] The U. S. Department of Agriculture estimated that each ton of fertilizer substituted for about 19 acres of cropland in the 1951-55 period. Currently about 330 million acres is classified as cropland used for crops. See Raymond Christensen and Ronald Aines, The Economic Effects of Acreage Control Programs in the 1950's, U. S. Department of Agriculture, Agricultural Economic Report No. 18 (October, 1962), p. 23.

[8] U. S. Department of Agriculture, Conservation Needs Inventory Committee, Basic Statistics of the National Inventory of Soil and Water Conservation Needs.

or mortgage default. When farm migration is high, and especially when it accelerates, a substantial amount of farm property is passed to the migrated generation from their farmer fathers. Some lag would be required for returning this property to owner-operators, even if the inheritors were anxious to reinvest in nonfarm property. Thus, during periods of farm depopulation, nonfarm ownership rises under contemporary institutions and customs.

Real estate dealer reports on the farmland market have indicated reduced activity in farm real estate by nonfarm investors. Between 1957 and 1962, acquisitions by nonfarmers dropped from 35.9 to 32.2 percent of the farms transferred, and their participation in sales increased from 15.1 to 25.4 percent of all sales made, as estimated by the U. S. Department of Agriculture.[9] The Census of Agriculture reports an increase in owner-operated acreage from the depression low of 49.0 percent to 59.7 percent in 1954 and only a slight decline to 59.5 percent in 1959.[10]

Two reasons for reduced participation of nonfarm investors in the farm real estate market are: (a) rates of returns on farmland have not been lucrative in relation to returns in other investments, and (b) uncertainty about farm programs and the duration of inflationary

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[9] U. S. Department of Agriculture, Farm Real Estate Market Developments (December, 1962), p. 12.

[10] U. S. Bureau of the Census, Census of Agriculture: 1959, Vol. II, Part X, p. 1042.

trends in land value. In recent years, returns on real estate ranged from 4.5 percent of current value in 1956 to 3.6 percent in 1962.[11]

Credit Arrangements

Credit arrangements have also been suggested as an important influence on general price trends for farm real estate. Seller-financing through land contracts is one of the financing devices noted. The general trend of the last decade has been toward expanded use of outside finance by land purchasers, and the down payment has become progressively smaller during this same period. The attendant lower down payment requirements have increased the potential number of buyers. This tendency might be expected to increase land demand and raise prices. Land prices have continued upward in the past five years, however, while the percentage of seller-financed transfers has declined slightly.[12]

Farm Programs

A growing body of research infers that farm programs have been a contributing factor to higher real estate values. Regression analyses of individual farm sales have produced significant estimates of value for acreage allotments for tobacco, peanuts and cotton. These values were estimated at $1,139 per acre for tobacco, $669 for peanuts, and

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[11] U. S. Department of Agriculture, Farm Real Estate Market Developments (August, 1963), p. 22.

[12] U. S. Department of Agriculture, Farm Real Estate Market Developments (December, 1962), pp. 15-16.

$463 for cotton in northeastern North Carolina[13] and up to $2,500 per acre of tobacco allotment in east central North Carolina.[14]

Linear programming studies have also indicated sizeable marginal income potentials from the acquisition of allotments. Hall found the MVP of wheat allotment to be more than one-half of the MVP of the best class of land studied, and greater than the land MVP's on the two poorest land classes considered.[15]

Changes in the productivity of land are also credited with contributions to real estate prices. These changes usually stem from investment in irrigation, drainage, terraces, buildings, etc., but often this investment is neither directly nor indirectly charged to land ownership. Public resource development projects are usually associated with land price increases greater than in similar areas where such public investment has not taken place. Both public and private research are suspected to contribute to the market value of the resource on which they are applied. We attempt to incorporate an estimate of this influence in the model employed in succeeding chapters.

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[13] James L. Hedrick, "The Effects of the Price-Support Program for Peanuts on the Sale Value of Farms," Journal of Farm Economics (December, 1962), p. 1751.

[14] Frank H. Maier, James L. Hedrick and W. L. Gibson, Jr., The Sale Value of Flue-Cured Tobacco Allotments, Virginia Polytechnic Institute, Technical Bulletin No. 148 (Blacksburg, 1960), p. 39.

[15] Harry H. Hall, unpublished research data generated in studies for "Short Run Adjustment Opportunities for Oklahoma Panhandle Farmers" (unpub. M. S. thesis, Oklahoma State University, 1963).

Capital Gains as an Influence on Real Estate Prices

Capital gains potentially can be an important influence in the land market. The lead paragraph on a recent issue of Farm Real Estate Market Development states:

> Annual increases in the market value of farm real estate have been at least as large, or larger than the annual returns from farm production in 5 of the last 13 years. Such increases in market values are not realized unless property is sold. But past gains create expectations that such gains will continue. Such expectations tend to reduce the quantity of land offered for sale and also contributes to the demand for land.[16]

Consider the case of average U. S. farm real estate purchased in 1950. The return on investment stemming from capital gain alone was 13.1, 6.1, 7.2, and 6.2 percent, respectively, in the years 1950, 1956, 1958, and 1961.[17] In two years, 1952 and 1953, there were capital losses of 1.8 percent. From 1950 to 1962, the average annual production return (residual income to land after paying all other production costs) on the 1950 investment in real estate averaged seven percent. The lowest return, 5.1 percent, was in 1959; the highest, 9.6 percent, was in 1951. Capital gains on real estate from 1950 to 1961 provided buying power for $34 billion of farm family living items or $43 billion of farm production items. One possible reason land prices continue to

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[16] U. S. Department of Agriculture, Farm Real Estate Market Developments (April, 1963), p. 1.

[17] Capital gains measured as the value of farm family items used in living that could be purchased with the difference between the current land price and what was paid in 1950.

rise is that farm real estate buyers bid up prices in competing for the opportunity to obtain these capital gains.[18]

One point of view holds that farm land (and other durable capital assets) are attractive investments as a tax haven and as a "store of value" against the effects of inflation. Long-term capital gains are taxed at one-half the rate on ordinary income but numerous other investments including common stocks receive similar tax treatment. And farm land prices have increased much more rapidly than the general price level in the postwar period.

Figures 3 and 4 illustrate graphically the concepts discussed above. The solid line in Figure 3 is the farm real estate price index P, deflated by the U. S. wholesale price index. The broken line is an index of capital gains.[19]

Our capital gains variable is constructed to represent the average cumulative difference between the price contracted by current owners and the current market price for a given year. Thus, an increase in Cg may result from current price rising more rapidly (falling slower) than during a determinate time period several years before. Constant real estate prices over long periods of time imply capital gains of zero.

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[18]Speculative investment is hazardous, since Figure 5, illustrated later, shows that the farm real estate share of farm gross income cannot continue to rise indefinitely at the past rate. The real estate share computed as the interest on the current value of farm land would eventually equal gross farm income if the current trend persists.

[19]The two variables illustrated in Figure 4 are listed in Appendix B, Table I for the U. S.

(1) P = Deflated Farm Real Estate Price Index, 1957-59 = 100

(2) Cg= Estimated Accumulated Capital Gains, measured in deflated land real estate price index points, 1957-59 = 100

The construction of the Capital Gains variable (Cg) is explained in Appendix A.

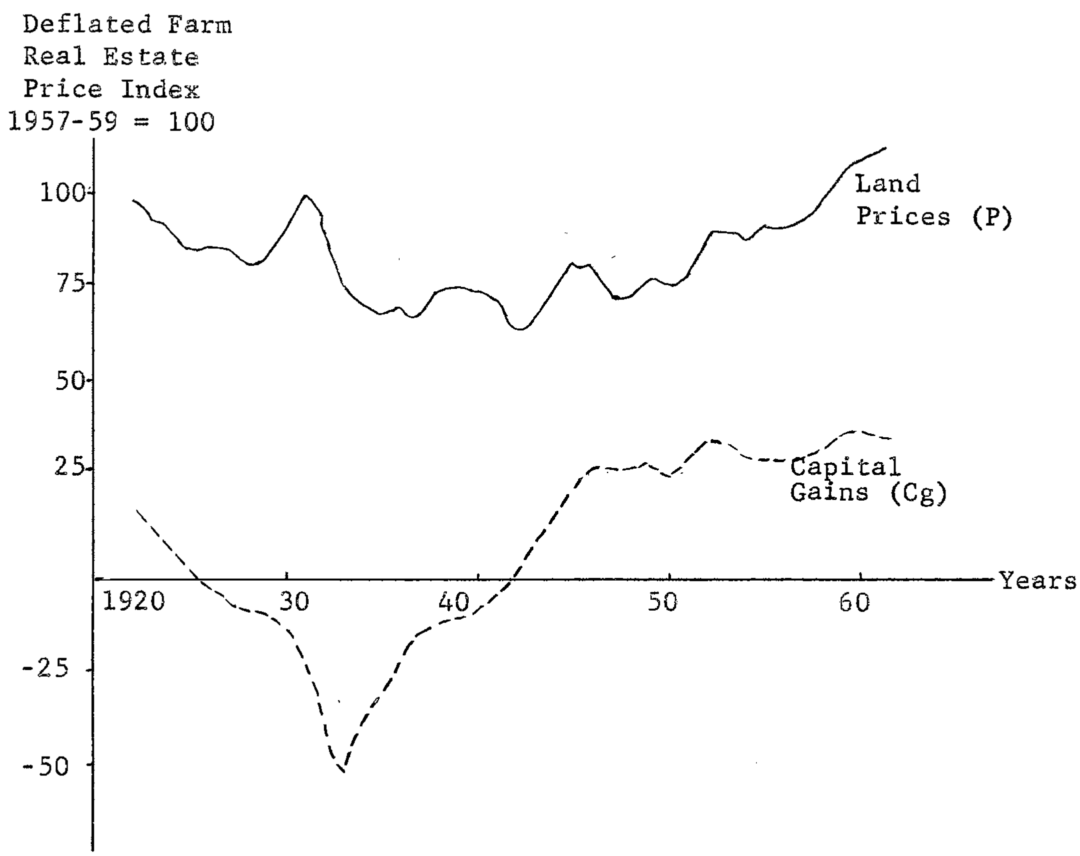

Figure 3. Deflated Farm Real Estate Prices and Accumulated Capital Gains: 1957-59 Price = 100, U. S., 1922-61.

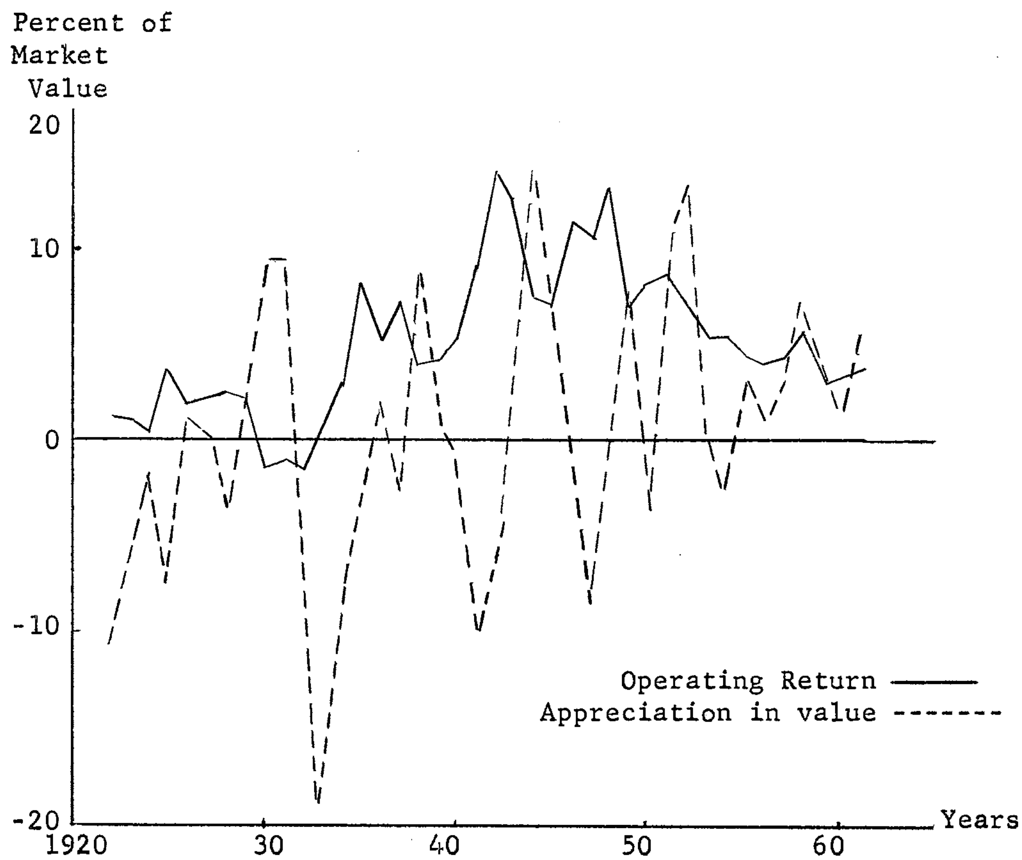

Figure 4. Rates of Earning for Farm Real Estate from Current Production and Capital Appreciation, U. S. 1922-1961.

Source: <u>Farm Real Estate Market Developments</u> <u>CD-49</u>, <u>CD-54</u>, <u>CD-64</u>. Appreciation calculated from "P" in Appendix B, Table I.

Current annual incremental appreciation and depreciation in real estate value as a percentage of current price is compared in Figure 4 with annual rates of earning (residual income) for farm real estate.

Capital gains were positive but falling in the initial phase of the period considered, but became negative in 1927. An increased rate of farm transfers and rapidly falling prices in the late 1920's and early 1930's was followed by a recovery of Cg from its minima of -51.4 in 1933. Current price continued to fall until 1935 when it reached 68.4. A second low occurred two years later. Capital gains have shown a rather steady upward trend since 1933. Decreases have occurred in 1947, 1950, 1953, 1954, 1956, 1960, and 1961, but none of them have been large. Capital losses in the late twenties and early thirties were regained rapidly in the late 1930's and the 1940's. Rapid increases characterize the war years, 1942-45 and 1950-51. The pattern of gains in the last decade has been uncertain, but the general trend has been a slow upward movement.

Figure 4 shows a volatile pattern of association between changes in land price and annual earning rates for past years. Some factors of recent years have had a dampening effect on annual appreciation. Lower commodity prices and uncertainty about the future of government programs seem to be possible explanations.

Farm Income as A Determinant of Land Price

The extent to which farmers impute income to their own labor and nonland resources and how much they attribute to land cannot be directly determined. Income data usually reported does not account for the cost of owned farm real estate except for taxes and interest on farm mortgages. Imputing a cost to all farm real estate is a somewhat arbitrary process. Only by making certain basic assumptions can we separate returns to farm land and other resources.

Net farm income, computed by conventional procedures, may not give an accurate measure of future farm earnings imputed to control of land. In a period of falling farm income, farm income imputed to land and land prices may be rising because of structural changes in farm production and marketing. Our tools are not sufficiently precise to test this hypothesis in later sections as a factor explaining recent land price changes. However, structural changes that might influence indirectly the earning power of land are introduced through land retirement, farm size (numbers) and other variables.

Figure 5 traces the factor share to farm real estate, i.e., the cost of real estate computed as interest on current market value expressed as a proportion of the total value of all farm output. Except for the early thirties, when farm commodity prices fell more rapidly than land values, a general downward trend until 1943 contrasts with an upward trend since 1943. Extension of the 1952-61 trend indicates the factor share is increasing four percent annually. That land values cannot continue to rise at the current rate is apparent. This share must level off well before it reaches the upper limit of one.[20] The analysis

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[20] The factor share Y for 1952-61 regressed on time T yields $Y = -.25 + .0083T$. Solution of this equation for $Y = 1.0$ estimates the land share would exhaust the total product in 150 years.

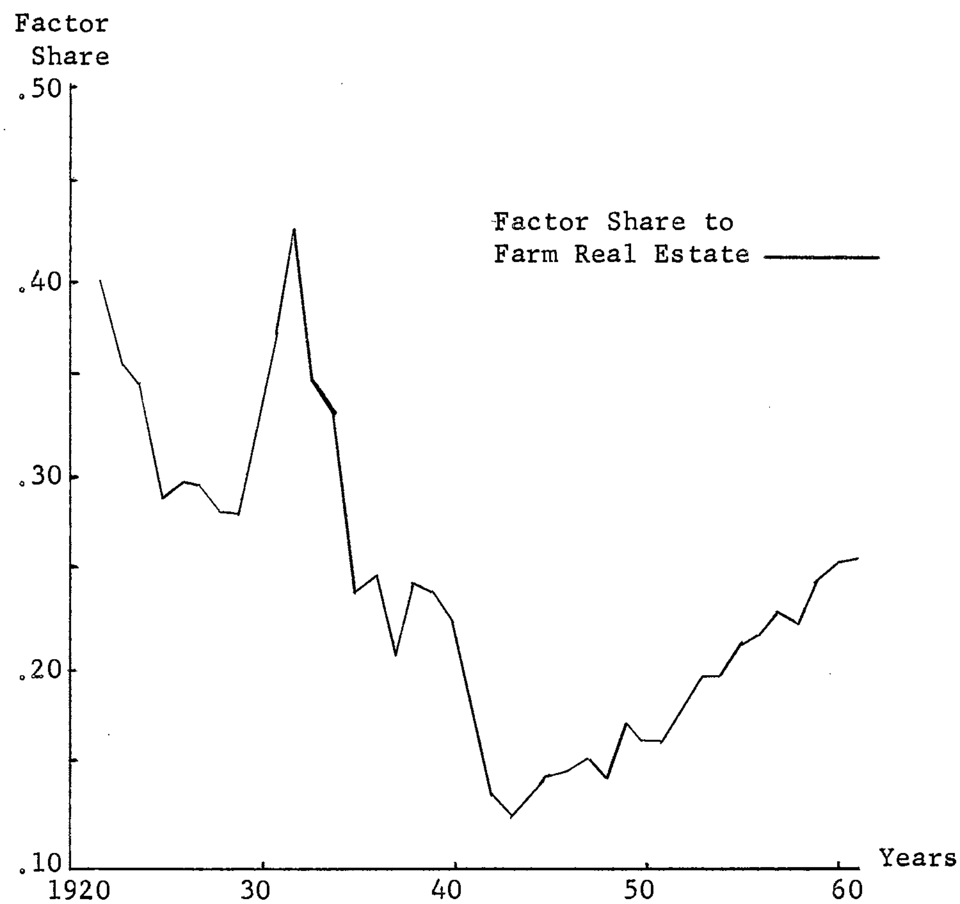

Figure 5. Real Estate Factor Share of Total Farm Product, U. S. 1922-1961

Sources: Computed from: Farm Income Situation and Farm Real Estate Market Developments.

of the following chapters concludes, however, that this leveling is not to be expected in the near future if present and expected conditions continue to prevail.

Other hypotheses, in addition to those listed previously in this chapter, have been cited as sources of rising land values.[21] One cites a widening distribution of income and equity in agriculture as an important source of demand. The argument is that early innovators and farmers in a position to obtain windfall gains from commodity programs have prospered and improved their financial condition despite falling average income for farmers as a group. These relatively few farmers with a favorable financial position have maintained a strong demand for land and pushed real estate values to levels that do not appear justified based on expected future earnings alone.

We quantify the contribution to land prices of certain of the foregoing hypotheses in Chapters IV and V. However, before doing so, in Chapter III, we develop historical and dynamic elements in an econometric model of the land market.

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[21]For a discussion of these see Earl O. Heady and Luther G. Tweeten, Resource Demand and Structure of the Agricultural Industry, Iowa State University Press (Ames, Iowa, 1963), Chapter 15. Also see Luther G. Tweeten, "National and Regional Changes in Factor Shares," discussion in Proceedings of Conference on Bargaining Power in Agriculture, Center for Agricultural and Economic Development (Ames, Iowa, forthcoming).

CHAPTER III

ECONOMIC MODELS OF THE LAND MARKET

The purpose of this chapter is to trace briefly the historic development of land value theory, to review certain structural aspects of models explaining land prices, and to formulate a model of the land market that can be estimated empirically.

The Historical Base

A market for land has existed for a relatively short time. Prior to the "enclosure" of common lands in England a land market as known today was nonexistent.[1]

The Physiocrats formulated an early theoretical model of factor returns in the latter half of the 18th century. They believed that wealth originated only in the extractive industries and thereby deduced their economic policy recommendations for taxation of owners of primary resources. Agriculture was considered to be the primary extractive industry. Mineral deposits and timber were also judged to be proper

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[1]"As late as the fourteenth or fifteenth century there was no land, at least in the modern sense of freely salable, rent-producing property... A medieval nobleman in good standing would no more have thought of selling his land than a respectable honorary society or exclusive club today would think of selling memberships. Every society takes some objects of value and places them outside the orbit of transaction; for the Middle Ages, land was one of these." Robert L. Heilbroner, The Worldly Philosophers (New York, 1953), p. 19.

subjects of taxation, but all forms of employment were deemed incapable of contributing to the support of the state on a sustained basis.

Classical Rent Theory

Adam Smith redefined the relevant basis of distribution to be three factors of production: land, labor, and "stock." Other Classicists agreed, but were often vague in their definitions and in the classification of certain factors. Their distributional shares were wages, profits, and rent. When the term "rent" was generalized to mean "surplus to the 'natural agent'," [2] the distinction between wages and surplus to nature-given ability was sometimes difficult and confusing.

Ricardo has been traditionally credited with the first clear statement of classical rent theory and it commonly bears his name in modern economics. Some assumptions of the Ricardian model are:

1. A variable, homogeneous labor supply at fixed wages, which is the subsistence wage in the long-run,
2. A variable capital supply at constant price,
3. Nonland factor use in constant, fixed proportions, and
4. A supply of land which varies in inherent productivity and may be placed in disposal if the product is insufficient to support the labor and capital necessary for operation.

The key feature of the Ricardian rent model illustrated in Figure 6 is the descending productivity of the land resource as more and more

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[2] Nassau William Senior, Political Economy (Oxford, 1836), Reprinted by Farrar and Rinehard, Inc., New York, 1939, p. 89.

land is brought into use. Five classes have been used in the illustration. Land Class 1 is the most productive and pays the highest rent R_1.

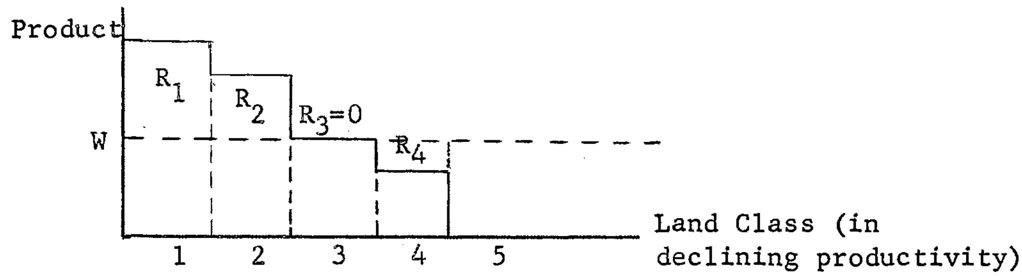

Figure 6. The Ricardian Differential Rent Model.

Class 2 land also yields a rent R_2 which is somewhat less than R_1. Class 3 land just produces enough to support the labor and capital required for operation represented by w product, and yields zero rent. Class 4 is incapable of maintaining labor and capital at rate w and, if operated, would yield a negative rent. Class 5 represents desert land yielding nothing.

Land values are functionally related to economic rents in the Ricardian system; the exact relation depending on earnings of capital in other employments and thereby the monetary discount rate. The functional relationship is the one generally used for capitalization of a perpetual annuity:

$$V = \frac{A}{r}$$

where V is the present value of the asset; A is the annual income residual (rent in this specific case) and r is the discount rate. The rate of discount is the rate of return on an alternative investment--the interest rate if capital is unlimited. Sometimes a subjective discount or "risk factor" may be added to r.

Taxation was a primary policy concern of the Classical School. They were interested in delineating "surplus" factor rewards as a means of obtaining tax revenue. Since taxes were collected largely from social groups, they stratified their population into three main classes--(1) the propertyless peasant and factory worker who could not be taxed below subsistence and remain productive; (2) the entrepreneuring capitalist, who could only be taxed with the consequence of reduced investment and subsequent reductions in social output; and (3) the landed gentry who received a taxable "surplus." The classical model was approximately appropriate for the problems and institutional framework of the times. The classical formulation described above is a useful analytic device, and can be made more flexible by broadening the concept of productivity.

Neo-Classical Extensions of Classical Concepts

The marginalist revolution in economic theory in the latter 19th century placed little emphasis on rent and land. The assumptions of marginal analysis included homogeneity of factors of production and the analysis required no particular distinctions between factors. Each factor would, in equilibrium, be employed to the point where its marginal value product (MVP) would equal the marginal factor cost (MFC) and production would be carried to the point where the marginal revenue product (MR) would equal marginal cost (MC) of the product. Given the assumptions of economic man and universal diminishing marginal productivity, the system was complete. And the marginalists were not prone to worry about the homogeneity assumption nor about what the marginal cost of an additional unit of land might be. They were occupied with developing the demand side of economic analysis.

The power of marginal analysis was woven into rent theory by Marshall in his Principles of Economics near the turn of the 20th century. Introducing the related concepts--length of run and quasi-rents--he was able to explain prolonged resource returns at nonequilibrium rates and to establish a base for our contemporary resource-fixity theories. Thus, the price of the factor becomes the dependent variable in the system, rather than the amount of the factor used, under certain conditions. Marginal analysis brings rent theory back to a rent as a residual, much like the Ricardian model but with modifications.

The Conventional Model

The modern concept of rent can perhaps best be described by two quotations:

"Rents are the returns to productive services in excess of what they can earn in alternative employments."[3]

"...when (the) free capital has been invested in a particular thing, its money value cannot as a rule be ascertained except by capitalizing the net income which it will yield;..."[4]

When a factor of production can be produced, an MVP higher than the marginal cost of production for the factor indicate profits and an

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[3]George G. Stigler, The Theory of Price (New York, 1952), p. 180.

