Aggregate Investment Demand for Farm Buildings:

A National, Regional and State Time-Series Analysis

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cooperating

CONTENTS

This study deals with the aggregate investment expenditure on farm buildings. It includes an econometric analysis of investment demand for farm buildings and related underlying variables. Aggregate time-series data are used in the study.

Three levels of aggregation are used in estimating demand functions: national, regional and state. The demand functions estimated are for annual expenditures on new farm buildings and remodeling of old farm buildings—both housing and service buildings.

The important variables identified by the study and included in the national demand relationship are net farm income, gross farm income, the rate of interest on new farm mortgages, the ratio of long-term assets to long-term debts and a time-trend. The same variables were significant in regional analyses. However, net farm income was not included in the analysis because of lack of data. All variables used in regional analyses were significant in the state models. An additional variable, farm size, was significant in demand functions for certain states.

The usual statistical criteria indicated all equations to be highly acceptable. "F" ratios range from 48 to 552, and R^2's range from 0.80 to 0.98. All "t" values for coefficients of explanatory variables are significant at a probability level of 0.05 or lower, and a large proportion are significant at a 0.01 probability level.

As expected from economic theory, income has a positive effect, interest rate a negative effect, and the asset-to-debt ratio a positive effect on farm building demand. The time trend has a negative effect in most models, and farm size has a negative effect upon aggregate investment in farm buildings.

Elasticities of demand were calculated at the means for all explanatory variables in all linear equations. The elasticities of demand with respect to income were most important in indicating the relative change in farm building investment because of the greater magnitude and variation of income compared with other explanatory variables. The elasticities with respect to gross income were largest, ranging from 0.48 to 0.75 for national data, depending on the specific variables included in the equation. These elasticities indicate the strong influence that a change in output has on building capacity requirements. Elasticities with respect to net income for national building investment ranged from 0.20 to 0.43. Elasticities with respect to equity-ratio (ratio of long-term assets to long-term debts) ranged from 0.36 to 0.67, and elasticities with respect to interest rate to building cost price-ratio ranged from −0.01 to −0.23.

Projections of demand for farm buildings on a national, regional and state basis were made for the year 1980. These projections suggest a moderate decline in farm building expenditures in real terms, not only for the nation, but also for all regions and nearly all states. The expected increase in size and decrease in number of farms appear to be the primary causes of the projected decline in new investment in farm buildings.

Ordinary least-squares single-equation regression techniques were used to estimate all equations. Both linear and logarithmic equation forms were used. With the Durbin-Watson d statistic serving as a criterion of necessity, at least one equation from each model was corrected for autocorrelation by one of the accepted methods. A model combining regression with covariance was used to estimate regional demand functions for all regions simultaneously and state demand functions simultaneously for all states within a region.

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Farm buildings represent an important part of the total investment in farming. Farm service buildings alone constitute about 20 percent of the total value of farm real estate and substantially more than 10 percent of all farm assets. Annual expenditure on repairs and maintenance of the farm building investment is a sizeable component of total farm operating expenses. Expenditures in 1962 for new construction and repairs on farm buildings in the United States were 1.3 billion dollars, or 5.2 percent of total farm outlays. This expenditure has ranged from 1.2 billion to 1.5 billion dollars over the last 15 years.

Forces Affecting Farm Building Investment

Although capital investment and annual expenditures for farm buildings are large in absolute terms, they have varied considerably over the last 3 decades. Too, capital expenditures have differed considerably among agricultural regions. What are the main forces or variables explaining these variations in capital expenditures? The major purpose of this study is to estimate the effect of important variables in explaining farm building demand.

Although building investment has been large in recent decades, the structural adjustments now occuring in agriculture may well alter past trends and levels of expenditures. Both technological change in agriculture and farm consolidation are occurring rapidly. The number of Iowa farms declined more than 12 percent from 1950 to 1959 and, in many Iowa counties, the decline was more than 20 percent (43,44,45). The rate of farm consolidation and the consequent decline in farm numbers has been even greater in other states. Further, farm numbers are projected to decline by 42 percent from 1962-63 to 1980 (8, p. 16). Investment problems associated with rapid farm consolidation are likely to be even more important in the future than in the past.

Tenure is another variable related to the magnitude and composition of farm building investment. Both the type of tenure and the proportion of tenure are changing. Other phenomena relating to farm building investment are taking shape. The average capital investment per farm has increased greatly. The average age of farm operators has increased considerably over the last decade (43, 44, 45). These rapid changes in farming have an important effect on use of existing forms of investment and on the demand for new investment. Yet very little research has been devoted to the economic effects of these dynamic forces on the conversion and use of existing farm buildings and the demand for investment in new farm buildings.

Importance to the National Economy and Individual Decisions

Investment decisions are important to both the individual firm and the national economy. The volume and kind of building investment are important to the national economy, because they affect the business cycle, the amount of employment and relative changes in income among economic sectors. Investment for the individual can mean growth in size or expansion into different items of production, or it can result in application of technological advances and maintenance of the farmer's relative position in the highly competitive agricultural industry. Farmers react to a change in economic environment by making investments to adjust their farm to the new economic situation. The amount and type of investment made indicate the rate of adjustment (20). Expenditures for investment also are made in anticipation of economic change rather than in reaction to it. Aggressive farmers may invest to increase business size, relative to competitors, with no appreciable change in the economic situation.