[4]Alfred Marshall, Principles of Economics, 8th Ed. (London, 1920), p. 341.

eventually increased supply of that factor. An MVP less than marginal cost means losses and the firm reduces production as the input is sold or reduced by obsolescence and attrition. If the marginal cost of production or acquisition of a resource is persistently greater than the MVP, economic rents may be sizeable and prolonged. The extreme case is that of the resource with zero initial acquisition cost, but absolutely fixed in quantity. In this case, economic rent is perpetual and is equal to the entire return to the factor.

Factor Interdependents

In addition to the single-factor, single-product situation of the preceding paragraphs, policy analysis must also be concerned with the interrelationships between changes in the price or quantity of one factor (e.g., land) and the prices and quantities of related factors. Some static models developing further the theory of resource valuation are presented in Appendix D. The appendix models aid in the interpretation of empirically derived coefficients of substitution and complementarity found later in this study.

Interdependency and the Recursive Model

Some important changes in price relationships or other parameters strategic to agriculture are related to the variables found within the system. One source of dependency within the system lies in the technical interrelationships of complementarity and supplementarity. This interdependency exists among products, factors of production, and geographic areas. An exogenous shift in one of the strategic variables may be followed by a series of repercussions throughout the agricultural sector of the economy. Thus, a change in the demand for beef, given time, affects the prices of other meat products, factors used in beef production, and substitutes and complements for beef; i.e., rangeland, feed grain cropland, farm income, etc.

The interdependency discussed in this section can be estimated by different statistical models, depending on the rationale underlying the structure of the system. If the re-establishment of equilibrium following a disturbance is sufficiently rapid, a system of simultaneous equations is implied. If two variables interact jointly and concurrently, and the direction of cause or time sequence is not established because of data limitations or other reasons, the parameters in the simultaneous system might be estimated by Limited Information, Reduced Form Least Squares, or Theil-Basman techniques.[5]

The relevance of simultaneous models to the variables given major attention in this particular study may well be questioned. Wold argues that the recursive system characterized by a triangular matrix of endogenous variable coefficients is the most fundamental causal structure. He has shown that under certain conditions, recursive systems fitted by least squares produce maximum likelihood estimates of

[5]For a discussion of these procedures, see Thomas D. Wallace and George G. Judge, Econometric Analysis of the Beef and Pork Sectors of the Economy, Technical Bulletin T-75, Oklahoma State University (Stillwater, 1958).

the structural coefficients.[6] Agricultural applications have recently been accomplished by Harlow[7] and by Heady and Tweeten.[8]

Among the attractive features of the recursive system are the following properties: (1) a rationale consistent with economic logic regarding causal chains involving disequilibrium systems of interrelated variables; and (2) the simultaneous reduction of least square bias by the use of predicted rather than observed values in estimating the coefficients of dependent variables reasoned to be influenced by past values of other variables. One example of the recursive model is the familiar cobweb phenomena in agriculture. Both current price and quantity enter the demand function, but the current quantity can be regarded as predetermined by variables in the supply equation. The current supply is predetermined by past price. By using the predicted current supply quantity in the demand equation, the quantity variable becomes independent of the current shock, and least squares bias is minimized.

To illustrate further the applied logic of the recursive system, consider the land price (demand) equation of the land model presented in full later in this chapter. Current values of land price P, land quantity Lf, and number of transactions T appear in the equation. It is expected that land quantity and number of transactions influence P

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[6] Herman Wold, "Dynamic Systems of the Recursive Type--Economic and Statistical Aspects," Sa'nkyha: The Indian Journal of Statistics, 11: pp. 205-216.

[7] Arthur A. Harlow, Factors Affecting the Price and Supply of Hogs, Economic and Statistical Analysis Division, U. S. Department of Agriculture, Technical Bulletin No. 1274 (Washington, 1962).

[8] Earl O. Heady and Luther G. Tweeten, Resource Demand and Structure of the Agricultural Industry (Ames, 1963), Ch. 16.

in the current year. But we do not anticipate that current land price has a significant influence on current land volume or number of transactions. The latter variables might be considered exogenous. Then single equation simple least squares might be appropriate if land price is the only endogenous (dependent) variable in the equation. But even if current land price, land volume and number of transactions are determined interdependently, we might satisfy statistical properties necessary for minimum least squares bias by the recursive approach. Suppose current land quantity and number of transactions are determined only by past land values, financial position and other exogenous or lagged endogenous variables. We first predict current values of Lf and T from predetermined variables. We then use these predicted values of Lf and T to estimate P in land price equation. Lf and T are made linear combinations of predetermined variables, hence, the predicted values of the two variables essentially are predetermined. Thus, the land price is estimated as a function only of predetermined variables, T and Lf are independent of the disturbance (error) in the land price equation, and least square bias is minimized.

Expectation and Adjustment Models

Many decisions on sales and purchases in the land market are based on expectations. The profitability of a land purchase may depend on the value of crops produced in the future and on the trend in future land values (capital gains). The expectations of future values of these variables tend to be based on past values.

Farmers may not regard prices at a given moment to be an adequate basis for long-range decisions. Several alternative models have been examined for consistency with farmer reaction to price conditions, and the way farmers form price expectations. One such model takes the form:

$$P^*_{t+1} = (4P_t + 3P_{t-1} + 2P_{t-2} + P_{t-3})\ 10^{-1}$$

where P^*, the expected price in year

$_{t+1}$, is determined by a weighted average of past prices P_i. Other more intricate and complicated models placing geometrically declining weights on lagged prices and various other functional forms are consistent with possible expectation models.

Given that market participants have formed expectations and are subjectively certain of prices and incomes, the adjustment to the desired or equilibrium sales may go slowly for several reasons. One impediment to reaction to changes in critical variables used in farm decision making is embodied in the theory of fixed assets. A factor MVP remaining below the acquisition price and higher than the salvage price may render the firm unresponsive to price variations which would dictate change under continuous functional relationships. When resource fixity applies to a semi-durable factor, such as machinery, the fixity is relaxed slowly only as the factor depreciates. Thus, while a reduced product-factor price ratio may dictate diminished factor use for profit maximization, the adjustment cannot be effected until the factor on hand at the time of the price change has been exhausted or reduced to its salvage value. This lag is believed to be several years for machinery and may extend to decades for buildings and land improvements including tiling, wells and irrigation systems. Breeding herds may also be included as a similar semi-durable resource.

Insensitivity to price changes is also prevalent in cases where resource prices are highly correlated with product prices. Feeder cattle as a factor of production in a cattle-feeding enterprise is one example. Declines in fat cattle prices may not immediately affect the input of feeder-cattle into such an enterprise. Reduced cattle receipts created by the reduced price of fat cattle may be offset by the price of feeders rather than by reduced feeder numbers in the short-run.

Other adjustment lags arise from time required for decisions and action in production and marketing. Institutions, lack of knowledge, risk aversion and human lethargy may also lengthen the adjustment period. When shifts in enterprises and land use are involved, reaction time to price changes may be retarded by pride, familiarity, and value structures. Years of uneconomic continuation of the enterprise may elapse before adjustment takes place. The lagged adjustments for any one farmer are discrete, but comprise a nearly continuous lagged response in data for a larger aggregate.

A Specific Adjustment Model

The logic and mathematical basis for the adjustment model used in this study is explained further in literature available.[9] Briefly, the

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[9] L. M. Koyck, Distributed Lags and Investment Analysis (Amsterdam, 1954); Mar Nerlove, Distributed Lags and Demand Analysis for Agricultural and Other Commodities, Agriculture Handbook No. 141, AMS, U. S. Department of Agriculture (Washington, 1958); Marc Nerlove, "Distributed Lags and Estimation of Long-Run Supply and Demand Elasticities: Theoretical Considerations," Journal of Farm Economics (May, 1958), pp. 301-311; Heady and Tweeten, Chapters 3 and 10.

logic of the adjustment model is that the equilibrium position of the dependent variable is approached with a distributed lag following a sustained change in an independent variable. With adjustment only possible between discrete production (time) periods, the adjustment process can be characterized by:

$$(1) \qquad Q_t - Q_{t-1} = g(Q_t^* - Q_{t-1})$$

where Q_t^* represents the desired or equilibrium quantity.

The model states that the actual adjustment $Q_t - Q_{t-1}$ of the quantity during a period t is some proportion g of the full desired or equilibrium adjustment $Q_t^* - Q_{t-1}$. The long-run equilibrium Q_t^* results with the full adjustment of Q to current values of explanatory variables X and Z. The long-run equation is expressed as a linear function in (2), with u the error. Substitution for Q^* from (1) into (2) gives equation (3) after rearrangement:

$$(2) \qquad Q_t^* = a + bX + cZ + u$$

$$(3) \qquad Q_t = (1-g)Q_{t-1} + ga + gbX + gcZ + gu$$

Estimation by ordinary least squares using untransformed data gives the short-run coefficients (1-g), ga, gb, and gc directly. Long-run coefficients may then be obtained by dividing each direct coefficient by the adjustment rate g which is one minus the b coefficient obtained on the lagged dependent variable.[10]

Given that the appropriate economic model is assumed or justified by some other means, elasticities (both long and short-run) may be estimated directly via transformation of the variables into logarithms

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[10]The computation of adjustment coefficients is explained in detail in Appendix C.

and the application of logic parallel to that outlined above for short and long-run coefficients. Linear, additive models were used exclusively in the analysis which follows and all estimates were with untransformed data. The procedure for finding elasticities was therefore the conventional technique and elasticities presented are specified either at the means or at recent values and identified as such in each case.

A Macro-Econometric Model for Land Prices

In this section, we present an econometric model of the land market, a composite hypothesis explaining the process through which land prices materialize. A very large number of variables is expected to influence land prices. Certain strategic variables do exist, however, which are believed to be sufficient for this purpose. The usefulness of such estimates is stated by Fox:

> A useful model must meet certain conditions: (1) It must include all of the relationships and variables which are important enough to affect the ranking of the alternative policies under consideration in terms of their quantitative effects, and (2) the coefficients in the relationships must be known accurately enough to give a high degree of probability to the rankings obtained.[11]

The dozen variables considered in this chapter were selected from a much larger group initially expected to have some important influence on the price of land and the related factor markets. Many of the variables originally included were dropped because of high correlation with one of the retained variables, and upon closer scrutiny were resolved to be functionally related to a retained variable.

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[11] Karl A. Fox, Econometric Analysis for Public Policy, The Iowa State College Press (Ames, 1958), p. 154.

Initially the variables were mnemonically designated, except where duplication required deviation. All money variables were first deflated by the wholesale price deflator removing the effect of inflation from the entire model insofar as possible.

The variables are defined as follows:

A = Number of farms, in thousands.

C = Cropland used for crops index, 1947-49 = 100; 379 million acres equivalent to C = 100.

Cg = Capital gains on farm real estate.

E = Employment, nonfarm, in millions.

F = Net farm income, in billion dollars (Gross farm income less cash expenses).

H = Index of output per acre of cropland, 1947-49 = 100.

JX = Ratio of farm to nonfarm labor earnings modified by nonfarm unemployment rate.[12]

J = Ratio of farm to nonfarm labor earnings.

Lr = Land retired from production by government programs, million acres.

Lf = Land in farms, in million acres.

P = Price of land, index 1957-59 = 100, deflated by wholesale price index.

S = Stock of machinery index, 1957-59 = 100.

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[12] JX = J(100-5U) thus, when unemployment exceeds 20 percent, JX becomes negative; and when unemployment is low, JX approaches 100J.

T = Transfers of farm real estate per 1,000 farms.

U = Nonfarm U. S. rate of unemployment.

A complete description of the variables, sources, and listing of the data is included in Appendices A and B.

The Recursive Model

The basic model is specified in five equations with the variables to the left of the equal sign defined as follows:

(1) P = Price of land index.

(2) Lf = Land in farms.

(3) C = Cropland used for crops index.

(4) T = Transfers of farm real estate per 1,000 farms.

(5) A = Number of farms.

(3.1) Land Demand $P_t = f(Lf_t, T_t, A_t; X_1, P_{t-1})$

Variables to the left of the semicolon are endogenous. X_1 refers to predetermined variables affecting land price in the current year. The lagged land price variable represents past effect on land price in a distributed lag adjustment model.

Land in farms Lf_t, transfers T_t and number of farms A_t are determined interdependently and recursively with land price.

The model is similar to other recursive models for agriculture where the current demand quantity is predetermined by lagged endogenous and exogenous variables in the supply equation. The "quantity" in this model is the land in farms Lf and transfers T. That is, the effective current supply of land is not only the total land available, but also is the amount of land offered for sale in the current year--measured by transfers in this model.

To insure that the disturbances in Lf, T, and A are not correlated with the disturbances in the demand equation, these variables are first estimated from predetermined variables. Estimating the land demand equation from values of Lf, T, and A predicted from predetermined variables essentially makes these variables predetermined in the statistical model for land demand. The assumption of the recursive land equation is that the decisions regarding the <u>current</u> land supply are made prior to or exogenously of land price.

(3.2) Land Supply $$Lf_t = f(C_t; P_{t-1}, P_{t-2}, Lf_{t-1}, X_2)$$

Land in farms is determined interdependently with cropland used for crops C. Lf also is a function of predetermined variables indicated by X_2. To satisfy the statistical assumption for avoiding least squares bias, equation (2) is estimated with the predicted current value of C. The predicted value $\hat{C}_t$, is predetermined from an equation for the cropland supply.

(3.3) $$\hat{C}_t = f(P_{t-1}, P_{t-2}, X_3, C_{t-1})$$

The current supply quantity of cropland is assumed to be a function of past land prices and other predetermined variables summarized in X_3. The supply equation for cropland (3.3) is identified by the assumption that current land prices do not influence cropland used for crops in year t. Given the demand equation (3.1), the presence of P_t in the supply equation (3.3) would imply a joint causal relationship, with current land in farms or cropland influencing the current land price, and with current land price affecting land in farms and cropland. This joint causal relationship would call for Limited Information or Theil-Basmann techniques. If Lf and C are not influenced by current price, the recursive model seems appropriate. The exclusion of current price from equations (3.2) and (3.3) appears defensible, since decisions regarding acreage C_t and Lf_t generally are made early in the year, before P_t is determined. Second, since land is not a cash production cost, it is not closely tied to current decisions on land use. In the long-run, as discussed earlier, land prices do have an important role in determining farm income available for family living. Land prices also potentially affect production decisions and land use in the long-run, thus, lagged values of land prices are included in equations (3.2) and (3.3).

(3.4) $$T_t = f(JX, Cg, T_{t-1})$$

The number of transactions per 1,000 farms T in (3.4) is assumed to be a function of variables reflecting agriculture's financial health. The number of farms placed on the market is closely tied to the farm-nonfarm income ratio JX and capital gains Cg. A negative relationship between JX (or Cg) and T would be anticipated if an unfavorable financial status either forced or encouraged farmers to leave farming and if capital gains encouraged farmers to reap their gain. A positive relationship would be anticipated if an improved financial status encouraged farmers to stay in farming to gain additional appreciation of property values. We judge that a negative relationship would be the most likely net result in the period studied.

(3.5) $$A_t = f(S_t, JX, Cg_t, A_{t-1})$$

The number of farms A_t is related to the national beginning-year stock of farm machinery S, the financial advantage of and availability of off-farm employment, JX, and capital gains Cg in (3.5). With the family farm as the basic unit of farm organization, factors that determine the farm population also influence farm numbers. Since machinery adopted in the time period under consideration tends to substitute for operator and family labor, a negative coefficient for S is anticipated. Capital gains and an income ratio favorable to farmers are expected to slow migration from farms and result in high values for A_t. The relationship is similar to equation (3.4) except that mobility of the labor resource rather than the land supply relationship is under observation.

The empirical land market model does not lend itself to the rigorous supply-demand dichotomy discussed above because certain variables are associated with both functions, raising questions about identification of an exact demand or supply equation. While retaining the basic model discussed above, we prefer to give the equations a less strict interpretation. In subsequent sections, the land demand equation (3.1) is called a "land price" equation; supply equation (3.2) is called the "land-in-farms" equation; and equation (3.3) is the "cropland" equation.

In addition to variables representing hypotheses that might explain recent price changes (see Chapter II), several additional variables enter the system. Researchers in an earlier study were confronted with more explanatory variables than could be simultaneously included in a single least squares equation explaining land price.[13] A heirarchal system of choosing variables was used to select a subset of variables with structural validity. In this study use of the recursive model increases the number of variables that can be included in the system, since each equation in the recursive chain is estimated separately by simple least squares. If desired, the effects on land price of variables not included directly in equation (3.1) but linked to land price through the recursive chain, can be ascertained by substituting estimated equations such as (3.2) for Lf in equation (3.1). The resulting equation for land price formed by substituting equations (3.2) through (3.5) into (3.1) is called the reduced form. It is hoped that this procedure, showing the effects of many variables on land price, is more reliable than direct estimation of the reduced form even with the heirarchal system.

[13] Heady and Tweeten, Chapter 15.

CHAPTER IV

LEAST SQUARES ESTIMATES OF THE RECURSIVE SYSTEM

The Five Equation System

The system of equations explained in Chapter III is estimated in this chapter with annual U. S. data for the years 1922-1961. The years 1941-1947 inclusive are omitted due to suspected distortions caused by conscripted labor migration, national efforts to maximize food-grain use of cropland, and other erratic features of an economy geared to all-out war. Coefficients and other statistical results presented in this section were obtained through the recursive chain in equations explained in Chapter III. The data used are presented in Appendix B.

The short-run land price equation was estimated recursively as:

$$(4.1)\quad \hat{P}_t = 96.46 - .14\hat{T}_t - .003\hat{A}_t - .04\hat{Lf}_t + .12Lr_t + .67F_{t-1} + .64P_{t-1}$$

Computed t = (.77) (.81) (1.9) (.97) (1.6) (5.0)

$R^2 = .886$ d' = The Durbin-Watson Statistic = 1.37

The variables are defined as in Chapter III. Student-t values are included below the coefficients. Coefficients on $\hat{Lf}$, land in farms; F_{t-1} farm income; and P_{t-1}, lagged land price index; are significant at the 95 percent one-tail level. All signs except on $\hat{A}$, number of farms, are consistent with the economic interpretation of a demand equation. The equation indicates that increased transfers $\hat{T}$ are associated with a lower land price. A decreased land quantity $\hat{Lf}$ results in a higher land

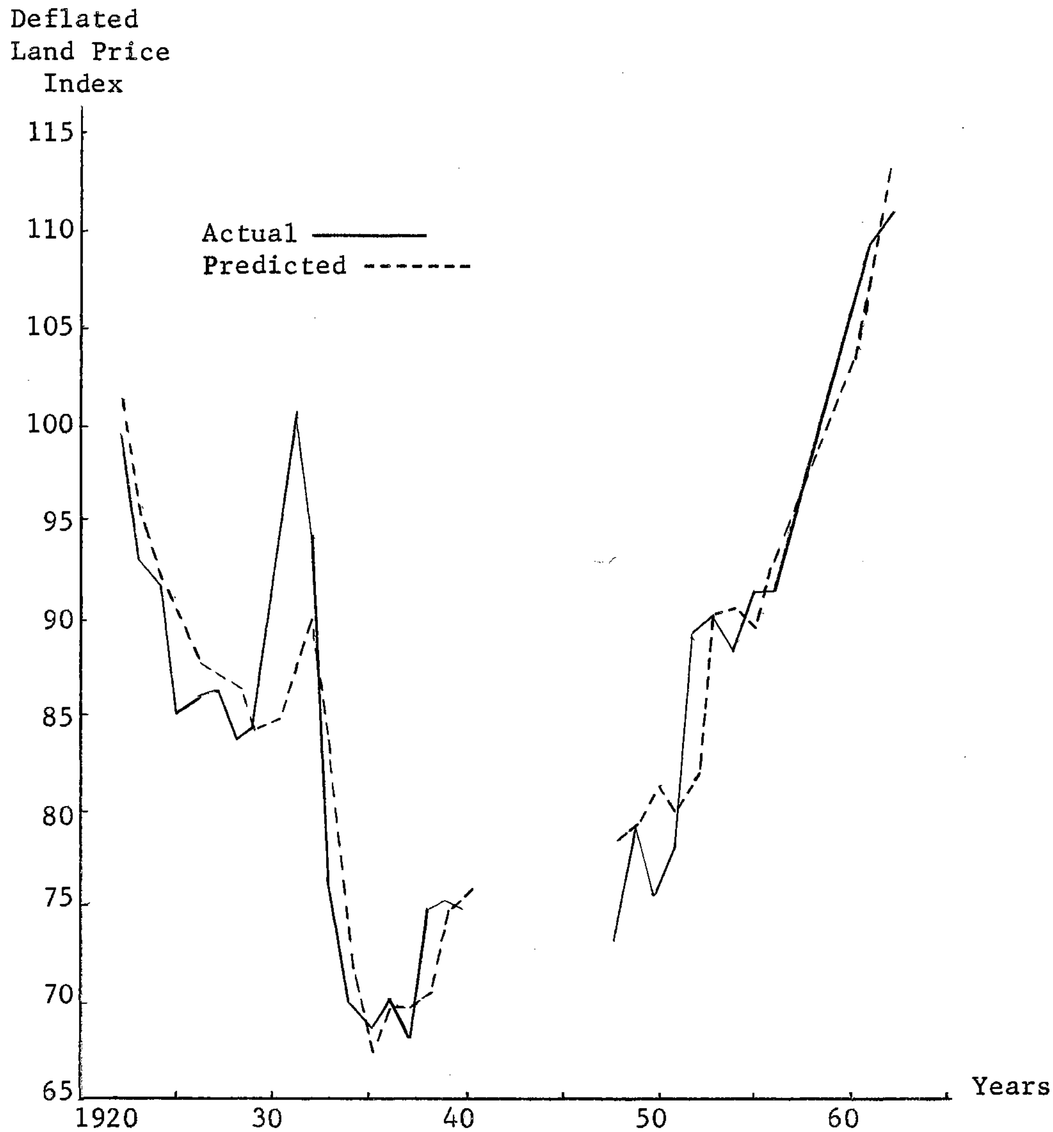

Figure 7. Actual and Estimated Deflated Land Price Indexes, Computed from Land Price Equation (4.1).

price index. A one million acre increase in land retirement Lr suggests a .12 point increase in P.[1] A one billion dollar increase in farm income creates a .67 point increase in the land price index. The highly significant coefficient on P_{t-1} indicates that current price is quite dependent on lagged variables.

The Durbin-Watson statistic d' is used to test for autocorrelation in the residuals. Values near 2.0 give no basis for rejecting the null hypothesis of no autocorrelation. The estimated d' = 1.37 in equation (4.1) suggests the possibility of positive autocorrelation.

The land transfers equation was estimated as follows:

$$\hat{T}_t = 40.09 + .122JX_t - .366Cg_t + .311T_{t-1} \qquad (4.2)$$

Computed t = (1.9) (5.7) (3.1)

$R^2 = .875$ $\qquad$ $d' = 1.44$

The income ratio variable JX gives an indication that more farms are transferred when farm incomes are comparatively favorable or when unemployment is low. The adjustment rate for transfers is rapid with one-half of the total adjustment taking place in two years and 90 percent completed in slightly over six years. The adjustment rates will be further discussed and compared later in this chapter. The coefficient of the capital gains variable suggests a decrease in transfers with capital gains. This is inconsistent with the response to higher farm income, if income and capital gains are substitute measures of financial gain. The negative sign of the coefficient is consistent with the

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[1]The deflated land price index P equals 100 when the deflated price of farm real estate (1957-59 = 100) is \$101.01 per acre, U. S. conterminous area average.

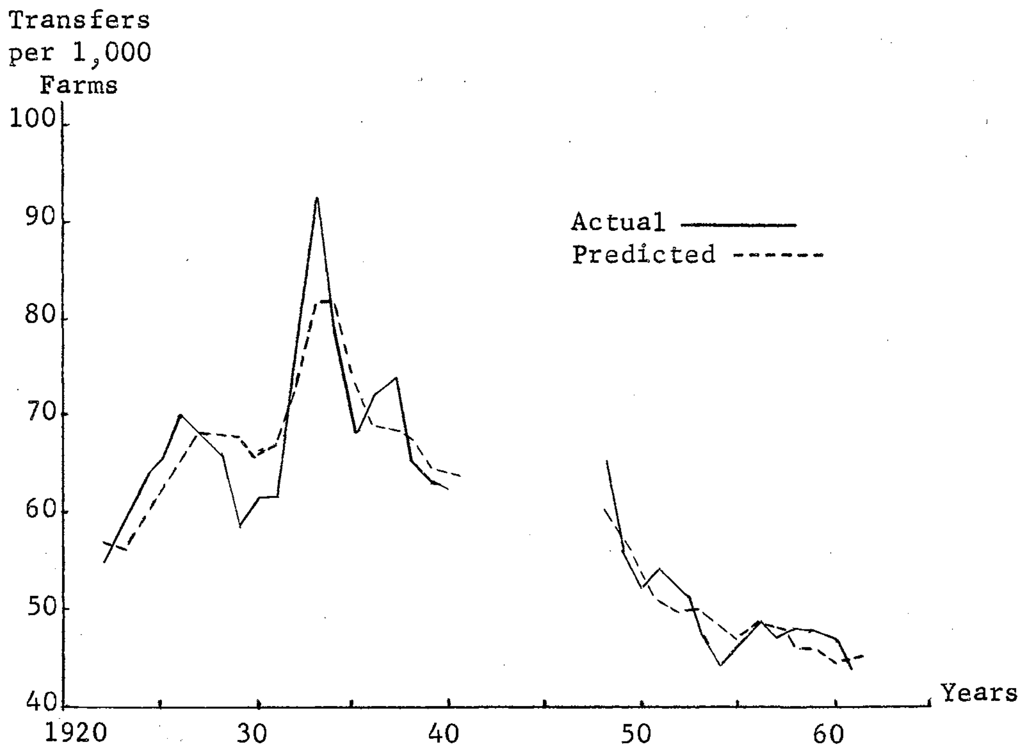

Figure 8. Transfers per 1,000 Farms; Actual and Predicted, Computed from Equation (4.2)

hypothesis that landowners hold for further gains as opposed to "profit-taking."

The equation predicting the number of farms for the U. S. as a component of the land price equation (4.1) was estimated as:

$$(4.3) \qquad A_t = 594.41 - 3.608S_t + 1.915JX_t - 2.713Cg_t + .918A_{t-1}$$

Computed t = (4.6) (2.6) (3.4) (36.2)

$R^2 = .998$ $\qquad$ $d' = .98$

Signs on the coefficients indicate that fewer farms result from increases in the stock of machinery and with capital gains. Machinery substitutes for farm family labor and is directly associated with fewer (larger) farms. Increased farm financial success again is predicted to work at cross purposes through the capital gains and income variables, although the latter (JX) is modified by nonfarm incomes and unemployment. Capital gains do provide an additional equity base to secure credit for expansion of farmland holdings and machinery stock and thus might contribute to a reduction in the number of farms, A_t. Increases in per capita farm incomes are predicted, ceteris paribus, to retard the mortality of farm firms, at least when the income ratios are corrected for unemployment in the nonfarm sector.

The adjustment rate is rather slow, as shown by a coefficient of .92 on lagged number of farms, A_{t-1}.[2] The equation predicts that nearly nine years are required to close half the gap between the situation at a given time and the equilibrium adjustment. The Durbin-Watson

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[2]The computation of adjustment rates is discussed on pages 57-58 and in Appendix C.

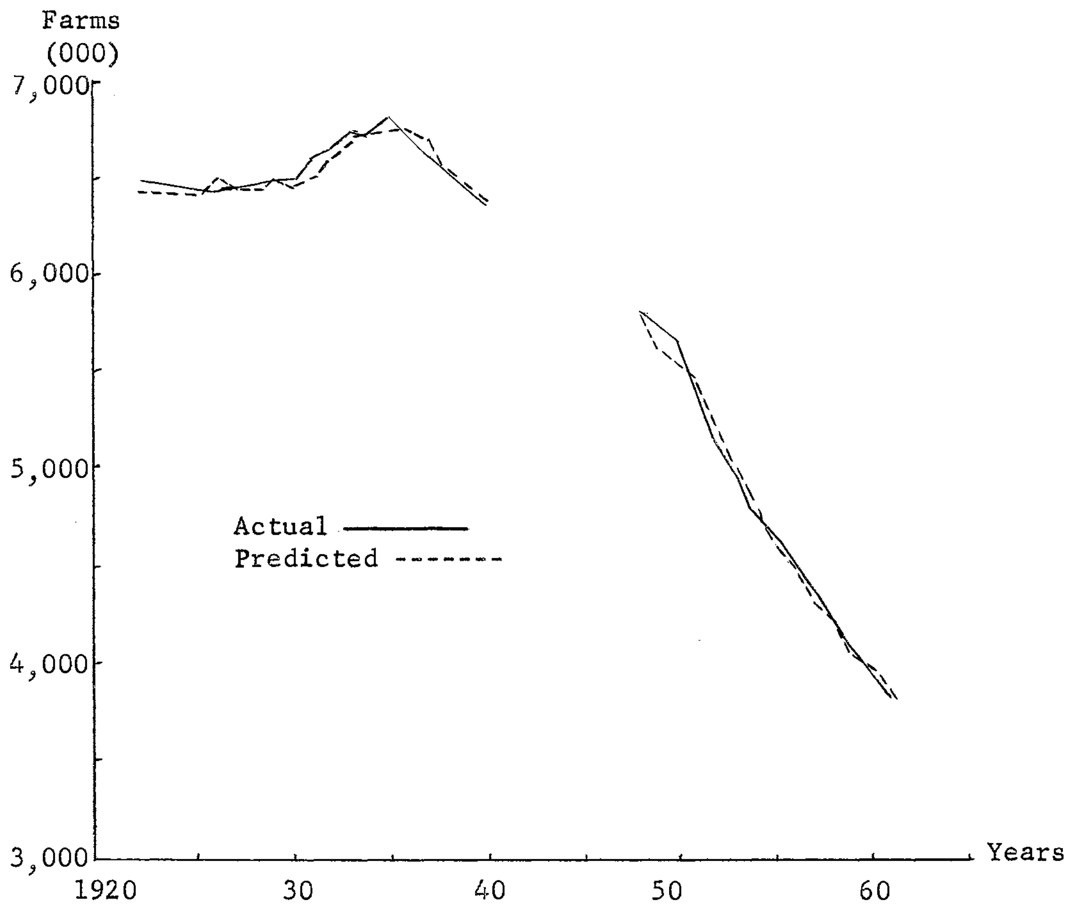

Figure 9. Number of Farms: Actual and Predicted, Computed from Equation (4.3).

statistic d' suggests a strong possibility of serial correlation in the residuals in this equation.

The land-in-farms equation includes the estimate of cropland used for crops as one of the endogenous variables and therefore necessitates a two-stage process of estimation.

The cropland equation is given as:

$$(4.4) \quad \hat{C}_t = 37.78 - .058Lr_t - .046H_{t-1} + .263F_{t-1} + .015P_{t-1} + .615C_{t-1}$$

Computed t = (1.7) (1.3) (2.0) (.6) (5.1)

$R^2 = .839$ $\quad$ $d' = 1.87$

The estimated values for C from the above equation result in the following estimates for the land-in-farms equation:

$$(4.5) \quad \widehat{Lf}_t = -357.65 + 4.05\hat{C}_t + .57Lr_t - .18F_{t-1} - .237E_t + .975Lf_{t-1}$$

Computed t = (3.97) (2.89) (.33) (.87) (34.05)

$R^2 = .996$ $\quad$ $d' = .884$

Substitution of (4.4) for $\hat{C}_t$ in (4.5) then gives a summary of the predicted combined effects of each of the variables included in the two equations on land-in-farms. The resulting equation is summarized in (4.6).

$$(4.6) \quad \widehat{Lf}_t = -204.7 + .332Lr_t - .185H_{t-1} + .883F_{t-1} - .236E_t + .061P_{t-1} + 2.49C_{t-1} + .975Lf_{t-1}$$

The coefficients are interpreted to predict decreases in the amount of land in farms as a result of increases in H (output per acre of cropland) and E (nonfarm employment). A one-point increase in output per acre (based on an index 1947-49 = 100) substitutes for 185,000 acres of farmland and the addition of one million employed requires 236,000 acres, about one-fourth acre per nonfarm employee. This estimate

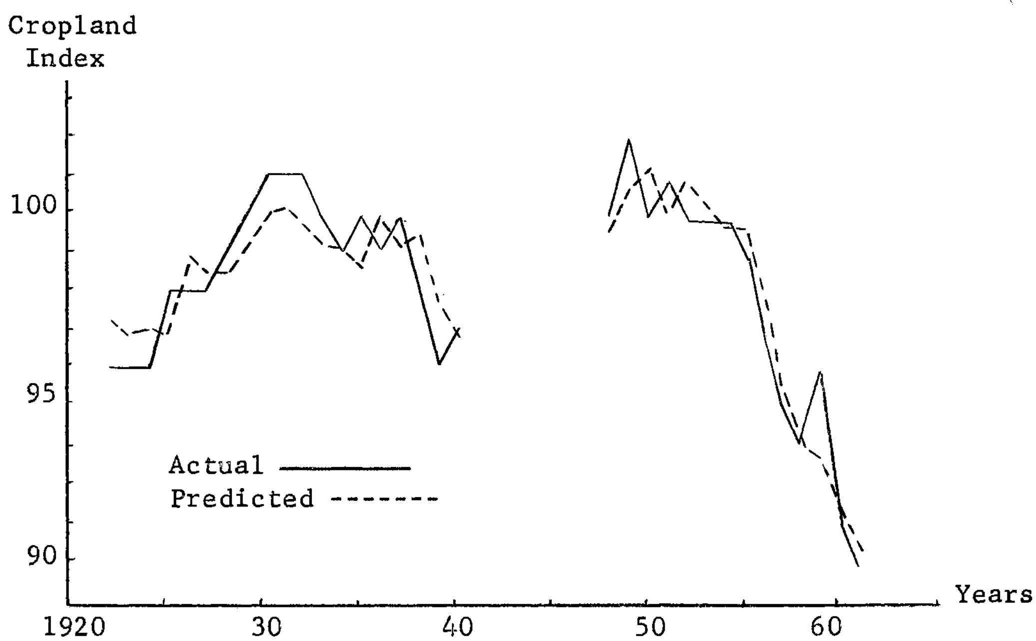

Figure 10. Actual and Predicted Values: Cropland Used for Crops, Computed from Equation (4.4).

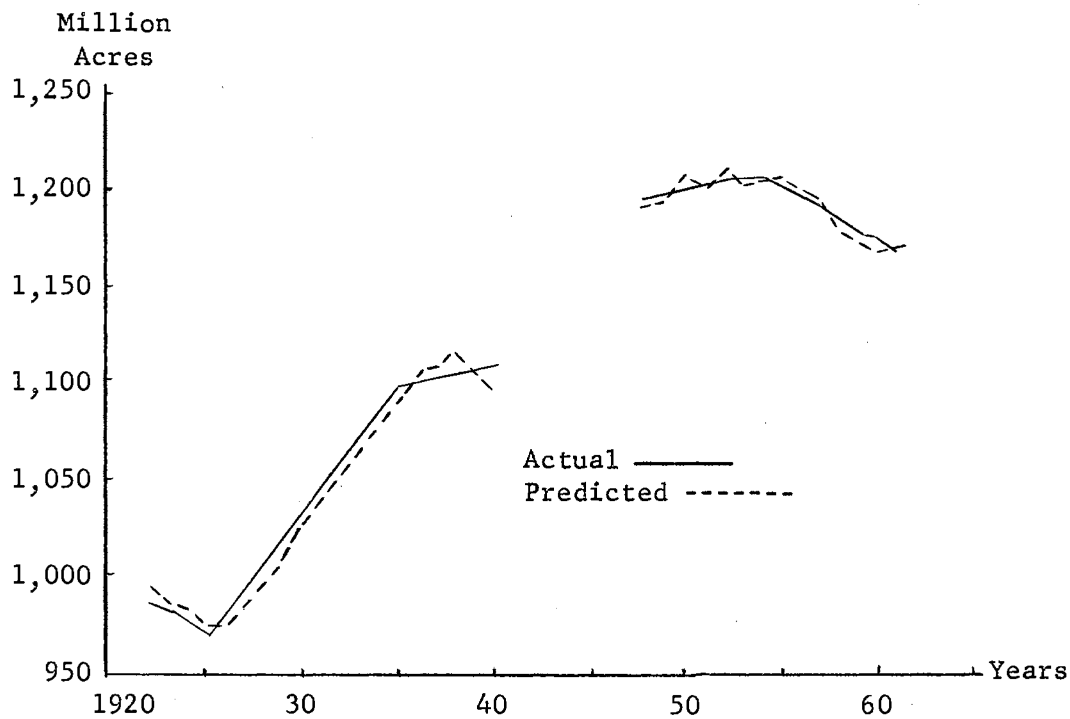

Figure 11. Actual and Predicted Acreages: Land in Farms Equation, Computed from Equation (4.5).

reflects requirements for housing, plant, shopping center space, schools, and other community services. All urban expansion does not require farmland, however, so this coefficient should be expected to underestimate the total land requirements per marginal nonfarm employee. Land-in-farms is affected in a positive manner by land retirement Lr, farm income F, and the cropland index C, and to a lesser extent by the price of land P, which also carries a low confidence level.

One million acres of land retirement is predicted to add, ceteris paribus in the short-run, 332,000 acres to land-in-farms. There is obviously a limit beyond which this relationship cannot be expected to hold. This equation will also be modified later in this chapter to include the cropland equation (4.4) in the reduced form equation (4.6). This substitution will relax the constant cropland assumption and reduce this coefficient to 267,000 acres in the short run, 5,000 acres after five years of adjustment, and reduce land-in-farms by 365,000 acres after ten years (see equation (4.6), Table IV). No attempt is made here to separate the portion of the addition resulting from government reclamation projects working at short-run cross purposes with land retirement programs and to what extent it is the result of farmers attempting to replace the land resource rented to the government.

Farm income appears to have little direct influence on land-in-farms but is indicated to expand Lf acting recursively through the cropland used for crops variable C. A one billion dollar change in income is associated with a .263 change in cropland index in (4.4). Combination of the positive effect of income F on cropland, the positive effect of cropland on land in farms Lf, and the negative direct effect of farm income on Lf provides a net positive result of .883 million acres of land added to Lf for each billion dollars increase in net farm income F. Since this same change in income adds 1.21 million acres to cropland (.263 x 4.6 million acres) the implication is that 1.21 - .88 = .33 million acres are converted from noncrop uses in response to the one billion dollar income change.

Adjustment Model Results

The mechanics of the adjustment model were introduced in Chapter III. We turn at this point to the application of this model to the equations of this chapter estimated with data for the U. S. Each of the equations in the preceding section was estimated by least squares yielding short-run coefficients in the general form:

$$Y_t = ga + gb_1X_1 + gb_2X_2 + \ldots + gb_iX_i + (1-g)Y_{t-1} + gu$$

where Y_t is the dependent variable,

X_i are predetermined variables,

b_i are regression coefficients,

and g is the adjustment rate.

The coefficients directly obtained and discussed above are the short-run coefficients gb_i. Long-run coefficients are obtained by the formula:

$$b_i = \frac{gb_i}{g}$$

Since different adjustment rates were obtained for each equation, the long-run equations obtained by this process are nonhomogeneous with respect to the time required to adjust by a given percent to the equilibrium. The amount of dissimilarity is estimated by determining the length of time required to accomplish some particular portion of the complete adjustment to equilibrium, which is assumed by the model to be asymptotic to 1.00 as time proceeds. This estimate is obtained by formula:

$$N = \frac{\log (1-A)}{\log (1-g)}$$

where A is the percentage of the adjustment completed,

N is the number of years required,

and g is the adjustment rate.

The amount of adjustment which is predicted to be completed by some particular time can be computed by assigning the desired time period for N and solving algebraically for the value of A.[3]

Short-run coefficients and coefficients adjusted to homogeneous five year and ten year values for equations predicting the land price index are presented in Table II. Observed rather than estimated values were used for all independent variables in estimating equations in the remaining tables of this chapter. Computed "t" values are shown in parenthesis immediately below the short-run coefficients, and elasticities appear in the third line of each section. Equation (4.1) is estimated recursively and equation (4.1') containing the same variables is estimated by simple least squares. In absolute magnitudes, the coefficients of T, Lr, and P_{t-1} are smaller; of A, Lf, and F are larger in the recursive equation. Equations (4.1A and (4.1B) are alternatives to (4.1'). (4.1A) does not include the number of farms A, or land retirement Lr;

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[1] For development of five year and ten year coefficients, see Appendix C.

TABLE II

ALTERNATIVE LAND PRICE EQUATIONS, SHOWING ADJUSTED COEFFICIENTS FOR P, DEFLATED LAND PRICE INDEX

Equation (4.1') $P_t = f(T_t, A_t, Lf_t, Lr_t, F_{t-1}, P_{t-1})$ $R^2 = .898$

	a	T_t	A_t	Lf_t	Lr_t	F_{t-1}	P_{t-1}	Portion of Adjustment Completed
SR*	73.5	-.254	-.0007	-.031	.166	.645	.683	.32
(t)		(2.0)	(.21)	(1.5)	(1.4)	(1.7)	(5.8)	
E		-.115	-.028	-.356	.052	.076		
5 year	197.4	-.683	-.0019	-.084	.446	1.73	.149	.85
10 year	226.7	-.784	-.0022	-.097	.513	1.99	.022	.98

Equation (4.1A) $P_t = f(Yd_t, Lf_t, F_{t-1}, P_{t-1})$ $R^2 = .904$

	a	Yd_t	Lf_t	F_{t-1}	P_{t-1}	
SR	68.2	.106	-.063	.661	.661	.34
(t)		(4.2)	(3.7)	(2.1)	(7.2)	
E		.34	-.712	.078		
5 year	175.7	.272	-.161	1.70	.126	.87
10 year	197.6	.306	-.182	1.92	.016	.98

Equation (4.1B) $P_t = f(A_{t-1}, Lf_t, F_{t-1}, P_{t-1})$ $R^2 = .870$

	a	A_{t-1}	Lf_t	F_{t-1}	P_{t-1}	
SR	125.4	-.008	-.048	.437	.641	.36
(t)		(3.7)	(2.7)	(1.7)	(5.9)	
E		-.331	-.546	.052		
5 year	310.5	-.020	-.119	1.082	.111	.89
10 year	345.2	-.022	-.133	1.203	.011	.99

*SR = short-run equation, estimated directly by least squares, t = computed t value, E = elasticity of price with respect to the variable indicated.

5 year = the short-run equation $\left(\frac{\text{percent adjustment completed}}{\text{adjustment rate g}}\right)$

10 year = SR equation $\left(\frac{\text{percent adjustment completed}}{\text{adjustment rate g}}\right)$.

but does contain deflated national disposable income Yd, measured in billions of 1957-59 dollars. (4.1B) is from an earlier model which included all years from 1922-1961.

National disposable income Yd is included in (4.1A) to measure the influence on land values of nonfarm economic forces. The coefficient is highly significant (t = 4.2). The equation explains 90 percent of the variation in land price and all t values are significant at the 95 percent probability level. Because of high correlation with other important variables, A and Lf, it is not possible to judge adequately the structural validity of the coefficient for Yd. Equation (4.1B) is obtained by eliminating two variables, A and Lr, from the land price equation (4.1'). All coefficients are significant at the 95 percent probability level in this equation and signs agree with their counterparts in (4.1'). The farm numbers variable A is lagged one year to account for a possible slow adjustment of land prices to farm size changes. Replacing the lagged variable with the current variable A resulted in nearly the same magnitude and significance of the coefficient. It is difficult to appraise adequately the role of current and lagged variables given the data available.

One additional point noted here is the similarity in the adjustment rate among equations (4.1'), (4.1A) and (4.1B) which have coefficients on lagged land price of .68, .66, and .64, respectively. This consistency suggests that the adjustment rate is not highly sensitive to the particular variables selected.

The absolute magnitude of the direct coefficients must be interpreted in terms of measurement units of the original data.

The dependent variable in (4.1'), the deflated 1957-59 land price index, conveniently falls at 100 when land is approximately $100 per acre, U. S. average. Cropland C is an index with 100 equal to about 379 million acres. Other land variables Lf and Lr are in millions of acres and aggregated money variables are in billions of 1957-59 dollars.

Elasticities

The elasticities for each of the short-run equations are provided below the computed values in Table II as an aid to interpretation. The elasticities shown were computed at the mean for the final five years of the data, 1957-1961. The recent five year period mean is used to approximate the current situation, on which policy considerations are likely to be based. A five year average was chosen over the most recent year to avoid atypical elasticities caused by temporary disturbances.

Elasticities for the five and ten year equations are not shown, but are larger in direct proportion to the change in size of the corresponding coefficient. The ten year coefficient on transfers in equation (4.1'), for example, is approximately three times the short-run coefficient. The elasticity of this parameter is therefore 3(-.115) or -.345. The absolute magnitude of a one percent change differs among variables, of course. A one percent change in land retirement Lr is only 300,000 acres, but a one percent change in land-in-farms Lf is 11 million acres.

Tables III and IV contain estimated current, five, and ten year coefficients and elasticities for the farm transfers T, number of farms A, cropland C, and land-in-farms Lf equations. Transfers are indicated

TABLE III

TRANSFERS, NUMBER OF FARMS, AND CROPLAND EQUATIONS, SHOWING ADJUSTED COEFFICIENTS, COMPUTED "t" VALUES, AND ELASTICITIES*

Transfers per 1,000 farms = T
Equation (4.2) $T_t = f(JX_t, Cg_t, T_{t-1})$ $R^2 = .875$

	a	JX_t	Cg_t	T_{t-1}	Portion of Adjustment Completed
SR	40.1	.122	-.366	.311	.69
(t)		(1.9)	(5.7)	(3.1)	
E		.091	-.277		
5 year	58.0	.177	-.532	.003	.997
10 year	58.2	.178	-.581	.000009	.9999

Number of farms = A
Equation (4.3) $A_t = f(S_t, JX_t, Cg_t, A_{t-1})$ $R^2 = .998$

	a	S_t	JX_t	Cg_t	A_{t-1}	
SR	594.4	-3.61	1.91	-2.69	.918	.08
(t)		(4.6)	(2.6)	(3.4)	(36.2)	
E		-.083	.016	-.023		
5 year	2,351.6	-15.4	8.15	-11.46	.652	.35
10 year	4,166.6	-25.3	13.42	-18.88	.426	.57

Cropland index = C
Equation (4.4) $C_t = f(Lr_t, H_{t-1}, F_{t-1}, P_{t-1}, C_{t-1})$ $R^2 = .839$

	a	Lr_t	H_{t-1}	F_{t-1}	P_{t-1}	C_{t-1}	
SR	37.8	-.059	-.046	.263	.015	.615	.38
(t)		(1.7)	(1.3)	(2.0)	(0.6)	(5.1)	
E		-.020	-.058	.034	.016		
5 year	89.6	-.140	-.108	.623	.036	.088	.91
10 year	97.5	-.152	-.118	.678	.039	.008	.99

*See footnote, Table II for notation.

TABLE IV

LAND-IN-FARMS EQUATIONS SHOWING ADJUSTED COEFFICIENTS, COMPUTED "t" VALUES, AND ELASTICITIES*

Land-in-farms = Lf
Equation (4.5') $Lf_t = f(C_t, Lr_t, F_{t-1}, E_t, Lf_{t-1})$ $R^2 = .997$

	a	C_t	Lr_t	F_{t-1}	E_t	Lf_{t-1}	Portion of Adjustment Completed
SR	-292	3.3	.46	-.049	-.29	.983	.02
(t)		(5.4)	(3.2)	(0.1)	(1.2)	(41.5)	
E		.263	.013	-.0005	-.015		
5 year	-1403	15.9	2.22	-.234	-1.39	.918	.08
10 year	-2693	30.4	4.26	-.450	-2.66	.843	.16

Land-in-farms = Lf
Equation (4.6') $Lf_t = f(Lr_t, H_{t-1}, F_{t-1}, E_t, P_{t-1}, C_{t-1}, Lf_{t-1})$

	a	Lr_t	H_{t-1}	F_{t-1}	E_t	P_{t-1}	C_{t-1}	Lf_{t-1}
SR	-167	.267	-.151	.819	-.288	.050	2.03	.983
E		.007	-.015	.009	-.015	.004	.164	
5 year	17.5	.005	-1.71	9.64	-1.38	.566	1.400	.918
10 year	274.5	-.365	-3.58	20.2	-2.66	1.18	.237	.843

*See footnote, Table II for notation.

to adjust more rapidly then land prices reported in Table II. Farm numbers adjust only about one-half as fast as transfers and land prices, but more rapidly than land in farms. The latter, Lf, achieves only 16 percent of the total adjustment in 10 years and would require over 100 years to complete nine-tenths of the total.

Equation (4.6') is the "reduced form" Lf equation obtained by substituting (4.4) into (4.5') and combining terms.

The heterogeneity of the adjustment rates among equations is illustrated in Tables II, III, and IV. Rates vary from 99 to only 16 percent completion of the adjustment to the "equilibrium" position in ten years. For some equations more than 20 years are required for 90 percent of the complete adjustment. When combining coefficients of two or more equations into the reduced form, the five-and ten-year equations were considered more applicable than those obtained for the "long-run."

Special note of the coefficients on Lr in Table IV reveals that a sign change occurs in the reduced form equation (4.6') between the fifth and the tenth year. Equation (4.5') indicates that, if cropland were held constant, land retirement would increase land in farms. But equation (4.4) in Table III shows that Lr reduces cropland used for crops with a more rapid adjustment rate. These two conflicting effects exchange dominance between the fifth and tenth year of sustained land retirement.

Reduced Form Equation for U. S. Land Price Index

Table V approximates the net effects of all variables considered when estimated values for T, A, L, and C have been substituted into the

TABLE V

REDUCED FORM ADJUSTMENT EQUATIONS FOR THE U. S. DEFLATED LAND PRICE INDEX

Section A. Coefficients $P = f(S, JX, Lr, \ldots\ldots C_{t-1})$

Time	a	S_t	JX_t	Lr_t	H_{t-1}	F_{t-1}	E_t	Cg_t	P_{t-1}	T_{t-1}	A_{t-1}	Lf_{t-1}	C_{t-1}	P
SR	68	.004	-.032	.16	.0047	.619	.0091	.0949	.682	-.079	-.00066	-.031	-.064	
E		.002	-.011	.05	.0054	.076	.005	.0325	.659	-.037	-.02683	-.352	-.058	
5 year	151	.030	-.137	.45	.1447	.919	.1168	.3857	.100	-.002	-.0013	-.078	-.118	
10 year	145	.056	-.169	.55	.3476	.031	.2579	.4603	-.093	-0	-.0010	-.082	-.023	

Section B. Predictions for 1961 Target Data

Year	a	S_t	JX_t	Lr_t	H_{t-1}	F_{t-1}	E_t	Cg_t	P_{t-1}	T_{t-1}	A_{t-1}	Lf_{t-1}	C_{t-1}	P_{61}
1961 1961	68.11	.26	-1.06	8.73	.60	7.40	.58	3.41	74.70	-3.72	-2.61	-36.28	-6.00 =	114.20
1957 1961	151.75	2.96	-5.10	12.44	15.77	11.10	7.19	12.31	9.14	-.10	-5.64	-92.77	-11.47 =	107.60
1952 1961	145.24	5.37	-9.68	0	34.06	.52	14.91	16.96	-7.27	0	-5.11	-98.38	-2.32 =	94.30

Section C. Predictions from 1957-1961 Average Data

														P_i
SR	68.11	.24	-1.14	5.09	.56	7.60	.57	3.39	68.71	-3.82	-2.79	-36.62	-6.07 =	103.83
5 year	151.75	2.78	-4.81	14.40	17.28	11.27	7.29	13.70	10.85	-.10	-5.29	-91.85	-11.26 =	116.02
10 year	145.24	5.25	-5.94	17.69	41.50	.38	16.10	16.36	-9.35	0	-3.99	-96.84	-2.19 =	124.21

Section D. Data Used in Sections B and C

Year	S_t	JX_t	Lr_t	H_{t-1}	F_{t-1}	E_t	Cg_t	P_{t-1}	T_{t-1}	A_{t-1}	Lf_{t-1}	C_{t-1}	P_i
1961	99	32.65	55.35	127	11.95	63.9	35.8	109.6	47.1	3939	1174	94	111.2
1957-61 Average	94	35.20	32.27	119	12.28	62.4	35.5	100.8	48.3	4233	1185	95	104.14
1957	100	37.37	27.89	109	12.08	61.6	31.9	91.4	49.7	4514	1197	97	94.6
1952	96	57.31	0	98	16.56	57.8	36.8	78.4	54.0	5428	1204	101	89.2

equation for land price P (Equation 4.1). All signs are consistent with the former discussion of the land price equation except that on lagged land price in the ten year equation. The negative coefficient suggests a cyclical pattern, and arises because of the negative coefficient on Lf in the land price equation (4.1).

One device for understanding the meaning and implications of a model is to substitute values for recent years into the model and compare results. Data for three time periods are used in this section of the analysis to provide two types of contrasts: (1) A common "target" year was selected and data from an appropriate previous year was substituted into the respective equation. For this phase, the year 1961 was chosen as the target year and data from 1952, 1957, and 1961 were substituted respectively into the ten-year, five-year, and short-run equations. Results are provided in Section B of Table V. (2) Each of the equations was applied to the data for a single time period. The time period used was the average of the five years 1957-1961. This particular period was used invoking the same arguments presented for the selection of the base data for computation of elasticities earlier in this chapter. The contribution of each variable and the estimated price indices are in Section C of Table V.

Variation in the estimates between time periods emerges from two sources, (1) changes in the coefficients due to heterogeneous adjustment rates, and (2) variation in the data over time. The data for each time period used are provided in Section D of Table V to enable the reader to observe these variations and their effects on the estimates.

The Coefficients

Inspection of the coefficients in Section A of Table V reveals that they generally maintain sign and increase in magnitude over time, consistent with long-run elasticity concepts. Secondly, it will be recalled that the longer-run equations contain the cumulative recursive effects of the short-run equations. Several exceptions to the generalization above may be cited. The coefficient of deflated farm income F_{t-1} becomes larger in the five-year equation and recedes to .031 in the ten-year coefficient. The source of this apparent inconsistency is the negative effect entering in increasing importance over time from the land-in-farms equation. The direct effect of F is to increase land price, but a delayed decrease evolves through a series of events including an increase in the amount of land in farms over time. The net effect of one billion dollars in the ten-year equation is only three cents per acre.

The coefficient of the lagged land price P_{t-1} changes sign from positive to negative in the ten year equation. Again the net effect is negligible. In this linear system, when a variable enters from two different equations (as F_{t-1}, P_{t-1}, A_{t-1}, and C_{t-1} do), the smaller short-run coefficient from the more slowly adjusting equation may dominate eventually.

The Predictions

In the first row of Section B, Table V, the short-run equation is used to predict the 1961 price index P from 1961 data. The predicted index is shown in the last column of Section B as 114.20, compared to the actual index for the same year of 111.2 shown in Section D. A major contribution to the total predicted price made by P_{t-1} indicates that influences prior to year t-1 are important in determining current price. Also past year variables Lf_{t-1}, F_{t-1}, and C_{t-1} play somewhat important roles. Thus, in the short-run, the past variables dominate the value of land price and current year variables have only a small impact on price. An exception is land retirement Lr which appears to have an immediate impact on land values. The time period assumed is too short for a change in technological gains H_{t-1} to be capitalized into land prices.

The second row of Section B presents the results of substituting 1957 data into the five year equation, giving a predicted price index of 107.60. Lf_{t-1} carries the largest value, but H_{t-1}, Lr_t, F_{t-1}, and JX_t have acquired sizeable magnitudes. Significant changes occurred in the data for JX, Lr, H, Cg, and A. If the 1957 values had been equal to the 1961 values for these variables, the effect of Lr would have been greater. Land retirement increased from 27.89 to 55.35 million acres between 1957 and 1961. JX, representing the farm-nonfarm income ratio and unemployment was about 15 percent greater in 1957 than in 1961, which accounts for part of the increased effect from that source.

Data for 1952 were plugged into the ten-year equation to obtain the third row of Section B. The results suggest what the land price would have been in 1962 if the 1952 values of the explanatory variables had persisted and had influenced P over the ten year period. There was no land retirement program in 1952. Some effects of the Korean conflict are introduced through JX. The large cumulative effects of nonfarm employment E and output per acre of cropland H_{t-1} have taken on significant proportions. Data for 1952 used in the short-run equation (not shown) gave an estimated index of 89.314, compared to the reported 89.2.

Section C presents the values obtained using average 1957-61 data in each of the three equations. The estimates are included to indicate what the land price would be in one, five, and ten years under 1957-61 conditions. The deflated land price index of 116.0 underestimates the deflated 1963 index by about five index points.

Further implications of the analysis of this chapter are discussed in Chapter VI. But before tracing this line of thought further we note important differences which exist among the several geographic regions in Chapter V.

CHAPTER V

REGIONAL VARIATIONS IN LAND PRICE STRUCTURE

In this chapter the national model in Chapter IV is applied to the geographical regions of the U. S. While some variations in results between regions can be attributed to measurement or statistical error, coefficients also behave differently among the regions because of real and important differences in the effects of the variables themselves or the structural manner in which they enter the economic model. One purpose of the regional analysis is to estimate structural diversity which would be overlooked in a national aggregated analysis.

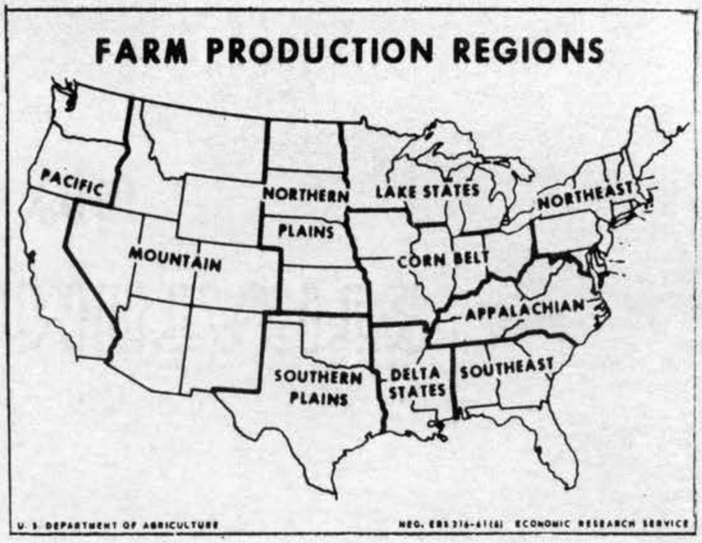
Data Used in the Regional Model

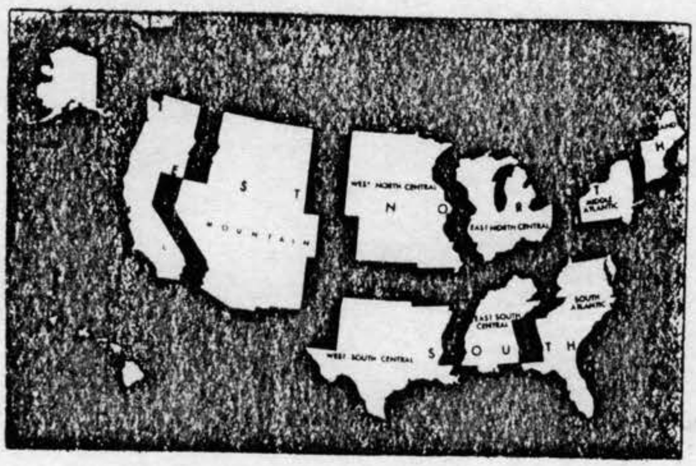
The use of the regional model imposes some restrictions on the analysis. Some of the variables in the national model are unavailable on a regional basis. While prices of farm land have been published on a state and regional basis since the inception of the modern series of USDA data in 1910, other variables were reported nationally only at first and were later estimated back from the time when regional estimates were initiated.

The variables selected for this analysis are published by two governmental agencies, the Department of Agriculture and the Department of Commerce. The Bureau of the Census in the Department of Commerce has consistently grouped states into specific "geographical regions." The USDA adopted these same areas for statistical reporting purposes for most series prior to 1958 and has continued to use them in some cases. Since 1958, much of the USDA data has been grouped by "production regions" with greater homogeneity of type-of-farming within regions. These production regions provide different grouping of states than the geographic regions, especially in the eastern two-thirds of the nation. The geographical regions were selected for use in this analysis because of greater continuity of the data available over time. The composition of the geographical regions is shown in Figure 12. The New England Region (states northeast of New York) containing 2.6 percent of the nation's farms and less than one percent of the land in farms is omitted in the analysis.

Estimated Regional Equations

Equations estimated nationally in Chapter IV also are estimated for the eight geographical regions in the current chapter. Observed values rather than recursively estimated values for C, Lf, A, and T were used to reduce computations. Observations for the years, 1930-1961, inclusive were included. Short-run coefficients, computed t values, elasticities and multiple correlation coefficients are presented in Tables VI through X for equations estimating deflated land price indices, transfers per 1,000 farms, number of farms, land in farms, and the cropland-used-for-crops indices. Table XI presents coefficients and elasticities for the "composite" land price index equation obtained by substituting into the land price equation P the equations for the





GEOGRAPHICAL REGIONS

Figure 12. Farm Production Regions and Geographical Regions of the U. S.

Source: <u>1959 Census of Agriculture</u>, Volume V, Part 6, Chapter 1, p. 5.

cropland index C, land in farms Lf, number of farms A, and transfers per 1,000 farms T. The results of the U. S. model of Chapter IV are included in each table for comparison and contrast. Discussion of these tables follows.

The Land Price Index Equation

(5.1) $$P_t = f(T_t, A_t, Lf_t, Lr_t, F_{t-1}, P_{t-1})$$

The coefficient on T, transfers per 1,000 farms, is consistently negative and generally significant implying, ceteris paribus, that a greater volume of land transfers is associated with lower land prices in agreement with the national model. The influence of the number of farms A is varied in sign and significance. In one sense, fewer farms mean that fewer farmers are competing for land and thus a positive relationship would be expected. However, few farms may also be associated with excess machinery on farms or potential cost economies from purchase of larger machines, creating pressure for farm enlargement. Where this pressure for consolidation is intense, and the adjustment out of farming lags behind the accumulation of machinery and labor-saving technology, this negative relationship may dominate in the land price equation.

Aggregate regional farm income F_{t-1} exhibits a positive coefficient consistent with marginal productivity theory. It is interesting to note here that the simple correlation between deflated aggregate farm income and deflated land price is extremely low and inconsistent in sign among regions. The simple correlation between these two variables in the national model for the period considered (1922-61) was .04.

TABLE VI

REGIONAL SHORT-RUN COEFFICIENTS, COMPUTED "t" VALUES AND ELASTICITIES, DEFLATED LAND PRICE EQUATIONS

Equation (5.1) $P_t = f(T_t, A_t, Lf_t, Lr_t, F_{t-1}, P_{t-1})$

Region	a	T_t	A_t	Lf_t	Lr_t	F_{t-1}	P_{t-1}	R^2
MA	1.19	-.496	.041	.340	6.186	10.297	.944	.804
t		(2.6)	(1.9)	(.2)	(.8)	(1.4)	(5.8)	
E		-.213	.086	.093	.044	.058		
ENC	132.50	-.206	-.006	-.860	-.224	2.310	.721	.933
t		(1.8)	(.3)	(1.5)	(.3)	(1.7)	(4.8)	
E		-.098	-.041	-.909	-.008	.048		
WNC	278.25	-.447	.029	-.969	.191	4.673	.806	.935
t		(3.8)	(.8)	(2.4)	(.6)	(5.0)	(9.2)	
E		-.180	.240	-2.707	.023	.136		
SA	109.65	-.136	-.024	-.585	.445	3.632	.648	.897
t		(1.5)	(1.5)	(2.2)	(.3)	(1.9)	(4.6)	
E		-.053	-.152	-.519	.010	.057		
ESC	96.61	-.192	-.009	-.732	1.460	7.987	.629	.948
t		(2.5)	(.6)	(1.6)	(.7)	(3.4)	(5.4)	
E		-.073	-.051	-.508	.026	.083		
WSC	143.16	-.340	-.023	-.412	.427	2.544	.751	.889
t		(2.9)	(1.0)	(1.4)	(.6)	(.9)	(5.3)	
E		-.159	-.122	-.866	.026	.036		
MTN	180.10	-.264	-.318	-.415	.711	26.760	.836	.873
t		(1.1)	(1.2)	(2.5)	(.3)	(3.0)	(6.6)	
E		-.140	-.169	-1.08	.013	.153		
PAC	236.14	-.309	-.355	-1.471	2.122	12.00	.661	.894
t		(1.7)	(2.9)	(3.0)	(.3)	(3.2)	(5.0)	
E		-.188	-.228	-1.08	.013	.153		
US	73.47	-.254	-.0007	-.031	.166	.644	.683	.898
t		(2.0)	(.2)	(1.5)	(1.4)	(1.7)	(5.8)	
E		-.115	-.028	-.336	.055	.076		

The coefficients on lagged land price indicate a rather rapid adjustment to the equilibrium level. The Middle Atlantic Region exhibits the slowest adjustment. In the Mountain Region also, adjustment is estimated to be rather slow with a lagged coefficient of .836. One-half of the adjustment in the Mountain Region would take place in four years,[1] and adjustment would be 90 percent complete in 13 years. The East South Central and South Atlantic Regions indicate 90 percent completion in about five years.

The R^2's for the regional land price index equations range from .80 in the Middle Atlantic to .948 in the East South Central. Eight of the nine equations possess an R^2 above .87.

The Farm Transfers Equation

The equation for transfers per 1,000 farms was constructed as:

$$T_t = f(JX_t, Cg_t, T_{t-1}) \qquad (5.2)$$

This equation is not as adequately specified as other equations in the system, measured by the percentage of variation explained by the regression in the regional equations. The R^2 ranges from a high of .90 in the West North Central Region to a low of only .39 in the Pacific Region. There is no variation in signs on each variable among regions. Computed t values are generally significant. The adjustment rate is decidedly faster than in the other equations.

The ratio of farm to nonfarm per capita incomes, modified for changes in unemployment, is JX. No satisfactory estimate of nonfarm unemployment was available on a regional basis and the national

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[1] $(1-g)^4 = .49$.

TABLE VII

REGIONAL SHORT-RUN COEFFICIENTS, COMPUTED "t" VALUES AND ELASTICITIES, TRANSFERS PER 1,000 FARMS EQUATIONS

Equation (5.2) $T_t = f(JX_t, Cg_t, T_{t-1})$

Region	a	JX_t	Cg_t	T_{t-1}	R^2
MA	17.66	.3915	-.2908	.6404	.819
t		(2.1)	(3.1)	(5.6)	
E		.1315	-.2046		
ENC	19.02	.4130	-.2837	.6067	.789
t		(2.4)	(3.2)	(5.1)	
E		.1724	-.2047		
WNC	15.55	.4305	-.5175	.6151	.902
t		(3.5)	(5.0)	(7.2)	
E		.5094	-.3255		
SA	28.53	.4440	-.3134	.502	.876
t		(1.7)	(4.1)	(4.2)	
E		.2182	-.4813		
ESC	15.87	.3684	-.2320	.740	.827
t		(1.0)	(2.6)	(7.2)	
E		.1673	-.3067		
WSC	25.36	.3009	-.2111	.506	.587
t		(1.4)	(2.4)	(3.6)	
E		.1540	-.1706		
MT	20.97	.2426	-.3445	.6217	.747
t		(1.9)	(2.6)	(4.8)	
E		.1780	-.1743		
PAC	32.24	.1977	-.1637	.483	.391
t		(1.7)	(1.8)	(3.3)	
E		.1208	-.0969		
US	40.09	.1223	-.3691	.3112	.875
t		(1.9)	(5.7)	(3.1)	
E		.091	-.277		

unemployment rate was used. There may be sufficient job mobility among regions to justify use of the national rate. Increases in transfers are associated with rising relative farm income and with falling nonfarm unemployment.

The equations indicate that capital gains reduce farm transfers, reinforcing the view that increasing prices encourage holding rather than "profit taking."

Elasticities indicate sensitivity to JX in the West North Central and to capital gains in the South Atlantic Regions. Real estate transfers are comparatively unresponsive to these variables in the Pacific Region.

The Farm Numbers Equation

Equation (5.3) illustrates regional variation in the ability of this model to predict the number of farms. The equation explains a high percentage of the variation in the number of farms in all but the Middle Atlantic Region. The stock of machinery S indicates that machinery substitutes for farms and farm workers except in the Mountain Region where predominance of livestock and irrigation has minimized opportunities for substitution. In this region, accumulation of machinery has been highly correlated with reclamation of additional land, keeping the two resources in a stage of complementarity.

JX associates higher farm incomes with more farms, ceteris paribus, except in the low income South Central regions. Capital gains are estimated to contribute to fewer farms except in the West South Central Region. The elasticity on Cg in Table VII is very similar in the WNC,

TABLE VIII

REGIONAL SHORT-RUN COEFFICIENTS, COMPUTED "t" VALUES AND ELASTICITIES, NUMBER OF FARMS EQUATIONS

Equation (5.3) $A_t = f(S_t, JX_t, Cg_t, A_{t-1})$

Region	a	S_t	JX_t	Cg_t	A_{t-1}	R^2
MA	400.44	-2.182	3.8309	-.8333	.1262	.449
t		(1.7)	(1.5)	(.5)	(.7)	
E		-.9588	.2646	-.0121		
ENC	42.49	-.1191	.2594	-.5413	.9523	.997
t		(.9)	(1.1)	(3.3)	(33.7)	
		-.0161	.0073	-.0264		
WNC	52.44	-.0389	.2151	-.6119	.9394	.995
t		(.2)	(1.2)	(3.2)	(23.0)	
		-.0045	.0124	-.0187		
SA	54.70	-.6627	.6632	-.1679	.9638	.998
t		(5.0)	(1.6)	(1.2)	(46.2)	
E		-.0947	.0200	-.0158		
ESC	53.80	-.5000	-.3382	-.0374	.9635	.997
t		(2.7)	(.7)	(.3)	(32.3)	
E		-.0791	-.0095	-.0032		
WSC	14.10	-.2515	-.0348	-.1323	.9848	.996
t		(.7)	(.1)	(.5)	(28.0)	
E		-.0428	-.0015	-.0092		
MT	-7.96	.018	.0541	-.9623	1.0	.995
t		(.4)	(.8)	(1.0)	(23.1)	
E		.0105	.0103	-.0160		
PAC	26.25	-.1610	.0893	-.0743	.9268	.993
t		(4.0)	(1.4)	(1.3)	(26.4)	
E		-.0732	.0172	-.0139		
US	594.41	-3.607	1.915	-2.690	.918	.998
t		(4.6)	(2.6)	(3.4)	(36.2)	
E		-.083	.016	-.023		

ESC, and WSC regions indicating that capital gains did not effect a different result in the transfers equation (5.2).

One of the most important results of the equation estimating number of farms is the extremely slow rate of adjustment. Nationally only about one-third of the final adjustment takes place in five years, and nine-tenths of the adjustment requires 30 years. Except for the Middle Atlantic Region, regional adjustments are even more lethargic.

The Cropland Equation

Discussion of the cropland used for crops equation in Table IX is complicated by the use of an index rather than acres for the dependent variable. We rely on the elasticities for most of our interpretations.

The coefficient of land retirement Lr carries the anticipated sign except in the MA and ESC regions where it is highly insignificant. Elasticities in the other regions indicate about a .02 change in the cropland index for each one percent change in land retirement.[2]

The Lr coefficient times the number of acres represented by a regional index point yields an estimate of the change in cropland area predicted as the result of an acre of land retirement. For the short-run, they are:

US	MA	ENC	WNC	SA	ESC	WSC	MT	PAC
-.22	.21	-.26	-.20	-.17	.14	-.33	-.26	-.25

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[2]An index of 100 represents a vastly different number of cropland acres in each of the regions.

TABLE IX

REGIONAL SHORT-RUN COEFFICIENTS, COMPUTED "t" VALUES AND ELASTICITIES, CROPLAND USED FOR CROPS EQUATION

Equation (5.4) $C = f(Lr_t, H_{t-1}, F_{t-1}, P_{t-1}, C_{t-1})$

Region	a	Lr_t	H_{t-1}	F_{t-1}	P_{t-1}	C_{t-1}	R^2
MA	49.69	1.480	-.208	-3.018	-.085	.766	.974
t		(.9)	(2.8)	(1.3)	(1.2)	(6.9)	
E		.012	-.283	-.020	-.099		
ENC	58.13	-.403	-.042	1.550	.097	.340	.571
t		(1.4)	(1.1)	(2.3)	(1.7)	(1.7)	
E		-.015	-.054	.033	.098		
WNC	13.64	-.146	-.003	.681	.019	.828	.861
t		(1.9)	(.1)	(1.4)	(.6)	(8.1)	
E		-.018	-.004	.021	.019		
SA	63.73	-.580	-.173	.131	-.078	.577	.958
t		(.7)	(2.5)	(.1)	(1.0)	(4.0)	
E		-.017	-.268	.003	-.097		
ESC	45.26	.550	-.140	.896	-.120	.748	.932
t		(.4)	(1.4)	(.3)	(1.3)	(5.9)	
E		.013	-.196	.012	-.152		
WSC	20.38	-.573	-.017	-1.990	.006	.841	.945
t		(1.6)	(.4)	(1.4)	(.1)	(9.7)	
E		-.042	-.024	-.033	.007		
MT	-1.87	-.756	.077	.914	-.062	1.000	.975
t		(1.5)	(1.5)	(.4)	(1.2)	(16.7)	
E		-.023	.081	.007	-.059		
PAC	22.54	-1.229	.018	1.562	.010	.721	.757
t		(.5)	(.5)	(1.5)	(.3)	(5.5)	
E		-.008	.023	.021	.010		
US	37.78	-.059	-.046	.263	.015	.615	.839
t		(1.7)	(1.3)	(2.0)	(.6)	(5.1)	
E		-.020	-.058	.034	.016		

Noting that the confidence level is low on the two regions where this estimate is positive, we find that the general tendency is for each acre of land retirement to remove approximately one-fifth to one-third of an acre from "cropland used for crops." The measurement and statistical limitation on this estimate are recognized, but the results do imply that land retirement is less effective in reducing crop acreage than implied by other published estimates.[3] One reports a reduction in harvested acreage of 59 crops from 341 million acres in 1952 to 321 million acres in 1960 and states that "The net reduction of 20 million acres in the total harvested acreage of 59 crops from 1952 to 1960 may be attributed chiefly to the large acreages in the Soil Bank." Each of the nearly 30 million acres in the Conservation Reserve removed approximately .7 acres of cropland, based on these USDA data. The results of this study indicate that this ratio varies from .2 in the short-run to .6 after 10 years. Harvested acreage and "cropland used for crops" used in Table X are not comparable data (cropland used for crops includes summer fallow and other minor crops), hence the estimates might be expected to differ not only because of error but also due to concept.

Output per acre of cropland H_{t-1} shows a generally stronger tendency to reduce cropland acreage than does the land retirement variable. The

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[3]Raymond P. Christensen and Ronald O. Aines, Economic Effects of Acreage Control Programs in the 1950's, U. S. Department of Agriculture, ERS, Farm Economics Division, Agricultural Economics Report No. 18 (Washington, 1962), p. 19.

negative coefficient on H_{t-1} is consistent with the hypothesis that improved technology, other things equal, reduces the need for farmland. Deflated farm income F_{t-1} exhibits a generally significant positive association with the cropland index. Land price P_{t-1} is a weak variable in the cropland equation. Only in the ENC region does it achieve significance at the 90 percent probability level. Though land prices appear to have little effect on cropland in the short-run, additional lags on the price variable might have added significantly to the explanation of variation in C.

The adjustment rate, R^2, and computed t values are more variable in the regional cropland equations than in other equations in the model. The ENC and Pacific regions are the most rapid in adjustment, while the Mountain region carries an adjustment rate g of zero, i.e., (1-g) = 1. This is interpreted to mean an adjustment rate slower than those in other regions. However, the strict interpretation of "no adjustment" is not justified by the statistical equation because of inadequate data.

The Land in Farms Equation

Regionally estimated land-in-farms equations in Table X are included to estimate the sensitivity of land resource use to cropland used for crops C, land retirement Lr, farm income F, and nonfarm employment E. The variables explain a high proportion of the variation in Lf with all R^2 estimates above .92. In all except the ENC region, the R^2 values are .959 or greater.

Mixed signs with significant computed t values on the coefficient of cropland C are partially explained by the typical type of cropland

TABLE X

REGIONAL SHORT-RUN COEFFICIENTS, COMPUTED "t" VALUES AND ELASTICITIES, LAND IN FARMS EQUATIONS

Equation (5.5) $Lf_t = f(C_t, Lr_t, F_{t-1}, E_t, Lf_{t-1})$

Region	a	C_t	Lr_t	F_{t-1}	E_t	Lf_{t-1}	R^2
MA	2.44	.043	-.210	.544	-.014	.797	.980
t		(2.5)	(.5)	(.9)	(.8)	(6.5)	
E		.129	-.005	.011	-.031		
ENC	11.64	.294	.028	.565	-.127	.682	.920
t		(3.0)	(.2)	(1.9)	(4.7)	(6.9)	
E		.268	.001	.011	-.073		
WNC	64.04	-.032	-.083	.234	.072	.774	.992
t		(.7)	(2.3)	(1.8)	(2.3)	(19.5)	
E		-.011	-.004	.002	.015		
SA	8.09	.033	-.432	.876	-.033	.887	.959
t		(.7)	(1.1)	(1.5)	(.7)	(14.2)	
E		.028	-.011	.016	-.022		
ESC	11.92	-.012	-.432	-.791	-.063	.890	.958
t		(.5)	(1.4)	(1.5)	(2.0)	(13.5)	
E		-.013	-.011	.012	-.053		
WSC	32.28	-.098	-.246	.164	-.028	.904	.990
t		(.8)	(1.2)	(.2)	(.3)	(16.9)	
E		-.038	-.007	.001	-.008		
MT	24.35	-.240	-1.740	-1.800	.731	.867	.998
t		(4.0)	(3.8)	(.7)	(5.9)	(25.2)	
E		-.092	-.021	-.005	.164		
PAC	8.34	-.013	-.798	.407	.072	.852	.9985
t		(.6)	(3.3)	(2.7)	(4.6)	(27.7)	
E		-.016	-.007	.007	.057		
US	-291.95	3.300	.462	-.049	-.288	.983	.9975
t		(5.5)	(3.2)	(.1)	(1.2)	(41.5)	
E		.239	.013	-.0005	-.015		

in the region in the period since 1930. Where topography and reclamation potentials have permitted, cropland and land in farms have varied in opposite directions. Thus the Western regions have been able to expand cropland while land in farms decreased slightly. A quite different phenomenon which would exhibit the same sign would be cropland reduction while land in farms increased. The Mountain region is adapted to this interpretation since government grazing land and Indian land are not included in the "land in farms" data. Acquisition of this land by private owners may have precipitated a spurious data change since some lands could have moved from "land not in farms" to the "land in farms" classification while remaining in the same physical use. Even cropland is subject to some error in this respect since some Indian tribal land has been sold to individuals. It then becomes part of "land in farms" for reporting purposes, even though used for wheat production both before and after the transfer in ownership.

Land retirement Lr carries generally negative coefficients in the land in farms regional equations and a highly significant positive national coefficient. The result suggests that land retirement may have increased land in farms in aggregate, but in many regions may have reduced Lf due to reforestation, irrigation, or other reasons. The result also could stem from specification or sampling error.

Contrast of the U. S. and Mountain equations indicates significant but opposite signs on the coefficients of C and Lr. Because retirement programs to date have not directly removed land from farms (Soil Bank and Feed Grain diverted acreages are still classified as "land in farms"), a direct negative effect would not be anticipated. The diversion of land by government programs would be expected to encourage conversion of nonfarmland to farmland to realize cost economies in use of labor and machinery.

Farm income in year t-1 is indicated to increase land in farms in seven regions, but the coefficients are significant only in the East North Central, West North Central and Pacific regions. Insignificant negative coefficients are found in the Mountain and U. S. equations.

Regions of relative low population density might be expected to exhibit a negative relationship between Lf and national employment E because land is not directly needed in large amounts for urban expansion, etc., but may be needed to supply food for an expanding national population. It appears that employment E, a proxy variable for land used for residential, business and recreational sites, has been expanding in the other regions in such a way as to require directly significant amounts of farmland. This interpretation is similar to that of the national model in Chapter IV. The indirect effects of employment representing increased demand for food and/or the general trend of development of farmland resources in the WNC, Mountain, and Pacific regions may have overshadowed the direct effects, resulting in positive coefficients on E.

The adjustment rate for land in farms is rather uniform in the regions. From six to ten years are required to make 90 percent of the adjustment. The adjustment rate for the national equation is slower than for three of the regions--the East North Central, the South Atlantic and the East South Central. Statistical complications appear to be especially troublesome in the regional land-in-farms equations.

The Reduced Form Equation

Again, as in Chapter IV, the last four equations have been substituted into the land price equation to obtain a composite or reduced form equation to estimate net results. The regional reduced form equations are presented in Table XI accompanied by their short-run elasticities. Because of regional differences in the magnitude of the variables, the elasticities are again preferred for inspection.

Capital gains, lagged land prices and lagged transfers per 1,000 farms consistently carry the same signs as in the national model and need no further discussion here. The stock of machinery S enters the reduced form model through the number-of-farms equation where there is a negative relationship between number of farms A and S. There also tends to be a negative relationship between the number of farms and land price. Hence, when the farm numbers equation is substituted into the land price equation, the strongest relationships between land price and machinery stock are positive. The result conforms with the hypothesis that machinery is a complement with land and that the presence of additional machinery stimulates the demand for land and results in higher land prices. Wherever a negative sign occurs in Table XI, the coefficient of S in Equation 3 was not statistically different from zero.

A high ratio of farm to nonfarm income consistently reduces regional land prices according to the coefficients of JX in this model. It also possesses a high elasticity in the South Atlantic region. There is little reason to believe that higher per capita incomes on farms should cause lower real estate prices, ceteris paribus, and we are led to reject this interpretation. The positive coefficient on farm income

TABLE XI

REGIONAL SHORT-RUN COEFFICIENTS AND ELASTICITIES, REDUCED FORM DEFLATED LAND PRICE INDEX EQUATION

Region	a	S_t	JX_t	Lr_t	H_{t-1}	F_{t-1}	E_t	Cg_t	P_{t-1}	T_{t-1}	A_{t-1}	Lf_{t-1}	C_{t-1}
MA	10.5	-.0900	-.035	6.136	-.0030	10.440	-.005	.111	.943	-.318	.00520	.271	.011
E		-.0830	-.005	.043	-.0034	.059	-.003	.033	.908	-.139	.00001	.076	.009
ENC	103.6	.0007	-.087	-.146	.0107	1.432	.109	.062	.696	-.125	-.00560	-.587	-.086
E		.00066	-.017	-.005	.0123	.030	.066	.021	.679	-.061	-.04050	-.625	-.084
WNC	211.2	-.0011	-.186	.267	-.00001	4.468	-.069	.214	.807	-.275	.027	-.750	.026
E		-.0011	-.088	.032	-.00001	.130	-.042	.054	.784	-.119	.229	-2.056	.024
SA	98.5	.0157	-.076	.709	.0034	3.117	.0194	.429	.650	-.068	-.023	-.518	-.011
E		.0144	-1.550	.016	.0040	.049	.0115	.269	.616	-.027	-.0002	-.469	-.009
ESC	78.8	.0043	-.068	1.780	-.0013	7.417	.0460	.045	.623	-.142	-.0082	-.651	.0068
E		.0040	-.012	.032	-.0013	.077	.0272	.023	.598	-.055	-.0508	-.476	.0052
WSC	121.7	.006	-.101	.505	-.0007	2.396	.0117	.074	.751	-.172	-.023	-.372	.0034
E		.005	-.024	.031	-.0008	.034	.0070	.028	.717	-.081	-.013	-.785	.0028
MT	165.1	-.0057	-.066	1.358	.0077	27.597	-.303	.121	.830	-.164	-.323	-.360	.0996
E		-.0054	-.026	.044	.0083	.208	-.181	.033	.806	-.087	-.534	-.958	.1032
PAC	205.0	.0571	-.093	3.273	.00032	11.440	-.106	.076	.661	-.149	-.329	-1.253	.0013
E		.0527	-.036	.021	.00038	.146	-.062	.029	.624	-.097	-.683	-.922	.0013
US	68.1	.004	-.032	.158	.0047	.619	.0091	.095	.682	-.079	-.0007	-.031	-.064
E		.002	-.011	.049	.0054	.076	.0054	.032	.659	-.037	-.0267	-.352	-.058

F_{t-1} tends to reinforce this interpretation. The sign of the JX variable may reflect the tendency for high unemployment to trap labor on farms and compete for real estate at higher prices. Elasticities on this variable are highest in the South Atlantic, WNC and WSC regions.

Land retirement Lr appears to increase land prices with an elasticity of about .04 in the short-run. The ENC region is the only exception. There the elasticity is low (.005), and the variable enters the model with insignificant coefficients wherever it appears in equations in this region.

The coefficients and elasticities are consistently small on the output per acre of cropland variable H_{t-1}. As indicated earlier, the variable does tend to depress the amount of cropland used for crops, but appears to have only a small and erratic influence on land price.

Lagged regional aggregate farm income F_{t-1} carries consistent positive coefficients among regions. Short-run elasticities range up to .21 in the Mountain Region.

Nonfarm employment E enters the system through the Lf land in farms equation and is intended to reflect nonfarm demand for land for suburban residences, industrial and recreational use as employment rises. Partially because it is a national variable (not measured separately in the regions), it does not show uniform effects. A positive sign is anticipated, but greater employment opportunities can reduce farmland values through reduced competition for farmland as farmers migrate. The overall national effect in Table XI seems to be a weak but positive influence on the price of farmland.

Transfers per 1,000 farms T, the number of farms A, and land in farms Lf are all lagged and produce expected negative effects in the regional equations consistent with the national model. The exceptions in the MA region carry low elasticities. The positive coefficient on the number of farms A_{t-1} in the WNC region enters through an insignificant coefficient in equation (5.1).

The coefficients of cropland used for crops C_{t-1} are generally inconsistent in sign with the national result, but in many cases this variable enters the regional equations with insignificant t values. Little emphasis can, therefore, be placed on them.

There are logical reasons to expect the Mountain Region to display the positive sign on the coefficient of cropland. Contrary to national trend, both land in farms and cropland used for crops have been expanding. Other things equal, an increasing supply should precipitate lower prices, but cropland expansion in this case has been the result of capital investment, both public and private. The regional addition to farm output has been a small part of the national total, and the effect on regional gross and net revenue more closely resembles the micro-effects on the individual farm than the macro results on the industry in total. Added production may well reduce gross revenue and net returns to agriculture nationally, but the regional effect is the opposite. It follows that land price could increase as farmland or cropland expands because the upward pressures on land prices due to capital improvements are not offset by the tendency for greater production to depress prices.

In summary, the results indicate some sizeable differences in effects of strategic variables among regions. Some of these differences are due to variation in resources, types of farming, population trends, etc. However, there is a strong possibility that some of the differences arise from errors in data and specification. As explained earlier, some regional data are unreliable. In instances where regional variables were unavailable, it was necessary to supplement with national data. These limitations require caution in interpreting the results.

CHAPTER VI

PREDICTED EFFECTS OF FARM PROGRAMS ON LAND PRICES

The purpose of this chapter is to apply the results of the preceding chapters, especially Chapters III and IV, to the dependent variable of the study--land price--and to assess the implications of these effects.

In the first part of the chapter we attempt to quantify equilibrium tendencies and the components of change in land price. The parameters estimated in Chapter IV are applied to the changes in the variables considered.

Major farm policy alternatives under consideration in recent years are then discussed in the light of the econometric model and the statistical estimates derived from the adjustment model.

Latent Adjustments in Land Prices

We have indicated earlier that the deflated price index for farm real estate in the United States has varied from a low of 63.9 in 1942 to a high of 111.2 in 1961 and have hypothesized that several measurable variables may have contributed to the variation in this "real price." Selected variables were retained in the econometric model of six equations which were combined into a "reduced form" land price equation applicable to various lengths of run. The six equations were fitted by least squares procedure and the estimated coefficients were reported and discussed in Chapter IV.

Application of the adjustment equations provides an estimate of the latent forces existing at a given time which would generate changes in land prices. In this model an equilibrium situation would be defined when the current land price index and predicted values for the short-run, long-run and all intermediate-run equations are equal.[1] Thus, the price level would be at rest and opposing forces for change exactly compensate one another.

Products of the ten year coefficients and the independent variables for the time period 1922-61 inclusive are shown in Table XII, along with predicted and observed values for the deflated land price index, $\hat{P}$ and P. The predicted and observed values for this index are also plotted for the same period in Figure 13 to facilitate comparisons. The predicted values $\hat{P}_t$ from the ten year equations are interpreted as the estimated land price if predetermined values of the current year were sustained for ten years without additional disturbances. $\hat{P}_t$ is a measure of the value of the land price nearly in equilibrium, given values of the explanatory variables in year t. The divergence between the actual current price, P_t, and $\hat{P}_t$ may be interpreted as a measure of disequilibrium in the system, or of latent adjustments to be made in land price over the next ten years, ceteris paribus. The interpretation of results is, of course, subject to limitations of the data and estimational techniques.

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[1]In the dynamic real world, equilibrium is only momentarily, if ever, attained.

TABLE XII

REDUCED FORM TEN YEAR DEFLATED LAND PRICE PREDICTED AND ACTUAL VALUES[a]

Year	S	JX	Lr	H_{t-1}	F_{t-1}	Cg	E	P_{t-1}	A_{t-1}	Lf_{t-1}	C_{t-1}	$\hat{P}$ Predicted	P Observed
1922	1.73	-3.05	0	25.37	.18	8.70	7.54	-10.34	-6.11	-81.14	-2.23	85.90	99.6
1923	1.79	-5.54	0	27.46	.25	7.78	6.06	-9.23	-5.25	-80.65	-2.21	85.68	93.1
1924	1.79	-5.13	0	27.46	.29	8.14	3.58	-8.63	-6.10	-80.16	-2.21	84.25	91.8
1925	1.84	-5.44	0	27.46	.27	1.66	8.29	-8.51	-6.09	-79.80	-2.21	82.92	85.0
1926	1.95	-8.41	0	27.81	.37	.02	8.65	-7.88	-6.08	-79.10	-2.26	80.32	86.0
1927	2.01	-6.56	0	28.50	.33	2.23	8.68	-7.97	-6.07	-81.14	-2.25	78.52	86.5
1928	2.12	-6.33	0	28.15	.33	-3.30	8.96	-8.02	-6.07	-82.20	-2.28	76.60	83.7
1929	2.12	-7.05	0	28.85	.34	-4.02	9.24	-7.83	-6.08	-83.18	-2.30	75.33	84.4
1930	2.24	-4.86	0	27.46	.36	-5.05	9.09	-7.83	-6.12	-84.24	-2.33	73.96	92.2
1931	2.12	-.98	0	26.07	.27	-9.97	8.34	-8.54	-6.15	-84.24	-2.33	69.82	100.7
1932	1.96	.98	0	28.85	.25	-18.82	7.47	-9.34	-6.21	-85.31	-2.33	62.73	94.8
1933	1.79	.97	0	27.46	.17	-16.90	7.44	-8.79	-6.28	-86.45	-2.33	55.55	76.7
1934	1.79	.43	0	24.67	.21	-17.11	8.05	-7.11	-6.34	-88.55	-2.28	58.90	70.3
1935	1.84	.03	0	20.51	.19	-12.47	8.34	-6.52	-6.37	-89.80	-2.30	58.69	68.4
1936	1.95	-1.36	0	26.42	.36	-9.22	8.93	-6.34	-6.41	-89.80	-2.30	67.47	70.4
1937	2.12	-1.99	0	22.59	.28	-6.11	9.48	-6.53	-6.33	-89.88	-2.28	66.59	68.3
1938	2.24	-.46	0	30.59	.37	-5.48	8.99	-6.33	-6.24	-90.04	-2.30	76.56	75.0
1939	2.23	-1.03	0	29.55	.31	-4.85	9.40	-6.95	-6.14	-90.13	-2.26	75.37	75.5
1940	2.35	-1.93	0	29.54	.32	-3.74	9.91	-7.00	-6.05	-90.21	-2.23	76.20	75.0
1941	2.46	-3.61	0	30.59	.33	-2.15	11.04	-6.95	-5.97	-90.28	-2.23	78.45	67.4
1942	2.46	-3.62	0	30.59	.33	.61	12.49	-6.24	-5.92	-91.60	-2.23	82.60	63.9
1943	2.79	-10.01	0	34.41	.58	3.42	14.00	-5.90	-5.83	-92.90	-2.28	83.50	66.4
1944	2.85	-10.38	0	31.63	.63	14.52	8.03	-6.15	-5.70	-94.29	-2.28	84.09	76.0
1945	3.02	-9.51	0	33.37	.63	11.11	14.34	-5.16	-5.64	-95.51	-2.26	89.62	82.5

TABLE XII (Continued)

Year	S	JX	Lr	H_{t-1}	F_{t-1}	Cg	E	P_{t-1}	A_{t-1}	Lf_{t-1}	C_{t-1}	P Predicted	P Observed
1946	3.24	-9.31	0	33.02	.64	12.92	12.98	-7.56	-5.61	-97.53	-2.23	86.17	81.5
1947	3.58	-11.56	0	35.11	.66	12.80	13.16	-7.56	-5.57	-97.15	-2.23	86.46	74.2
1948	4.02	-10.50	0	33.02	.56	13.54	12.75	-6.88	-5.19	-97.40	-2.26	86.57	73.3
1949	4.47	-9.82	0	36.84	.59	13.32	13.39	-6.80	-5.45	-97.64	-2.30	91.85	74.2
1950	4.81	-7.42	0	34.41	.48	11.61	13.88	-7.37	-5.38	-97.97	-2.34	89.93	76.0
1951	5.14	-8.57	0	33.72	.48	14.62	13.97	-7.04	-5.31	-98.22	-2.30	91.72	78.4
1952	5.37	-9.68	0	34.06	.52	16.96	14.88	-7.26	-5.10	-98.46	-2.33	94.19	89.2
1953	5.42	-9.05	0	35.80	.50	15.98	15.17	-8.27	-4.89	-98.46	-2.30	95.13	90.5
1954	5.48	-6.49	0	35.80	.45	13.92	14.86	-8.39	-4.68	-98.54	-2.30	87.77	88.2
1955	5.53	-6.93	0	35.10	.43	15.26	14.15	-8.18	-4.51	-98.54	-2.30	95.25	91.2
1956	5.53	-7.64	7.38	35.11	.39	13.81	15.71	-8.46	-4.37	-98.21	-2.28	102.20	91.4
1957	5.90	-6.31	15.29	37.89	.38	14.70	15.86	-8.47	-4.24	-97.80	-2.23	115.88	94.6
1958	5.53	-5.45	14.84	38.93	.37	15.63	15.67	-8.87	-4.11	-97.31	-2.19	118.39	99.0
1959	5.64	-6.93	12.28	43.80	.44	17.55	16.04	-9.18	-3.98	-97.64	-2.16	121.05	106.3
1960	5.59	-5.52	15.72	42.75	.35	17.43	16.35	-9.86	-3.85	-96.34	-2.21	125.70	109.0
1961	5.59	-5.51	30.35	44.14	.37	16.45	16.47	-10.16	-3.71	-95.92	-2.16	141.08	111.2

[a]The variables are defined in Chapter III. The estimated equations, from which the above results were obtained, are found in Chapter IV.

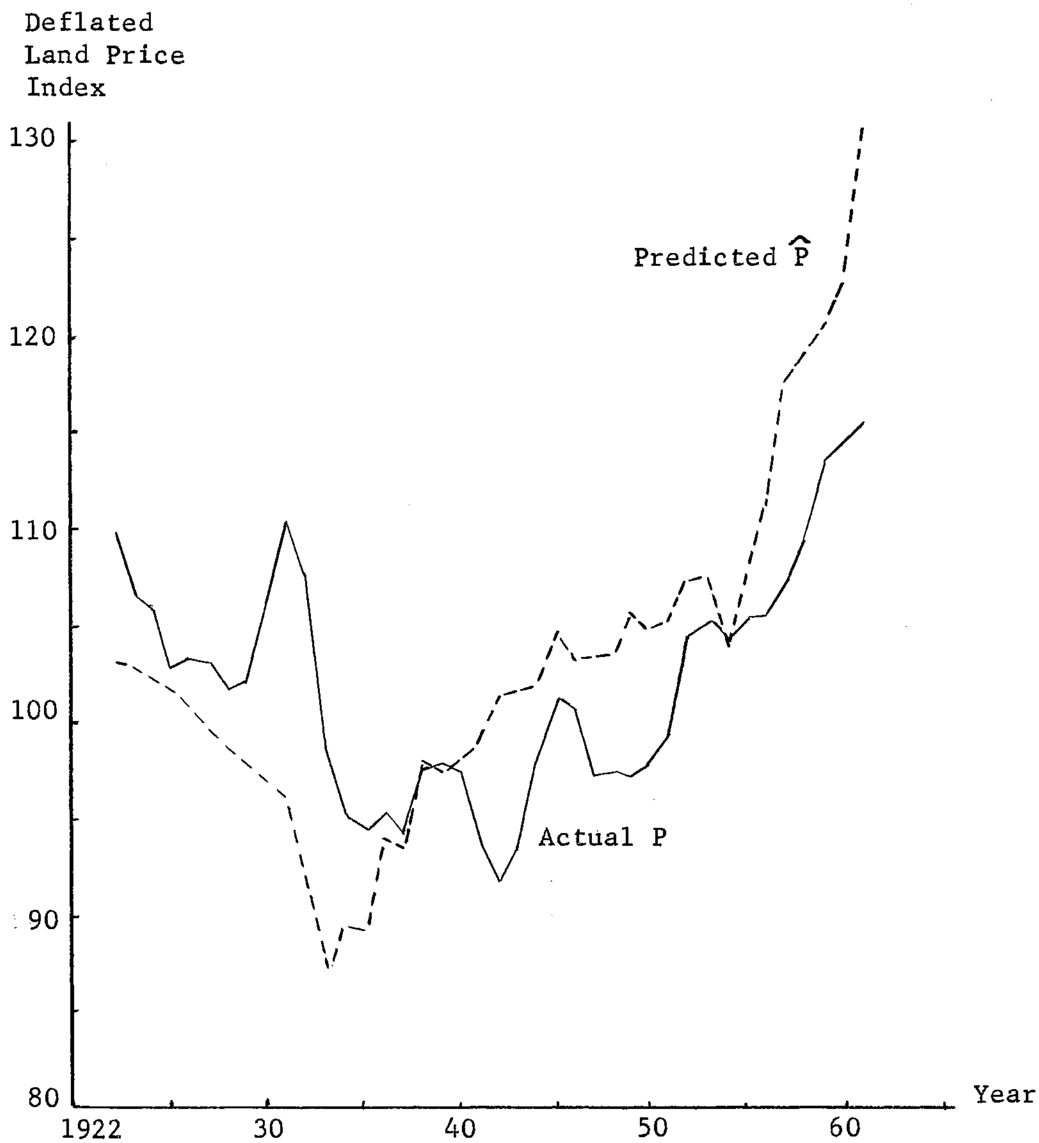

Figure 13. Actual and Predicted Deflated Land Price Index
Ten-Year Reduced Form Equation.

The lag which has existed between observed price indices and predicted prices from the ten year adjustment equation has been large in three distinct time periods over the past 40 years.

The first of these periods ran from 1930 through 1934 when actual prices were above the predicted adjusted levels. Failure of market prices to fall fast enough to adjust to the falling general price level and the accumulative or "snowballing" effect of the capital gains variable Cg can be identified as the cause of this discrepancy.[2] The predicted deflated index for 1931 is 62.7, compared to the 94.8 which existed at the time, a difference of 32.1. The observed index in the following year fell to 76.7 while the predicted ten year adjusted index also dropped to the low for the entire period studied; 55.6. Even the rapid adjustment of that year left a gap of 21.1 index points, but the conditions of 1932 did not continue. By 1936 the variables had changed to raise the expected adjusted price index to 67.5 and the market had adjusted to 70.4. This condition of near-equilibrium continued until the pressures of World War II placed the predicted price above that which prevailed.

A second period of major disequilibrium according to the adjustment model came between 1947 and 1951, the period of rapid inflation after price controls were removed in the U. S. market and while foreign demand for farm commodities remained high. Part of the inability of the post-war market to keep up with the adjusted price estimated by the system of equations must be attributed to the rapid inflation taking place and to

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[2]The variables are defined in Chapter III and in Appendix A.

farmer-psychology carried over from the Depression. The undeflated land price index rose from 142 in 1946 to 221 in 1952 (1910-14 base). Corrected for general price level, the deflated index for these two years was 86 and 94, respectively (1957-59 base). So what appeared as a 55 percent increase in price was only a 10 percent change in real terms. A slight deflation of the general price level in 1953 and stability in 1954 gave the continually increasing land price a chance to "catch up" to the predicted level and equilibrium was again approximated in 1954. The greatest discrepancy between the observed index and the predicted value for this period was in 1950 when the deflated index was 76.0 and the predicted 10 year index was 89.9.

The third period of disequilibrium as defined by difference between predicted 10 year adjusted price index and the observed deflated index begins with the introduction of land retirement programs in 1956 and continues on through the remainder of the time period included in the study. The greatest discrepancy between the predicted and observed prices is found in 1961. The large land withdrawal associated with the combination of Soil Bank and the Feed Grain program (55.35 million acres) contributes 30.35 points to the deflated index, given 10 years to adjust. The existing index of 111.2 is 29.9 points below the predicted index of 141.1 in 1961. A rapid rise did, in fact, occur in 1962 and 1963, consistent with the prediction made by the model.

The short-run effects of the land retirement programs in 1961 are quantified as 8.7 points in Chapter IV, Table III in line one of Section B. But the coefficients in Section A of this table point out the increasing importance of land retirement in land price as adjustment takes place. The coefficient on land retirement Lr grows from .16 in the short-run equation to .45 in the five year equation to .55 after 10 years have elapsed. The implication is that land retirement effects are quickly and sizeably capitalized into land values.

Land Retirement and Farm Real Estate Values

Several variables have contributed to recent increases in real estate prices, and create latent pressures to continue the land price rise according to Table XII. Some of the contributing increases are the effective farm-nonfarm income ratio JX, productivity H, and nonfarm employment E. The net effects on recent land values of farm income, capital gains and the variables mentioned above tend to be overshadowed by the recent influence of land retirement programs, however.[3]

The coefficient of land retirement Lr in Table XII and inferences from it should be interpreted more broadly than as strictly direct effects of land retirement programs. Land retirement programs have been relied on heavily as the instrument used to maintain farm income. Because farm income has not materially improved during the recent period of major commodity programs, and because of other limitations of data and

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[3] Farm income is a component of the F and JX variables. One interpretation is that an improvement in the farm income has multiple influences on land price. An expansion in income directly increases the residual income to land, and contributes to higher land values. Also, farm incomes affect land values indirectly through resources. Higher farm incomes can restrain land price by reducing the pressure for farm enlargement to obtain economic units, hence increase land demand and price. But increased income provides funds for fertilizers and machinery resource use which might have conflicting influences on land values. Our results, though imperfect, suggest these influences tend to offset each other and have little net influence on land prices through farm income.

statistical techniques, the sum of all effects of commodity programs on land prices may tend to be reflected in the coefficient of Lr, land retirement.[4] Interpreted in this broad context, Table XII shows approximately 30 index points or about 30 1957-59 dollars will be added to per acre farmland values by 1971 through commodity programs. This might be further interpreted to mean that land market participants, including farmers, will build into land prices net expected benefits of $30 per acre or $35 billion nationally due to farm programs.

Land retirement programs of recent years have supported farm net income at approximately $12 billion per year. Without these programs, farm income would fall approximately $5 billion in the short-run.[5] The discounted present value (capitalized value) of $5 billion discounted at five percent for 9.5 years is $35 billion.[6] Interpreted in this way, the projected addition to land values from farm programs is consistent with the hypothesis that land market participants will anticipate annual

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[4] Commodity programs have not raised farm income but have kept it from falling further. See Tweeten, et al., Farm Program Alternatives, Oklahoma Journal No. 911, and CAED Report No. 18, Ames, Iowa, 1963.

[5] The $5 billion short-run fall in income is based on Luther G. Tweeten, et al., Farm Program Alternatives, pp. 7-28.

[6] The number of years n is computed from the formula:

$$n = \frac{\log [R/(R - Vr)]}{\log (1 + r)}$$

where R is annual cost or returns, V is the present capitalized value, and r is the discount rate.

benefits of $5 billion from farm programs for about ten years into the future.[7] The projected value of real estate imputed to current farm programs, $35 billion, is also consistent with the hypothesis that farmers impute $1.75 billion annual benefits of programs in perpetuity.[8] The exact interpretation is arbitrary, and the above estimates are included only as possible interpretations.

Estimated Effects of Land Values on Farm Income

Given the tendency for program benefits to be capitalized into land values in approximately 10 years, what is the influence on farm income? Owners of land when programs are initiated receive not only the annual direct benefits of higher commodity prices, but also the value of capitalized future benefits when land is sold. The benefits of commodity programs to farm operators, therefore, tend to be lost when land is sold since the new owner must pay cash interest on a capitalized value derived from the privilege of owning land with allotments.[9] Since a redistribution of income occurs with land transfers, benefits to disposable income

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[7] For example, in 1965 they would anticipate program benefits will last to 1975. Or in 1970 they will anticipate farm program benefits will remain until 1980, etc.

[8] The annual benefits must be R in perpetuity for an asset to have at present value V discounted at the rate r.

$$R = Vr$$

If V is $35 billion, r is five percent, then R is 1.75 billion.

[9] The new owner must also pay a greater principal, but we assume he will receive back the principal when he later sells the farm. It is recognized, nevertheless, that considerable risk is involved. If the government terminates programs, then land values would fall and the owner would experience a capital loss.

are lost to farmers at the rate transfers occur. Annually, approximately 4.5 percent of all farms transfer ownership. Nearly one-half of these transfers are for farm enlargement.[10] For buyers consolidating new purchases with older units, the capitalization effect is mixed--gains on the old unit tend to offset the capital costs on the new unit. For these individuals, capitalization does not appear to be a serious problem. Furthermore, many of the farm transfers are from father to son as an inheritance or sale where capitalized land values do not become a direct cost.[11] In addition, a given farm may change hands several times over a period of years while another farm remains in the hands of the same owner for 50 years or more. For our calculations, we assume that no more than three percent of farms change ownership each year in a manner that redistributes income away from the farm community. The reasonable implication is that real estate in the U. S. tends to receive new ownership each generation or slightly over 30 years.[12] Thus, given

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[10] The figure was 46 percent for farm enlargement in 1961 and 1962. See Farm Real Estate Market Developments, CD-62, December, 1962.

[11] Also affecting the income distribution is the fact that about two-thirds of all farm real estate sales are made by farmers and about two-thirds of all purchases are made by farmers. Thus, there does not appear to be a marked tendency for ownership to be shifting to nonfarmers. The condition described in the text does not have the same impact on farms operated by owners and by tenants. The ratio of rents to market value of rented land in the U. S. declined from 4.4 percent in 1955 to 3.6 percent in 1962. This trend reflects the slow adjustment of rents to higher land values. However, in time this gap is expected to close, and the tenant farmer is expected to pay as rent a greater share of the capitalized farm program benefits included in land values.

[12] The assumption throughout the text discussion is that there is a close relationship between the proportion of farm numbers transferred and the proportion of farm real estate value transferred.

that land values reflect complete capitalization of program benefits, the program benefits are lost to the current farm generation gradually over a period of approximately 30 years.

From the data above it is possible to gain an approximate measure of the current farm "costs" due to capitalization of program benefits. In 1961, an estimated $20 billion of commodity program benefits of, say, $4 billion annually were capitalized into land values. The "paper" cost of interest on $20 billion at five percent is $1 billion.[13] This cost becomes "real" only for the farmer who purchases land at the high prices. Since only about three percent of farmland is sold under these circumstances, the interest cost that represents a real decline in farm disposable income is only one-third billion dollars per year. As more farms change hands and as benefits are further capitalizad into land values, this real cost increases. In slightly over 30 years, about $50 billion will be capitalized into land values. Since the majority of farms will have changed ownership and sellers will have left the farm community, the transfer is away from farmers. At five percent interest, the real cost to farmers would be $2.5 billion per year. This figure perhaps is a reasonable expectation of what might be the long-run annual monetary benefits of farm programs--aside from advantages of stability, etc. Thus, monetary benefits to farmers will appear to be lost over time.

[13]Disposable income is defined as income remaining to pay operating and living expenses after making real estate payments and other fixed obligations. The higher cost of real estate is not a charge against disposable income even for farms transferred after land values have risen, once the mortgage is paid. However, it is anticipated that many farmers would not both have purchased and paid for land in the time period considered in this study. Also, the interest, even when the mortgage is paid, represents an opportunity cost although not included in disposable income.

The conclusion is that capitalization represents an important threat to the long-term monetary benefits of farm programs. But that effect is not yet a serious drain on aggregate farm disposable income, because not enough farms have changed hands at inflated values. The implication is that policy makers may need to reshape farm programs if the goal is to maintain farm disposable income over long periods of time.

Implications of Results for Specific Farm Programs

The implications for land values can be found by inserting expected values of farm income, land retirement, etc. into the model. We emphasize, however, that this procedure can be only an approximate guide due to limitations in specification and estimation of the model. Certain broad inferences about specific farm programs appear to follow from the model. The model suggests that the effects on farmland values of alternative programs to raise farm income might be quite different.

Land Retirement

Land retirement programs have increased farm income through reduced farm output. Because of the inelastic demand for farm commodities, farm prices are increased by a greater proportion than output is reduced, thereby increasing farm income.

The advantages of employing the land restriction as a means of controlling output and raising incomes have been discussed by Bottum and others.[14] Suppose, for example, that farm income would be supported in

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[14] J. Carroll Bottum, et al., Land Retirement and Farm Policy, Purdue University Agricultural Experiment Station Research Bulletin No. 704 (Lafayette, 1961).

the future by retiring 80 million acres of cropland.[15] Assuming for the moment that other variables remained at 1961 levels, the effect of such a program on land prices in 10 years would be to increase the index by 44 index points over that which would be expected to prevail without it. This would increase the value of farmland nationally by about 50 billion dollars. As discussed in Chapter I, the short-run and long-run effects of this development would be quite different, so far as farm families are concerned. The result is approximate, but does suggest unique effects of resource restriction programs that are not found in direct payment and other programs.

The economic model of Chapter II and Appendix D gives a possible explanation of why land retirement is a potent stimulus to land price. We hypothesize here that dual influence exists: Direct income provided by diversion payments; and income accruing from price supports that are contingent on compliance with allotments. A maximum of approximately one-seventh of cropland used for crops was retired in any one year, and the secondary effect on land not diverted is important also. There is the effect of a reduced available supply of land on which to employ other resources--labor and machinery. Our factor-factor model in Appendix D suggests that if these resources were employed in the complementary range with land, a reduction of the supply of land would eventually reduce the productivity of each unit of labor and machinery and raise the economic productivity of each remaining unit of land.

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[15] J. Carroll Bottum, "Land Retirement as a Solution of Supply-Demand Imbalance," Dynamics of Land Use--Needed Adjustment, Iowa State Center for Agricultural and Economic Adjustment (Ames, 1961), p. 195.

Land price increases would then be expected to follow the rise in land productivity.

Quantity Controls

Another type of supply control is that of direct restriction of quantities marketed, sometimes described as "bushel controls." Our land model contains no variable which could be directly interpreted as applicable to this device unless one assumes that the quantities to be marketed were to be set in proportion to existing allotments and, therefore, to land. This appears to be a logical conclusion because some historical base for allocation seems inevitable, if such controls were to be attempted. The land retirement variable Lr is inappropriate for estimating the effect of quantity controls on land prices, however. It seems likely that the "right to produce" would probably acquire value and, if it were transferable inter-personally via control of land, this value would be an integral part of the land price. But the effect on resource use would be quite different. Cropland would be more plentiful, and with the disappearance of an alternative rental market (to the government) land would compete more actively with other factors for employment in the production of the limited quantity of product. The size of the coefficients generated on farm income F and land retirement Lr in the preceding chapters indicates that the resource restricting feature of farm programs, rather than the income effects, has had the greatest influence on land values.

The implication of the above model is that marketing controls or direct payments would not be as stimulating to land prices as a land retirement program. While this study is not an evaluation of administrative or political feasibility, these considerations are apparent difficulties of such an approach to the income problems of farmers.

Labor Withdrawal

A second type of resource restriction which might be employed as an agricultural program has been outlined by Schultz as "Homesteads in Reverse."[16] This is essentially a labor withdrawal program which can be interpreted as a parallel to land retirement. Labor has been included in this model indirectly in the Number of Farms, variable A. Since U. S. agriculture has been characterized by family-type farms, the number of farms serves as a proxy variable for "number of farmers." The coefficient on this variable in the reduced form land price equation (Table V) is consistently negative. The magnitude of this coefficient is never impressively large, however. The sign is consistent with Schultz's hypothesis that large scale labor removal would serve to decrease land prices and raise labor returns. Both are consistent with the factor-factor graphic economic analysis of Appendix D. Recalling from Chapter IV that the elasticity of the land price index with respect to the number of farms is only -.027, one would not ascribe much importance to farmer withdrawal as a potent force in the land market. This conclusion is, of course, subject to the limitations of the analysis.

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[16] Theodore W. Schultz, "An Alternative Diagnosis of the Farm Problem," Journal of Farm Economics (December, 1956), p. 1152.

Cash Payments

Cash payments tied to persons rather than to land, a farm allotment based on past production or other instruments might be one means of reducing problems of capitalization. Payments might be used to support farm income in depressed periods and might be a fixed amount per person or family. The payment also might be given only in return for some service deemed consistent with the public interests. For example, the payment could be used to encourage greater general education, training for new skills and employments, or to subsidize migration, industry location, etc. These measures to raise farm income, while avoiding problems of capitalization, do not avoid other problems. Taxpayer acceptance of cash treasury outlays sufficient to maintain farm income in the short-run and establishment of politically acceptable criteria for payment are difficult features. Also, administration and other problems mitigate to some extent the feasibility of the noncapitalization type programs.

Summary and Conclusions

Land has become a less important factor of production in recent years in terms of physical area, but it has become a more important component of resource cost to the farm firm during a period of time in which the quantity and value of nonland inputs has increased. This increased importance of land as a cost to the farm firm has resulted from land prices which have advanced in both current and deflated values.

Competition with disposable farm family income exerted by this resource cost varies among tenants and owner-operators. The short-run effects of nearly all farm programs are to increase the spendable income of nearly all farm families. The rapidity with which these benefits may be transferred into resource costs are dependent upon the media through which income is transferred to farmers and on the rate of turnover in farm ownership.

Variables Measured in the Land Market

Least squares regression procedures were used to estimate coefficients for a recursive system of equations to obtain estimates of the effects of selected variables on farm real estate prices. An adjustment model of the Nerlove type was used to allow market adjustment with a distributed lag to equilibrium prices following a change in a strategic variable. The system of equations was estimated nationally for the United States and for eight of the nine geographical regions.

Increases in output per acre of cropland, land retirement through government programs, nonfarm employment, and machinery used on farms were estimated as positive influences on farm real estate prices in both the short-run and after 10 years of adjustment to a given situation. Rising magnitudes of farm numbers, land in farms, the ratio of farm to nonfarm incomes, cropland used for crops and transfers of farm real estate were estimated to depress the real price of farmland. Aggregate farm income was assessed to have little effect after consideration of the other variables in the model. Lagged land price was extremely important in the short-run, but showed a cyclical tendency in the 10 year adjustment model. The strong positive influence in the short-run was reversed to a relatively small negative effect after 10 years of adjustment.

The adjustment rate obtained from the land price equation estimated that 85 percent of the price change, to be eventually obtained from a change in the explanatory variables, would occur within five years. The model estimated that only 16 percent of the eventual adjustment in acreage of land in farms occurs in 10 years after a change in one of the variables in that equation. (These variables were cropland used for crops, land retired, farm income lagged one year, and nonfarm employment.)

Extremely slow adjustment rates obtained for land in farms and number of farms re-emphasize that resources tend to be immobile in agriculture. Nearly 10 years were required for half of the total adjustment in farm numbers A to a given change in variables affecting A according to the estimates of this model.

Capital gains were an important factor in the determination of farm real estate prices. Coefficients estimated for this variable indicate that current buyers and sellers of farmland are influenced by past gains or losses from land ownership.

Land retirement programs were estimated to be about 60 percent efficient in reducing cropland used for crops in the long-run, i.e., an acre taken out of crop production through such programs is replaced by about .4 of an acre which was not used for this purpose before. The elasticity of land price with respect to land retirement was estimated at .055 in the short-run and .17 after 10 years of adjustment to continuous operation of the program at a given level. This elasticity was computed at the mean of a recent five year period from 1957-1961, when an average of 32.27 million acres were out of production through retirement programs of one type or another. Land retirement programs were estimated to contribute 15 percent of the 1961 land price. The model predicts that continuation of 1961 conditions for 10 years would raise the land price index from 111 in 1961 to 141 in 1972. The model estimates that 30 of the 141 index points predicted from 1961 data in the 10 year estimate would be contributed by land retirement. It is interesting to note that it is just 30 points which separate the predicted equilibrium estimate of 141 and the observed deflated land price index for 1961 of 111.

The implications of this study point to unique effects from resource restricting programs which do not arise from other farm income supporting measures. In addition to the increased social cost of production utilizing less than all of the natural resources available to the economy, the capitalization of the right to produce and/or government rental payments into land pose problems of income distribution and eventually compromising the supposed purpose of farm programs--the improvement of farm family disposable income.

Commodity programs have been effective in increasing farm income, especially for persons who were land owners when the programs were initiated. However, capitalization of farm program benefits into land values severely impares the effectiveness of these programs in raising disposable farm income in the long-run. Disposable income benefits decrease as current farm owners are replaced. The income distribution effects will become more acute with time for two reasons. First, current programs have lagged effects that will tend to raise land values even further in the future according to this study. Second, the impact on disposable income will be felt increasingly as a greater percentage of farms change hands through the years at higher land values.

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A P P E N D I C E S

APPENDIX A

SOURCES OF STATISTICAL DATA AND CONSTRUCTION OF VARIABLES USED

A = Number of farms, in thousands nationally and by regions.
Sources: U. S. Department of Agriculture, Statistical Reporting Service, Bulletin No. 316.
U. S. Department of Agriculture, Farm Labor, March, 1962.

C = Cropland Used for Crops Index, 1947-49 = 100, national and by regions.
Sources: U. S. Department of Agriculture, Agricultural Research Service, Statistical Bulletin No. 233, July, 1963, p. 19.
U. S. Department of Agriculture, Agricultural Research Service, Statistical Bulletin No. 233, August, 1958, p. 11.

Cg = Capital Gains, in land price index points, 1957-59 = 100. Constructed nationally and by regions.
Sources: See P and T below. Computed to represent the difference between average price contracted at purchase date by current owners in year t and current market price. 1910-14 land price indices were used to arrive at the difference (gain or loss) which was then deflated to 1957-59 dollars.

$$Cg = \left(P_t^* - \sum_{j}^{k} T_i P_i^*\right) \text{(deflator, 1957-59 land price = 100)} \text{(implicit gen. price deflator 1957-59 = 100)}$$

$$P^* = \text{1910-1914 index} \qquad \sum_{j}^{k} T_i = 1{,}000 \text{ farms.}$$

E = Nonfarm Employment, in millions, U. S. only.
Sources: Historical Statistics of the U. S., p. 73.
Historical Statistics of the U. S., p. 70.
Statistical Abstract of the U. S., 1962, p. 215.

E = Total Labor Force - Agricultural Employment - Unemployed.

F = Net Farm Income, in billions of 1957-59 dollars. U. S. and regions.
Sources: The Farm Income Situation, July, 1962, p. 59.
U. S. Department of Commerce, "Personal Income by States Since 1929," a supplement to the Survey of Current Business, 1957, Tables 4-61.

Survey of Current Business, August, 1959, pp. 15-23.
Survey of Current Business, August, 1962, pp. 12-16.

H = Index of Output Per Acre of Cropland, 1947-49 = 100, U. S. and geographical regions.
Sources: U. S. Department of Agriculture, Statistical Bulletin No. 233, August, 1958, p. 12.
U. S. Department of Agriculture, Statistical Bulletin No. 233, July, 1963, p. 20.

JX = Ratio of per capita farm to nonfarm income modified by nonfarm unemployment, U. S. and geographical regions.

$$JX = \frac{\text{Per capita farm operator net income}}{\text{Per capita nonfarm income}} \left[100\text{-}5 \text{ (Unemployment Rate)}\right]$$

Sources: U. S. Department of Agriculture and U. S. Department of Commerce, Population Estimates, Series P-25, Nos. 139, 229, and 261.
Farm population was taken from several sources, since consolidated into Farm Population Estimates for 1910-62, by Vera J. Banks, Calvin L. Beale, and Gladys K. Bowles, Economic and Statistical Analysis Division, Economic Research Service, U. S. Department of Agriculture, ERS-130. Nonfarm population was derived as the difference between total and farm populations, both nationally and regionally.
Nonfarm unemployment taken from U below.
Income data from sources shown for F above.

Lf = Land in Farms, in millions of acres, U. S. and geographical regions.
Sources: U. S. Department of Agriculture, Economic Research Service, Statistical Bulletin 316.
Census of Agriculture, 1920-1959.

Lr = Land Retired by Government Programs, in millions of acres, U. S. and geographical regions.
Sources: Agricultural Statistics, 1957-1962.
Hearings of House Agricultural Appropriations Committee, 88th Congress, 2nd Session, 1963, p. 526.

P = Price of Farm Real Estate Index, 1957-59 = 100, U. S. and geographical regions.
Sources: Computed from indices provided in Agricultural Statistics, 1940, 1946, 1950, and 1955; and in Current Real Estate Market Developments, CD-42, CD-49, CD-55, CD-60.

S = Stock of Machinery Index, 1957-59 = 100. U. S. and geographical regions.
Sources: U. S. Department of Agriculture, Statistical Bulletin 233, 1963, pp. 46-47.

U. S. Department of Agriculture, Supplement to Farm Income Situation, August, 1963, was used to compute estimates for recent years.

T = Transfers per 1,000 Farms, U. S. and geographical regions.
Sources: Agricultural Statistics, 1931, 1941, 1945, 1952, 1961.
Current Farm Real Estate Market Developments.

U = Unemployment as a Percentage of the Nonfarm Work Force.
Sources: Historical Statistics of the United States, Table D-47, p. 203.
Statistical Abstract of the United States, 1962, p. 215.

APPENDIX B, TABLE I

DATA USED IN THE ANALYSIS, NATIONAL, 1922-1961

Year	P	T	A	Lf	C	S	JX	Lr	J_{t-1}	H_{t-1}	F_{t-1}	Cg	En	U_{t-1}
1922	99.6	55.9	6500	987	96	31	18.05	0	.330	73	5.828	18.89	29.3	11.9
1923	93.1	59.1	6492	981	96	32	32.83	0	.373	79	8.111	13.16	30.2	7.6
1924	91.8	63.7	6480	974	96	32	30.37	0	.391	79	9.142	7.78	31.6	3.2
1925	85.0	65.2	6471	968	98	33	32.24	0	.407	79	8.758	3.60	32.2	5.5
1926	86.0	70.0	6462	980	98	35	49.78	0	.464	80	11.961	0.04	33.6	4.0
1927	86.5	68.5	6458	993	98	36	38.87	0	.439	82	10.740	4.86	33.7	1.9
1928	83.7	66.0	6470	1006	99	38	37.52	0	.444	81	10.517	-7.17	34.8	4.1
1929	84.4	58.0	6512	1018	100	38	41.75	0	.436	83	10.847	-8.72	35.9	4.4
1930	92.2	61.5	6546	1031	101	40	28.76	0	.520	79	11.453	-10.96	35.3	3.2
1931	100.7	61.9	6609	1044	101	38	5.78	0	.381	75	8.731	-21.66	32.4	8.7
1932	94.8	76.7	6687	1058	101	35	-5.81	0	.277	83	7.896	-40.47	29.0	15.9
1933	76.7	93.6	6741	1071	100	32	5.73	0	.231	79	5.427	-51.40	28.9	23.6
1934	70.3	78.6	6776	1085	99	32	2.56	0	.307	71	6.739	-37.17	31.3	24.9
1935	68.4	69.1	6814	1099	100	33	0.16	0	.380	59	5.966	-27.08	32.4	21.7
1936	70.4	72.9	6739	1100	99	35	8.06	0	.408	76	11.497	-20.03	34.7	20.1
1937	68.3	74.0	6636	1102	100	38	11.77	0	.434	65	8.939	-13.28	36.8	16.9
1938	75.0	65.4	6527	1103	98	40	2.70	0	.418	88	11.905	-11.91	34.9	14.3
1939	75.5	63.8	6441	1104	96	40	6.09	0	.393	85	10.083	-10.58	36.5	19.0
1940	75.0	62.8	6350	1105	97	42	11.45	0	.386	85	10.231	-8.12	38.5	17.2
1941	67.4	63.5	6293	1121	97	44	21.41	0	.372	88	10.625	-4.67	42.9	14.6
1942	63.9	65.9	6202	1137	98	48	40.93	0	.452	89	13.600	1.33	48.5	9.9
1943	66.4	66.8	6089	1154	99	50	59.28	0	.521	99	18.535	7.43	54.4	4.7
1944	75.0	76.0	6003	1169	100	51	61.85	0	.594	91	20.114	17.45	56.4	1.9
1945	82.5	69.5	5967	1185	98	54	56.29	0	.593	96	20.249	24.12	55.7	1.2
1946	81.5	74.8	5926	1189	97	58	55.14	0	.659	95	20.420	28.07	50.4	1.9
1947	74.2	75.6	5871	1192	98	64	68.48	0	.766	101	21.097	27.80	51.1	3.9
1948	73.3	65.9	5803	1195	100	72	62.18	0	.757	95	17.845	27.69	52.6	3.6
1949	79.5	56.8	5722	1199	102	80	58.14	0	.666	106	19.050	28.94	52.0	3.7
1950	76.0	52.2	5648	1202	100	86	43.95	0	.596	99	15.236	25.22	53.9	5.5

APPENDIX B, TABLE I (Continued)

Year	P	T	A	Lf	C	S	JX	Lr	J_{t-1}	H_{t-1}	F_{t-1}	Cg	En	U_{t-1}
1951	78.4	54.0	5428	1204	101	92	50.77	0	.526	97	15.304	30.34	56.8	5.3
1952	89.2	52.1	5198	1205	100	96	57.31	0	.571	98	16.563	36.83	57.8	3.3
1953	90.5	47.6	4984	1206	100	97	53.61	0	.538	103	16.088	34.71	58.9	3.1
1954	88.2	44.1	4798	1206	100	98	38.45	0	.513	103	14.311	30.23	57.7	2.9
1955	91.2	46.6	4654	1202	99	99	41.03	0	.471	101	13.656	30.72	59.3	5.6
1956	91.4	49.7	4514	1197	97	99	45.28	13.46	.431	106	12.626	30.00	61.0	4.4
1957	94.6	47.8	4372	1191	95	100	37.37	27.89	.460	109	12.082	31.94	61.6	3.8
1958	99.0	48.0	4233	1185	94	99	32.27	27.06	.429	112	11.898	33.95	60.8	4.3
1959	106.3	48.1	4097	1179	96	101	41.04	22.39	.479	126	14.141	38.12	62.3	6.8
1960	109.6	47.1	3949	1174	94	100	32.69	28.66	.420	123	11.303	37.85	63.5	5.5
1961	111.2	44.6	3811	1169	91	99	32.65	55.35	.441	127	11.950	35.77	63.9	5.6
Mean	86.5	60.3	5815.8	1106.8	98.2	60.5	29.35	5.297	.446	90.5	11.419	6.74	44.0	8.8
Standard Deviation	11.6	11.4	974.4	84.6	2.5	29.5	19.68	12.494	.102	16.9	3.3655	25.79	13.0	6.9

APPENDIX B, TABLE II

DATA USED IN THE ANALYSIS, MIDDLE ATLANTIC REGION, 1930-1961

Year	P	T	A	Lf	C	S	JX	Lr	J_{t-1}	H_{t-1}	F_{t-1}	Cg
1930	104.11	58.0	395.3	35.0	110	67.1	11.19	0	.198	75	.6793	-6.98
1931	108.64	55.0	395.3	35.2	110	63.4	-3.94	0	.192	76	.6575	-13.06
1932	115.74	55.3	396.0	35.3	110	57.0	-3.24	0	.180	88	.6440	-19.56
1933	97.49	69.9	395.6	35.5	110	48.3	-3.52	0	.144	80	.4579	-31.90
1934	86.89	68.3	396.0	36.5	112	43.5	-1.56	0	.184	79	.5679	-25.02
1935	83.30	67.2	398.4	36.0	113	43.2	-.07	0	.153	79	.4634	-19.50
1936	85.45	67.3	391.0	35.0	110	45.7	3.86	0	.249	87	.7283	-13.96
1937	80.93	69.2	386.8	34.0	110	50.2	5.56	0	.195	78	.6243	-10.13
1938	89.83	59.4	380.4	33.8	108	50.8	1.16	0	.232	91	.7099	-8.72
1939	90.51	57.9	378.0	33.7	108	51.8	2.91	0	.208	89	.6397	-8.46
1940	89.83	56.2	376.2	33.6	110	53.5	4.80	0	.178	87	.5878	-6.22
1941	81.71	60.6	372.0	33.6	110	58.2	9.09	0	.180	88	.6210	-3.68
1942	74.71	62.0	366.8	33.7	112	62.0	15.68	0	.205	85	.7029	-0.31
1943	78.24	59.7	358.6	33.8	111	64.0	23.35	0	.258	92	.9353	6.03
1944	82.22	66.3	353.8	34.0	114	70.0	24.16	0	.257	82	1.0284	10.05
1945	88.21	64.7	350.1	34.4	111	72.0	21.72	0	.240	87	1.0893	16.04
1946	83.11	73.8	344.1	34.2	109	75.0	19.34	0	.240	86	1.1105	18.24
1947	76.11	73.7	338.0	34.0	101	81.1	22.96	0	.280	100	1.1408	20.79
1948	73.73	62.5	333.0	33.4	101	83.2	20.25	0	.244	97	.8217	20.52
1949	83.27	53.7	327.9	33.2	98	86.7	19.79	0	.273	103	.8763	24.64
1950	77.63	45.3	321.9	33.0	97	94.1	17.71	0	.241	100	.7715	20.05
1951	76.34	48.2	304.0	32.8	97	100.9	18.70	0	.224	108	.7453	22.24
1952	87.21	49.3	288.0	32.3	96	100.7	22.65	0	.268	107	.8355	28.47
1953	88.43	45.6	273.0	31.9	96	102.1	21.63	0	.253	104	.8427	26.95
1954	87.31	43.4	258.0	31.3	95	106.9	16.92	0	.235	106	.7682	24.29
1955	89.33	44.0	249.6	30.8	92	109.0	15.37	0	.197	109	.6133	25.37
1956	91.46	47.2	241.2	30.2	90	104.5	14.58	.0365	.180	107	.5623	27.12
1957	95.81	46.1	233.0	29.6	88	105.9	16.56	.3426	.211	116	.6240	30.39
1958	98.75	45.1	226.0	29.0	88	100.4	12.87	.4294	.195	108	.5363	29.04
1959	105.91	44.1	219.0	28.5	87	93.8	17.62	.6420	.243	123	.6743	32.58

APPENDIX B, TABLE II (Continued)

Year	P	T	A	Lf	C	S	JX	Lr	J_{t-1}	H_{t-1}	F_{t-1}	Cg
1960	109.22	44.9	209.8	28.1	86	91.1	13.61	.9315	.189	118	.5178	33.00
1961	110.72	43.5	200.2	27.6	84	86.9	14.50	1.3288	.218	125	.5948	32.38
Mean	89.75	56.5	317.1	32.9	102.3	75.7	12.63	0.1159	.217	95.6	7.2413	8.77
Standard Deviation	11.18	9.80	74.70	2.33	9.50	21.62	8.48	0.3019	.035	14.0	1.7904	19.54

APPENDIX B, TABLE III

DATA USED IN THE ANALYSIS, EAST NORTH CENTRAL REGION, 1930-1961

Year	P	T	A	Lf	C	S	JX	Lr	J_{t-1}	H_{t-1}	F_{t-1}	Cg
1930	77.27	61.6	1027	114.0	96	40	14.38	0	.255	75	2.0226	-19.06
1931	83.01	60.9	1034	115.2	99	38	-4.18	0	.204	68	1.5453	-30.22
1932	78.07	72.4	1055	116.4	97	35	-4.07	0	.236	85	1.7717	-46.24
1933	65.38	82.7	1078	117.7	95	32	-4.25	0	.166	84	1.0506	-52.65
1934	60.35	71.4	1082	118.9	96	32	-1.64	0	.193	67	1.1163	-39.52
1935	59.11	64.1	1086	120.1	98	33	-0.08	0	.167	61	1.0561	-30.61
1936	62.01	67.6	1077	119.4	97	35	6.04	0	.389	84	2.4885	-21.73
1937	61.30	74.0	1070	118.8	99	38	6.99	0	.245	66	1.7440	-12.66
1938	69.06	61.8	1062	118.1	96	40	1.85	0	.360	90	2.6615	-9.21
1939	69.47	59.4	1055	117.5	94	40	3.91	0	.280	90	1.9887	-7.59
1940	69.06	61.9	1038	116.8	94	42	6.85	0	.254	95	1.9955	-4.24
1941	63.72	65.4	1027	117.2	96	44	11.32	0	.224	89	1.8585	-0.53
1942	62.75	66.7	1012	117.5	97	48	24.02	0	.314	95	2.7112	6.60
1943	64.69	68.5	988	117.9	99	50	34.70	0	.383	99	3.5077	11.25
1944	73.60	78.5	968	118.2	103	51	31.82	0	.338	90	3.6143	19.93
1945	78.25	69.8	962	118.6	101	54	26.90	0	.297	88	3.3330	24.28
1946	77.18	76.4	958	117.9	101	58	28.43	0	.353	96	3.8892	27.50
1947	71.27	74.9	950	117.2	98	64	32.94	0	.402	100	3.8824	27.81
1948	69.73	67.7	938	116.6	101	72	30.25	0	.364	87	3.0800	26.72
1949	76.60	57.3	928	115.9	101	81	33.69	0	.470	108	3.8612	28.64
1950	72.81	53.5	920	115.2	100	88	25.55	0	.348	105	2.7026	24.39
1951	76.37	52.2	892	114.3	100	97	26.62	0	.319	101	2.5862	30.38
1952	85.45	49.8	862	113.5	101	98	32.03	0	.380	104	3.0069	35.38
1953	87.89	47.0	837	112.7	102	100	29.93	0	.350	107	2.8941	34.46
1954	86.47	42.4	814	111.9	102	103	22.59	0	.314	108	2.7126	30.84
1955	89.46	45.2	795	111.3	100	107	25.94	0	.333	109	2.6620	31.40
1956	91.42	51.6	777	110.5	99	104	20.77	1.0939	.257	114	2.1320	32.05
1957	95.75	46.9	758	109.6	98	103	21.61	2.0718	.275	120	2.2526	34.96
1958	98.97	49.0	739	108.7	98	99	18.84	2.7577	.285	117	2.1755	35.65
1959	105.73	51.8	721	107.8	102	98	24.17	2.1087	.333	128	2.3735	38.49

APPENDIX B, TABLE III (Continued)

Year	P	T	A	Lf	C	S	JX	Lr	J_{t-1}	H_{t-1}	F_{t-1}	Cg
1960	105.96	49.4	698	106.9	99	95	18.38	2.9440	.255	130	1.8419	35.54
1961	104.28	45.8	679	106.1	95	92	18.40	8.8048	.277	136	1.9076	30.61
Mean	77.89	60.86	933.97	113.0	98.56	65.97	17.65	.6181	.3006	96.75	2.4508	9.14
Standard Deviation	13.61	10.97	126.28	2.73	2.46	27.60	12.52	1.691	.07	18.35	7.8815	27.45

APPENDIX B, TABLE IV

DATA USED IN THE ANALYSIS, WEST NORTH CENTRAL REGION, 1930-1961

Year	P	T	A	Lf	C	S	JX	Lr	J_{t-1}	H_{t-1}	F_{t-1}	Cg
1930	113.14	68.0	1,124.1	271.8	99	40	19.26	0	.341	88	2.5350	-19.23
1931	119.36	66.8	1,138.5	272.9	97	38	-5.42	0	.265	84	2.0146	-33.32
1932	111.71	83.8	1,158.5	274.0	99	35	-2.89	0	.153	77	1.1878	-50.86
1933	87.04	107.1	1,172.6	275.1	96	32	-2.77	0	.118	90	0.8090	-59.47
1934	80.23	85.9	1,178.2	276.2	94	32	-0.90	0	.106	69	0.6454	-40.84
1935	76.22	78.5	1,181.1	277.4	95	33	-0.02	0	.034	35	0.2098	-30.17
1936	78.87	83.1	1,163.2	278.0	95	35	6.57	0	.424	73	2.5570	-21.90
1937	73.85	79.4	1,133.9	278.5	94	38	5.00	0	.175	43	1.1808	-16.39
1938	79.93	72.6	1,133.0	278.8	94	40	2.01	0	.402	79	2.5237	-15.22
1939	79.12	73.3	1,111.7	279.8	92	40	4.36	0	.312	82	1.9957	-13.80
1940	74.22	76.1	1,105.0	280.7	93	42	8.42	0	.312	80	2.0951	-12.85
1941	66.77	75.0	1,098.7	282.0	94	44	16.98	0	.336	87	2.3144	-8.70
1942	62.73	79.3	1,089.8	284.1	95	48	32.11	0	.419	93	3.0752	-2.55
1943	66.04	81.1	1,074.9	286.3	98	50	55.78	0	.616	112	4.7708	3.75
1944	75.94	86.5	1,053.6	288.5	98	51	49.15	0	.523	99	4.9047	11.63
1945	81.41	76.4	1,042.8	289.7	98	54	39.65	0	.438	103	4.5752	15.37
1946	78.74	79.5	1,041.0	290.0	97	58	34.57	0	.430	101	4.6456	17.33
1947	71.96	82.7	1,034.9	290.3	98	64	42.60	0	.520	107	5.0822	18.18
1948	75.41	73.9	1,026.7	290.6	100	72	43.37	0	.523	92	4.5042	21.58
1949	83.50	64.4	1,017.3	290.5	102	81	46.23	0	.638	115	5.4487	23.82
1950	79.76	56.7	1,009.1	290.6	101	90	30.85	0	.420	93	3.4670	20.74
1951	83.27	57.9	993.5	290.6	102	98	43.40	0	.520	101	4.1057	25.51
1952	93.50	52.5	965.1	290.5	102	100	45.49	0	.538	92	3.8847	29.99
1953	93.75	45.4	943.2	290.5	102	102	44.10	0	.516	107	3.8836	27.56
1954	89.32	42.7	923.5	290.4	104	103	29.23	0	.406	96	3.1021	22.43
1955	93.25	43.1	911.0	290.0	104	105	38.09	0	.488	98	3.4895	23.66
1956	92.38	48.9	893.3	289.8	102	103	28.29	6.6053	.349	96	2.5291	22.27
1957	94.23	43.0	882.5	289.4	99	100	29.85	12.2194	.380	98	2.5688	23.04
1958	99.28	42.5	868.4	288.6	99	97	34.57	9.1892	.524	116	3.1795	25.48
1959	106.93	42.6	854.6	288.1	99	103	43.19	7.7353	.596	135	3.8236	28.89

APPENDIX B, TABLE IV (Continued)

Year	P	T	A	Lf	C	S	JX	Lr	J_{t-1}	H_{t-1}	F_{t-1}	Cg
1960	108.35	39.4	837.4	287.7	99	99	27.37	10.2791	.380	120	2.4920	28.06
1961	107.10	39.9	819.3	287.5	95	95	30.41	22.4607	.457	140	2.9621	24.97
Mean	86.79	66.5	1,030.6	285.1	98.0	66.3	25.59	2.1402	.3955	93.8	3.0176	2.78
Standard Deviation	14.51	17.6	109.4	5.74	3.25	27.9	18.24	5.0024	.1498	21.3	1.3441	25.69

APPENDIX B, TABLE V

DATA USED IN THE ANALYSIS, SOUTH ATLANTIC REGION, 1930-1961

Year	P	T	A	Lf	C	S	JX	Lr	J_{t-1}	H_{t-1}	F_{t-1}	Cg
1930	72.55	62.7	1,113.5	90.0	106	32	12.21	0	.216	79	1.4930	-12.27
1931	77.94	68.3	1,124.2	91.9	109	30	3.43	0	.167	76	1.1437	-27.04
1932	72.30	83.4	1,136.7	93.8	108	27	-2.88	0	.160	80	1.1628	-50.20
1933	59.41	104.9	1,144.1	95.8	110	24	-3.10	0	.126	61	.8202	-60.31
1934	56.89	87.3	1,146.7	97.7	107	24	-1.70	0	.200	72	1.2770	-39.30
1935	56.92	69.8	1,148.8	99.6	110	25	-0.09	0	.189	70	1.2268	-25.98
1936	58.83	72.7	1,143.0	98.9	108	27	3.76	0	.243	78	1.5296	-18.36
1937	59.07	70.8	1,140.2	98.2	113	30	5.33	0	.187	72	1.3798	-7.32
1938	66.08	65.2	1,128.9	97.6	110	32	1.12	0	.224	84	1.6041	-5.46
1939	67.34	60.1	1,113.7	96.9	107	32	2.76	0	.197	77	1.4398	-3.26
1940	66.71	58.1	1,100.2	96.2	107	34	4.99	0	.195	87	1.5263	-0.19
1941	61.70	59.0	1,096.0	97.0	104	36	9.18	0	.182	87	1.4654	4.36
1942	59.00	58.0	1,088.8	97.8	106	40	14.84	0	.194	76	1.5962	8.80
1943	58.08	54.4	1,070.5	98.6	107	42	20.38	0	.225	88	2.1520	15.32
1944	60.26	64.7	1,072.3	99.4	105	43	20.89	0	.222	84	2.4054	26.55
1945	67.60	62.8	1,075.1	100.2	102	46	21.61	0	.239	95	2.7936	25.68
1946	76.66	65.2	1,072.0	101.4	99	50	19.95	0	.248	96	2.8340	44.04
1947	71.65	64.5	1,068.9	102.6	101	56	23.69	0	.289	104	2.8838	45.14
1948	68.01	59.3	1,056.6	103.7	99	64	20.84	0	.251	100	2.1178	40.70
1949	75.77	48.0	1,035.6	104.9	100	72.8	17.99	0	.248	104	1.9756	45.48
1950	71.04	43.3	1,018.3	105.8	95	80.7	16.49	0	.224	96	1.7563	38.42
1951	69.31	45.4	970.8	105.1	96	88.3	21.28	0	.255	103	1.9676	39.49
1952	79.57	45.1	924.1	104.6	97	90.9	23.61	0	.279	117	2.2200	48.93
1953	84.16	42.7	879.4	103.6	96	94.8	23.47	0	.274	106	1.9961	51.13
1954	83.11	41.4	842.5	102.7	92	99.9	19.85	0	.276	108	1.9390	46.57
1955	86.30	42.0	810.3	100.9	90	105.8	22.14	0	.284	105	1.7496	47.98
1956	88.34	42.8	777.1	99.0	87	103.0	24.62	.1802	.304	120	2.0312	49.65
1957	93.16	42.9	742.9	97.1	82	101.1	22.58	1.3122	.289	128	1.7722	54.62
1958	99.06	42.2	707.8	95.1	81	101.8	16.20	2.5147	.246	112	1.4413	59.85
1959	108.19	41.1	675.7	93.4	83	97.2	24.51	1.8167	.338	126	1.8735	67.55

APPENDIX B, TABLE V (Continued)

Year	P	T	A	Lf	C	S	JX	Lr	J_{t-1}	H_{t-1}	F_{t-1}	Cg
1960	111.13	42.7	644.8	92.1	81	93.8	18.97	2.4799	.263	127	1.5248	67.40
1961	115.62	38.5	614.9	90.3	77	90.2	19.66	3.9725	.296	132	1.6702	69.03
Mean	75.06	57.8	990.1	98.5	99.2	59.8	14.0	0.3836	.235	95.3	1.7740	20.22
Standard Deviation	15.99	15.41	167.6	4.28	10.06	29.95	9.28	0.9450	.047	19.0	.4847	36.00

APPENDIX B, TABLE VI

DATA USED IN THE ANALYSIS, EAST SOUTH CENTRAL REGION, 1930-1961

Year	P	T	A	Lf	C	S	JX	Lr	J_{t-1}	H_{t-1}	F_{t-1}	Cg
1930	72.48	56.5	1,094	74.9	110	31	15.06	0	.267	82	1.4642	-10.49
1931	78.54	62.6	1,102	76.2	117	29	3.24	0	.158	66	.8583	-23.90
1932	72.98	87.2	1,111	77.5	117	26	-3.38	0	.189	85	1.0325	-46.63
1933	58.62	106.6	1,118	78.7	107	23	-3.66	0	.150	68	.7023	-58.22
1934	55.53	85.9	1,129	79.9	111	23	-1.60	0	.188	77	.8864	-38.23
1935	56.88	74.3	1,139	81.2	111	24	-0.09	0	.192	73	.9293	-23.21
1936	58.18	81.4	1,134	80.8	111	26	3.55	0	.229	71	1.1004	-16.35
1937	57.89	81.7	1,122	80.4	117	29	5.89	0	.207	74	1.1400	-7.43
1938	66.65	69.9	1,109	80.0	112	31	1.36	0	.272	95	1.4282	-1.59
1939	69.19	67.8	1,085	79.6	112	31	3.18	0	.227	84	1.1909	2.09
1940	69.77	60.5	1,072	79.2	111	33	5.13	0	.190	75	1.1021	6.07
1941	64.44	59.1	1,054	79.0	109	36	9.18	0	.188	76	1.1281	8.65
1942	62.50	63.9	1,035	78.8	109	39	17.27	0	.226	84	1.3912	15.55
1943	66.85	70.1	1,010	78.7	108	41	22.87	0	.253	92	1.7501	24.35
1944	74.85	76.8	989	78.5	102	42	20.29	0	.216	89	1.8691	34.25
1945	82.81	72.8	981	78.3	99	45	18.48	0	.204	97	2.0258	43.09
1946	85.91	78.9	967	78.8	98	49	15.56	0	.193	98	2.0050	50.98
1947	81.15	79.0	970	79.4	98	55	17.61	0	.215	94	1.9018	55.98
1948	78.01	63.4	966	80.4	100	63	19.58	0	.236	96	1.7076	47.03
1949	87.58	54.8	961	80.9	102	71.1	18.74	0	.259	112	1.8686	52.76
1950	81.47	50.0	955	81.7	94	82.3	14.21	0	.193	92	1.4112	42.71
1951	82.27	53.0	908	81.8	93	91.9	18.14	0	.217	93	1.3271	47.53
1952	92.90	47.7	862	81.4	91	93.0	22.51	0	.266	99	1.4404	56.25
1953	94.49	45.5	816	80.8	91	95.1	23.39	0	.274	98	1.4513	53.29
1954	89.38	40.3	776	80.2	87	101.0	19.60	0	.272	107	1.4156	43.01
1955	89.38	42.2	743	78.8	88	104.6	18.45	0	.237	97	1.1761	39.67
1956	89.94	42.3	712	77.4	84	102.5	23.38	.3528	.289	116	1.4292	39.60
1957	94.16	44.0	682	75.9	80	100.7	21.86	1.2056	.279	112	1.2480	44.07
1958	98.18	41.8	652	74.4	77	99.0	14.09	2.1431	.214	100	.9534	47.00
1959	108.10	37.7	625	72.9	81	100.3	20.64	1.2278	.285	105	1.1803	55.64

APPENDIX B, TABLE VI (Continued)

Year	P	T	A	Lf	C	S	JX	Lr	J_{t-1}	H_{t-1}	F_{t-1}	Cg
1960	111.83	38.9	596	71.8	78	98.5	17.88	1.6315	.248	122	1.0785	58.07
1961	114.99	36.6	568	70.8	80	96.1	16.02	3.3885	.241	116	.9890	58.30
Mean	79.62	61.7	939.1	78.4	99.53	59.8	13.08	0.3109	.227	92.3	1.3307	21.87
Standard Deviation	15.94	17.44	177.14	2.8	12.52	30.93	8.58	0.7650	.037	14.73	.3485	34.03

APPENDIX B, TABLE VII

DATA USED IN THE ANALYSIS, WEST SOUTH CENTRAL REGION, 1930-1961

Year	P	T	A	Lf	C	S	JX	Lr	J_{t-1}	H_{t-1}	F_{t-1}	Cg
1930	96.93	53.3	1,104	183.9	113	55.90	17.53	0	.209	78	1.7425	-10.98
1931	102.23	51.6	1,122	187.3	114	50.03	8.59	0	.152	68	.9957	-22.06
1932	91.85	71.3	1,132	190.8	114	45.96	3.47	0	.169	96	1.1051	-49.84
1933	76.57	88.3	1,130	194.2	115	37.63	-2.46	0	.137	83	.8174	-63.13
1934	72.35	71.6	1,131	197.7	114	34.39	-5.11	0	.209	70	1.1274	-48.10
1935	70.04	59.8	1,139	201.1	112	32.25	-1.55	0	.183	51	.9805	-40.06
1936	71.69	63.0	1,119	201.0	110	39.37	-0.14	0	.281	68	1.4817	-33.65
1937	68.56	65.3	1,080	200.8	111	42.68	3.21	0	.199	62	1.1989	-26.17
1938	77.61	61.1	1,042	200.7	110	42.71	7.79	0	.273	94	1.5850	-23.27
1939	77.49	60.6	1,015	200.6	107	46.63	2.75	0	.221	77	1.3723	-23.55
1940	77.61	59.0	984	200.5	109	44.89	3.26	0	.233	76	1.4813	-19.45
1941	69.81	59.9	974	200.7	105	50.30	6.79	0	.251	83	1.5933	-15.69
1942	65.55	65.2	944	201.8	105	73.01	14.23	0	.282	80	1.8368	-7.89
1943	66.82	61.7	922	202.9	102	78.64	30.48	0	.398	89	2.7447	-1.59
1944	74.06	76.5	903	204.1	101	77.75	26.40	0	.340	79	2.8621	7.76
1945	80.93	68.9	895	205.0	96	67.30	20.95	0	.281	93	2.6829	16.68
1946	78.54	74.7	884	207.5	96	62.75	23.70	0	.232	78	2.1657	22.35
1947	70.58	77.3	869	210.1	99	63.46	31.91	0	.294	81	2.3300	23.48
1948	72.87	64.5	853	213.0	99	76.79	29.49	0	.389	94	2.4529	27.53
1949	79.53	55.4	832	215.0	102	79.54	29.56	0	.355	95	2.1861	29.27
1950	74.56	55.1	812	218.2	95	89.76	22.42	0	.408	111	2.5577	23.45
1951	78.78	57.1	772	219.3	99	96.66	32.41	0	.305	85	1.9054	31.34
1952	91.45	60.7	733	220.5	95	98.80	32.62	0	.388	85	2.1735	39.94
1953	89.82	49.1	694	221.7	94	101.41	26.74	0	.386	89	2.0983	34.17
1954	88.90	47.2	664	222.6	94	101.33	22.32	0	.313	96	1.7113	30.40
1955	91.87	53.5	640	222.2	93	102.20	24.29	0	.310	95	1.5441	30.60
1956	90.41	51.0	617	221.8	89	97.89	21.12	2.6427	.311	101	1.5204	28.00
1957	95.34	46.6	595	221.4	86	99.66	23.29	7.1404	.261	96	1.2012	32.38
1958	98.71	49.2	574	221.0	86	99.97	28.79	4.9466	.297	105	1.2665	33.60
1959	106.42	50.2	549	220.6	88	100.37	27.36	5.0743	.436	135	1.7709	43.83

APPENDIX B, TABLE VII (Continued)

Year	P	T	A	Lf	C	S	JX	Lr	J_{t-1}	H_{t-1}	F_{t-1}	Cg
1960	110.24	50.0	524	220.1	87	95.24	29.04	5.9813	.377	126	1.5864	44.47
1961	113.82	49.7	503	219.8	84	90.84	32.96	8.6567	.403	137	1.5243	43.98
Mean	83.5	60.24	867.2	208.4	100.75	71.13	17.94	1.0763	.290	89.3	1.7376	4.93
Standard Deviation	13.1	9.99	203.9	11.3	9.53	24.20	12.20	2.3837	.0807	78.8	.5436	31.51

APPENDIX B, TABLE VIII

DATA USED IN THE ANALYSIS, MOUNTAIN REGION, 1930-1961

Year	P	T	A	Lf	C	S	JX	Lr	J_{t-1}	H_{t-1}	F_{t-1}	Cg
1930	86.49	81.7	259.1	174.3	85	40	17.31	0	.306	82	.4970	-8.02
1931	100.53	72.8	259.7	177.6	84	38	6.50	0	.317	87	.5031	-8.12
1932	92.39	75.5	260.3	180.7	83	35	-2.36	0	.131	68	.2155	-24.31
1933	65.55	85.4	261.0	184.1	83	32	-3.31	0	.135	77	.2022	-32.96
1934	67.50	78.1	262.9	187.4	83	32	-1.61	0	.189	71	.2687	-25.72
1935	64.10	71.7	265.3	190.7	82	33	-0.08	0	.161	55	.2317	-20.71
1936	66.25	78.8	258.5	194.3	83	35	5.69	0	.367	73	.5228	-15.70
1937	63.73	78.7	251.0	197.9	80	38	8.93	0	.313	66	.4999	-11.27
1938	69.96	70.5	244.0	201.5	79	40	1.25	0	.250	81	.3708	-10.66
1939	71.28	66.8	239.3	205.1	79	40	4.61	0	.329	95	.4931	-9.29
1940	70.89	62.0	234.7	208.7	81	42	9.15	0	.339	82	.5309	-6.87
1941	65.45	65.1	232.2	219.4	83	44	18.93	0	.374	91	.6048	-3.41
1942	62.39	58.7	227.3	230.1	84	48	36.47	0	.476	104	.8243	1.92
1943	65.31	65.5	224.0	240.8	88	50	45.43	0	.502	105	1.0519	7.62
1944	75.69	76.5	221.6	251.5	91	51	50.80	0	.540	103	1.2018	17.22
1945	83.13	67.7	218.7	261.2	89	54	40.39	0	.446	98	1.1438	23.63
1946	81.31	76.8	216.8	262.4	89	58	39.31	0	.488	98	1.1087	26.10
1947	73.60	77.8	214.0	263.5	95	64	45.58	0	.556	99	1.1000	25.60
1948	73.47	70.8	211.2	264.7	98	72	57.11	0	.688	102	1.1605	26.02
1949	78.30	66.1	208.3	265.8	107	80.4	47.26	0	.652	105	1.0356	25.56
1950	80.87	60.9	205.3	267.0	109	89.5	43.00	0	.585	93	.9105	27.16
1951	85.03	63.1	201.4	269.1	111	97.5	55.87	0	.669	93	.9734	33.83
1952	96.43	57.5	197.5	271.7	113	100.4	66.74	0	.789	92	1.2263	39.75
1953	98.65	56.1	193.4	274.1	110	103.5	58.98	0	.689	98	1.1023	37.63
1954	97.14	47.6	189.7	276.6	112	105.4	42.07	0	.584	108	.9118	33.38
1955	98.55	53.6	185.5	277.5	111	107.6	39.87	0	.511	94	.7779	31.60
1956	96.73	53.9	181.2	278.2	110	104.0	38.00	1.2479	.469	100	.7146	28.49
1957	94.81	52.1	177.1	278.5	109	99.7	38.76	3.7116	.494	98	.7228	25.34
1958	99.48	54.0	173.0	278.7	109	98.7	39.92	2.6309	.605	112	.8110	26.51
1959	105.87	57.2	168.8	278.8	108	101.6	48.31	3.0362	.666	121	.9044	29.51

APPENDIX B, TABLE VIII (Continued)

Year	P	T	A	Lf	C	S	JX	Lr	J_{t-1}	H_{t-1}	F_{t-1}	Cg
1960	110.84	59.0	164.7	278.7	106	98.1	39.28	3.4564	.545	116	.7495	30.53
1961	112.04	55.0	160.6	278.7	104	94.5	37.12	4.0352	.558	116	.7537	28.33
Mean	82.93	66.2	217.7	239.7	94.9	66.5	30.48	0.5661	.460	93.2	.7539	10.89
Standard Deviation	15.14	10.0	32.1	38.1	12.5	28.2	20.91	1.2430	.173	15.4	.3086	21.70

APPENDIX B, TABLE IX

DATA USED IN THE ANALYSIS, PACIFIC REGION, 1930-1961

Year	P	T	A	Lf	C	S	JX	Lr	J_{t-1}	H_{t-1}	F_{t-1}	Cg
1930	86.51	57.6	280.5	62.7	93	40	19.84	0	.351	66	.7676	-2.40
1931	101.12	58.1	283.1	63.1	93	38	6.85	0	.334	70	.7314	-5.48
1932	95.52	73.7	286.1	63.5	95	35	-4.64	0	.258	65	.5714	30.08
1933	76.63	82.7	288.0	63.9	93	32	-5.01	0	.205	67	.3990	-48.21
1934	68.18	74.3	295.1	64.3	91	32	-2.82	0	.332	67	.6260	-37.51
1935	66.45	66.2	300.2	64.7	95	33	-0.14	0	.385	68	.6976	-28.71
1936	68.46	75.7	298.1	64.9	96	35	7.25	0	.468	74	.8401	-22.15
1937	67.16	79.4	297.1	65.2	98	38	12.62	0	.443	73	.9184	-14.38
1938	73.05	73.7	293.1	65.5	96	40	1.93	0	.386	79	.7925	-14.34
1939	73.07	66.3	289.8	65.7	87	40	4.76	0	.335	79	.7490	-14.26
1940	72.38	65.0	287.0	65.9	89	42	7.76	0	.288	86	.6778	-11.15
1941	65.72	63.4	287.0	67.0	88	44	16.72	0	.331	90	.8397	-7.55
1942	61.37	69.7	285.1	68.5	91	48	32.70	0	.428	93	1.2364	-1.16
1943	64.27	72.3	285.4	70.2	93	50	48.14	0	.532	92	1.7224	7.05
1944	75.97	82.8	286.5	72.0	95	51	57.92	0	.616	92	2.2143	20.82
1945	85.11	77.4	286.7	73.7	95	54	54.45	0	.602	95	2.2613	30.46
1946	84.58	85.1	284.3	74.5	96	58	51.42	0	.639	95	2.2693	35.16
1947	76.31	83.1	283.7	74.8	99	64	51.98	0	.657	105	2.3678	34.10
1948	68.85	67.4	282.0	75.3	100	72	49.14	0	.634	100	1.6878	26.32
1949	67.64	64.7	281.1	75.9	101	79.7	42.93	0	.592	100	1.4737	18.89
1950	70.38	61.3	280.2	76.5	99	88.4	38.87	0	.529	100	1.3358	22.68
1951	72.72	70.5	270.4	77.0	100	95.8	45.31	0	.543	106	1.4296	29.02
1952	83.70	72.6	260.2	77.4	101	98.2	55.16	0	.653	112	1.6265	36.53
1953	87.36	69.7	250.9	77.9	101	101.9	65.42	0	.765	116	1.6950	35.62
1954	85.00	62.4	242.0	78.5	101	104.0	43.41	0	.603	115	1.5171	28.64
1955	88.74	68.8	236.0	78.6	99	106.9	46.28	0	.593	117	1.4397	30.00
1956	90.77	72.2	231.5	78.6	101	103.9	47.84	.0450	.591	118	1.4550	31.56
1957	94.03	67.7	226.5	78.6	100	100.8	48.51	.6802	.618	122	1.4882	33.26
1958	99.03	68.2	222.0	78.5	100	99.1	38.64	.3703	.585	128	1.3372	36.07
1959	107.38	70.2	217.0	78.4	100	100.4	42.59	.6239	.588	127	1.3197	41.12

APPENDIX B, TABLE IX (Continued)

Year	P	T	A	Lf	C	S	JX	Lr	J_{t-1}	H_{t-1}	F_{t-1}	Cg
1960	113.29	68.9	211.0	78.4	98	97.0	41.15	.7812	.572	134	1.3578	44.42
1961	120.55	68.0	205.5	78.4	98	94.8	38.59	.9219	.580	129	1.3227	48.10
Mean	81.61	70.6	269.2	71.8	96.3	66.2	31.42	.1069	.5011	96.3	1.2865	11.01
Standard Deviation	17.61	6.9	28.4	6.0	4.0	27.8	21.53	.2552	.1391	21.0	.5272	20.67

APPENDIX C

COMPUTATION OF FIVE YEAR, TEN YEAR, AND LONG-RUN COEFFICIENTS

Given the basic equation containing a lagged variable with time specified by the subscript on the dependent variable Y, successive iteration gives:

$$Y_1 = ga + (1-g)Y_0$$

$$Y_2 = ga + (1-g)Y_1 = ga + (1-g)[ga + (1-g)Y_0]$$

$$= ga + (1-g)\ ga + (1-g)^2 Y_0$$

$$Y_3 = ga + (1-g)Y_2 = ga + (1-g)\ [ga + (1-g)ga + (1-g)^2 Y_0]$$

$$. \quad . \quad . \qquad = ga + (1-g) + (1-g)ga + (1-g)^2 ga + (1-g)^3 Y_0$$

. . . .

. . . .

. . . .

. . . .

$$Y_t = ga + (1-g)ga + (1-g)^2 ga + (1-g)^3 ga + \ldots + (1-g)^{t-1} ga + (1-g)^t Y_0$$

Therefore:

(1) The coefficient on Y_0 in the equation Y_t is $(1-g)^t$ where $0 < g < 1$ and as $n \rightarrow \infty\ (1-g)^t \rightarrow 0$.

(2) The remainder of the equation is a geometric progression.

In general form; $a + ar + ar^2 + \ldots + ar^{n-1}$.

In this particular form; $ga + ga(1-g) + ga(1-g)^2 + \ldots + ga(1-g)^{n-1}$

But the definite sum over "n" terms in the genëral case is;

$$S_n = \frac{c - cr^n}{1 - r} = \frac{c(1-r^n)}{1 - r}$$

In this case c = ga and r = (1-g) and t is equivalent to n, so we have:

$$S_n = \frac{ga[1 - (1-g)^t]}{1 - (1-g)} = \frac{1 - (1-g)^t}{g} ga$$

where ga is the estimated short-run coefficient.

In the long-run, (1-g) $\longrightarrow$ 0 as t $\longrightarrow \infty$ giving $\frac{1-0}{g}$ ga.

Therefore, the long-run coefficients on the independent variables are given by $\frac{1}{g}$ ga; or $\frac{ga}{g}$ or simply a.

It follows directly that the coefficients for the five year adjustment equation are computed as:

$$\frac{1-(1-g)^5}{g} \left[\text{each of the coefficients in the equations except the lagged dependent variable}\right]$$

and

$$(1-g)^5 \quad \left[\text{the coefficient on the lagged dependent variable}\right]$$

APPENDIX D

In Appendix D we present additional concepts from static economic theory, deriving conditions under which resources are economic complements or substitutes. Also, concepts of resource valuation are extended to multiproduct situations.

Figure 1 is the traditional factor-factor diagram with factor X_1 measured on the horizontal axis and factor X_2 measured on the vertical. Curve abc is a ridge-line defining the successive quantities of X_2 at which the MPP of $X_2 = 0$. Curve Muvw is the ridge-line for X_1 where $MPP_{x_1} = 0$. Thus point M represents maximum physical product,

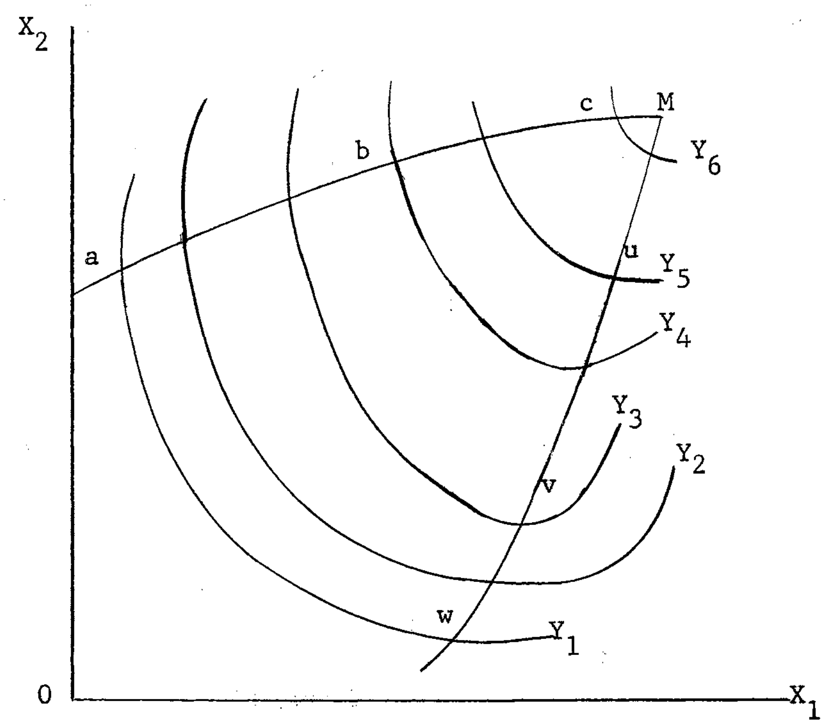

Figure 1. Single Product, Factor-Factor Production Surface.

which would only be attained where $MPP_{x_1} = MPP_{x_2} = 0$. Since $P_y MPP_i = P_i$; then prices must be zero for both factors if M level of production is to maximize profit.

The introduction of prices into the model in Figure 2 prescribes more narrow limits to the region of economic use of resources X_1 and X_2.

Isoclines lnH and rpH delineate the area within which the $MVP_{x_2} \geq P_{x_2}$ and $MVP_{x_1} \geq P_{x_1}$ with point H being the High Profit Point (HPP) where both MVP's are equal to the factor prices. Isocline wzH is the isocline known as the Expansion Path on which the $MRS_{x_1 x_2} = \frac{Px_2}{Px_1}$ satisfying the equi-marginal condition. X_1 and X_2 are shown to be technical substitutes in the range of rational production by the convexity of the iso-product contours (iso-quants). The slope of the isoclines lnH and rpH indicate that X_1 and X_2 are economic complements at the margins of profitable production. Both pseudo-scale lines (lnH and rpH) slope back toward the origin from the High Profit Point (H). Economic substitutes are characterized in the factor-factor model by the isoclines delineating $MVP_{x_i} = P_{x_i}$ sloping away from the origin as they move from the HPP toward the axes.

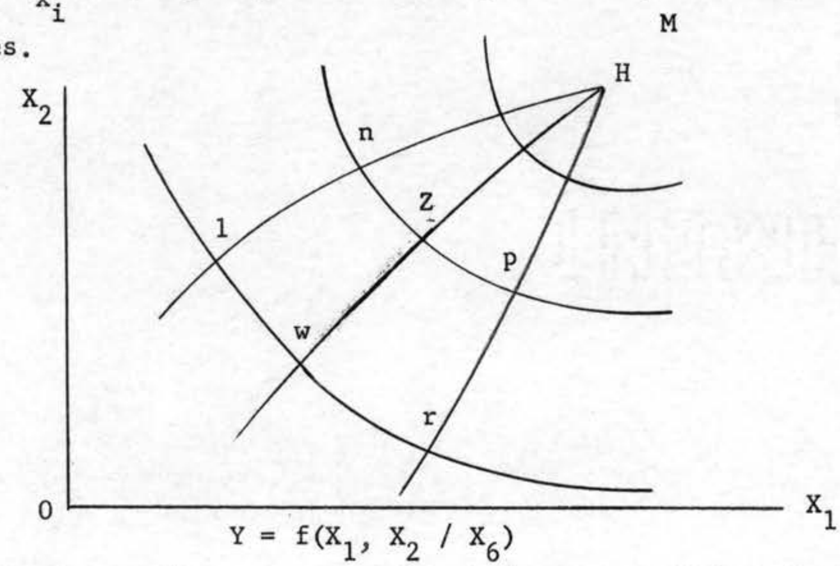

Figure 2. The Area of Rational Production and Expansion Path.

Figure 3 illustrates the case of economic substitutes where a change in the use of one resource caused by some outside influence would call for adjustment in the use of the substitute resource, but in the opposite direction. Specific factors, L and K, have been inserted in the place of the general notation for X_1 and X_2 in Figures 1 and 2.

An increase in the price of factor L, for instance, would cause the pseudo-scale line to pull down to $MVP_L = P_{L_2}$ and the resulting HPP would be at u; to the result that a decrease in L would require increased use of K, and from K_1 to K_2 in Figure 3.

The basic model of Figure 3 also illustrates the effect of non-economic restrictions on resource use.

Suppose that a farm firm is using land (L) and labor (K) in optimum quantities with given resource prices P_L and P_K.

If L and K are economic substitutes the pseudo-scale isoclines are represented in Figure 3.

If they are economic complements the pseudo-scale isoclines are represented in Figure 4.

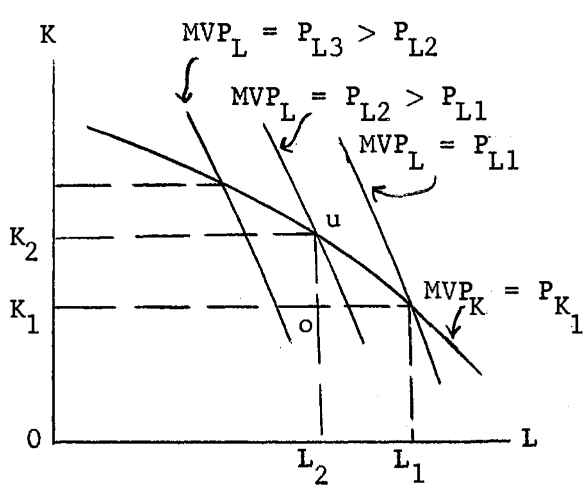

Figure 3. Economic Substitutes

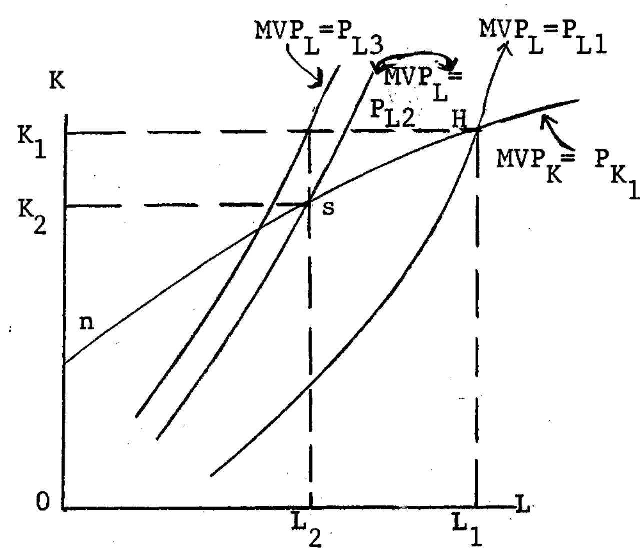

Figure 4. Economic Complements

The initial optimum organization is found at point H. An institutional restriction of land is shown at L_2 which precludes the use of the portion of land represented by $L_1 - L_2$.

If the amount of labor cannot be varied in the short-run, the new organization is illustrated at point s. The short-run use of labor (K) is then at greater returns than the price of labor P_{K_1} would specify in the case of substitutes in Figure 3 and at lower returns than before if L and K are complements (Figure 4). The MVP of land is increased in both cases to P_{L_3}. Assuming the price of labor in the long-run is independent, the equilibrium use of labor will return to $MVP_K = P_{K_1}$.

The long-run return to land will settle at $MVP_L = P_{L_2}$ with land prices ordered $P_{L_3} > P_{L_2} > P_{L_1}$.

Complementarity between land and other resources, particularly labor, is a matter of special concern in a policy context. This relationship identifies a situation where addition of one factor requires a related increment of expansion of its complementary factors. The practical importance of this situation so far as farm land and labor are concerned is this: if they are complements, restriction or reductions of the amount of labor needed in equilibrium aggravates further an existing condition of excess labor in agriculture. This result simultaneously forces land prices up and returns per unit of labor down.[1] If we assume that labor is fixed over a significant period, labor returns

[1] Whether land and labor; land and capital; land and technology are actually substitutes or complements (or independent) is a difficult "what is" problem. The argument here is theoretical, on an "if-then" basis.

would be increased in a substitute relationship and decreased if complementary to land.

Total output is, of course, decreased from the initial situation in both models by a resource restriction on land.

The logic of the factor-factor model of Figure 2 applies equally well to larger systems involving three or more factors.

Multiproducts and Alternative Uses for Factors

The models outlined in the preceding sections show how resources are allocated in the production of <u>one</u> product. Alternative uses also exist for factors, and entrepreneurs as well as society have a continual interest in attaining an optimum allocation of resources to the production of the several products possible. We now consider the determination of rents in a static multiproduct model. Each factor possesses a "family" of MVP curves, one for each product. Thus, if factor X could be utilized in the production of four different products (Y_1, Y_2, Y_3, Y_4) marginal theory indicates that the allocation be such that the MVP's of X are equal in each employment. Figure 5 illustrates:

Given eleven units of X available to the market, the allocation is given as follows:

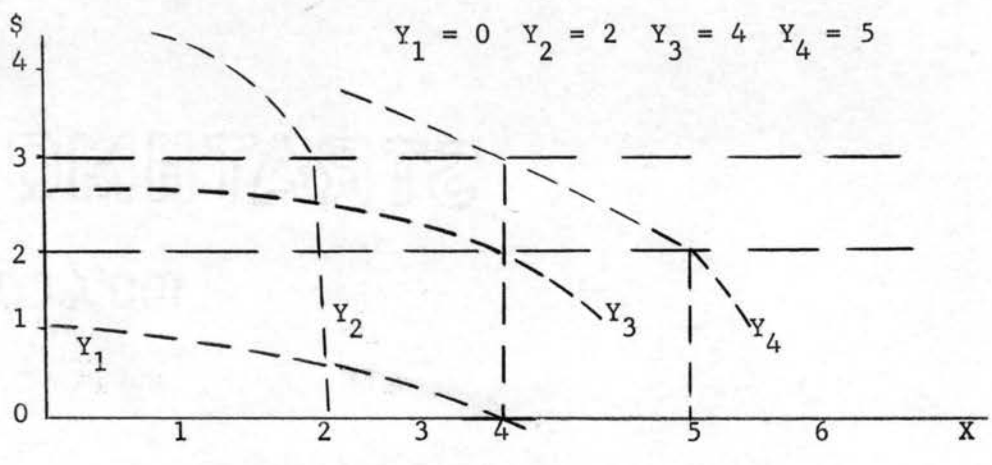

Figure 5. Marginal Value Products of X.

The price of X (P_x) would be \$2 and total income to the owners from X would amount to P_xX = \$2(11) = \$22. Should the supply of X fall to 6 units, then 2 would go to Y_3 and 4 to Y_4. Total factor earnings would fall to \$3(6) = \$18.00 for this factor. Y_3 would not compete effectively for the use of this factor under the conditions specified.

The height of the MVP curve is immaterial to the allocation or the pricing mechanism; so long as it is higher than the factor price, the product concerned receives the service of the factor. To clarify the point, the assumption of a completely fixed supply of the factor can be made and only two products considered, as in Figure 6. Five units of X are available, and can be used in production of either Y_1 or Y_2 or some combination thereof. The equi-marginal principle dictates that the allocation coincide with the intersection of the MVP curves and that this equal the factor price (P_x). Thus, given $MVP^{y_1}_{x_1}$ and $MVP^{y_2}_{x_1}$, the allocation of 2X to Y_1 and 3X to Y_2 is determined. Since $MVP^{y_1}_{x_1} = MPP^{y_1}_{x_1} P_{y_1}$ any change in either P_y will shift that MVP^y_x curve. Assume P_{y_2} increases

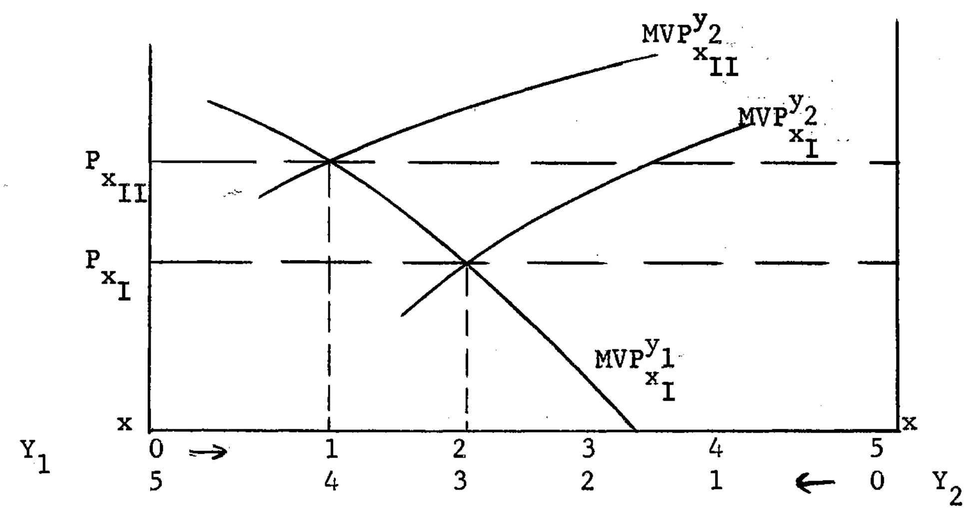

Figure 6. Allocation of a Fixed Resource.

moving $MVP^{y_2}_{x_1}$ upward to $MVP^{y_2}_{x_{II}}$. With P_{y_1} constant and a fixed amount of X_1 in the market the allocation changes to 1X in production of Y_1 and 4X in production of Y_2.

The model in Figure 6 assumes perfect competition in both the product and factor markets and assumes a fixed supply of the resource. In the Marshallian market period and short-run, this is acceptable for many resources. How closely it resembles the supply of agricultural land in the U. S. in 1964 is not clearly established.

The model is applicable to problems of the firm, and with factors exhibiting characteristics of "lumpiness" or fixity or both--such as family labor, land, and some specialized machines.[2]

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[2]More complete discussions of resource fixity theory are found in Glenn L. Johnson, "Supply Functions--Some Facts and Notions," Agricultural Adjustment Problems in a Growing Economy, edited by Heady, Diesslin, Jensen, and Johnson (Ames, 1959), p. 78 ff.
Clark Edwards, "Resource Fixity and Farm Organization," Journal of Farm Economics (November, 1959), pp. 747-760.

VITA

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