PURPOSE AND OBJECTIVES

The over-all purpose of this study is to estimate the effect of major variables on farm building investment or demand. Specific objectives include: (a) identification of the causal and related variables affecting the investment demand for farm buildings, (b) descrip-

tion and quantification of the causal variables, (c) development of a model or models to describe the aggregate demand for farm building investment by using the causal and related variables, (d) estimation of the parameters of the models developed by using the data available and the statistical methods appropriate for the models developed and, (e) use of the models developed and parameters estimated to simulate and project the demand for farm building investment (based upon certain assumptions indicated later).

RECENT INVESTMENT MODELS AND METHODS USED

Nonagricultural Studies

Most recent economic studies of investment demand for plant and equipment in industry have been based upon the accelerator and marginal theories or their modification. The accelerator theory, introduced by Keynes (24), expresses the effect of changes in gross output on current investment (22, 35). The single period accelerator or modified accelerator model has been used in a number of studies (2, 17, 29). Since the work of Koyck (28) and Nerlove (31), several econometric studies of investment demand have included some form of the distributed lag accelerator (3, 9, 11, 30). Modifications have been made to account for undercapacity production in some industries and firms. Equations with these modifications, called capacity adjustment models, often have given better results than the original accelerator model (2, 16, 29).

The rate of interest has always received attention as a possible variable affecting investment demand (1, 7, 12, 13, 14, 18, 26, 27, 33, 34, 47, 48) for several reasons: The rate of interest is the theoretical link between savings and investment; it is a criterion for choice between alternative investment opportunities; it allows time comparisons; it allows comparison with the marginal efficiency of capital (24); and it allows a logical assessment of risk. Although the theoretical literature places strong emphasis on the effect of interest rate on investment, only a few econometric studies have found the interest rate statistically significant (14, 19, 25).

Agricultural Studies

In addition to the variables included in nonagricultural models, most agricultural investment models have included profits or net income (5, 6, 19, 21) and relative price ratios of various inputs (5, 6, 21). Inclusion of price ratios adds marginal return theory to the theoretical basis of the models.

The demand for farm machinery, tractors and farm trucks has been investigated (5, 6, 19, 21) with some positive results. The aggregate demand for buildings

and machinery together has been investigated (21). However, the analysis presented here is the first investment demand study of farm buildings as a separate capital input.

DATA AND RESULTS

Method of Study and Variables Used

The quantitative technique used in this study is single-equation, least-squares regression analysis. The analysis is based on time-series data available at the national, regional and state levels. Alternative models, representing different aggregations of variables and including different sets of variables, were used in estimating the regression equations. Alternative models were tried as a means of improving the prediction of farm building investment and to conform to the time-series data available. Theoretically optimal models, while easy to formulate, were not always applicable because of limitations in the available data. For national estimates, data for the following time-series variables, on an annual basis for the years 1910 to 1963 inclusive, are available from the U. S. Department of Agriculture:

I_t = annual investment expenditures on new and remodeled farm buildings in millions of current year (t) dollars, from unpublished sources in the Farm Production Economics Division of the U.S. Department of Agriculture and from the Farm Income Situation (41, 42),

I_t^D = annual investment expenditures on new and remodeled farm dwellings in millions of current year (t) dollars, from unpublished sources in the Farm Production Economics Division of the U. S. Department of Agriculture,

b_o = the over-all intercept for the regression equation,

b_w = the dummy intercept coefficient to obtain the difference in intercept for the World War II years 1942, 1943, 1944, 1945 and the over-all intercept,

b_{pw} = a dummy coefficient to obtain the difference in intercept for the pre-World War II years, 1913 to 1941 inclusive, and the over-all intercept,

Y_{t-i} = gross farm income to farm operators lagged to the i-th year in millions of current dollars, from the Farm Income Situation (41, 42),

y_{t-i} = net farm income to farm operators lagged to the i-th year in millions of current dollars, from the Farm Income Situation (41, 42),

r = the current rate of interest on new farm mortgages in percent from Agri-

cultural Finance Review (39) and Farm Mortgage Credit Facilities in the U. S. (23),

$(ER)_{t-1}$ = the ratio of the total value of land and buildings in millions of current dollars from Agricultural Finance Review (39), to the mortgage debt outstanding in millions of current dollars from Agricultural Finance Review (39), lagged 1 year,

T = time trend is the last two digits of the year of observation,

P_B = the price index of building materials with 1910-14 = 1, from Prices Paid by Farmers (40),

Y_w = the weighted gross income = $(3Y_{t-1} + 2Y_{t-2} + Y_{t-3})/6$; where Y_{t-1} is previously defined,

y_w = the weighted net income = $(3y_{t-1} + 2y_{t-2} + y_{t-3})/6$; where y_{t-1} is previously defined,

$(r/P_B)_{t-1}$ = price ratio of cost of money to building materials, lagged 1 year, r and P_B are previously defined,

$(I/P_B)_t$ = annual investment expenditures on new and remodeled farm buildings deflated by the building cost index, in millions of dollars,

$(Y/P_B)_{t-1}$ = gross farm income to farm operators deflated by the building cost index lagged to the i-th year in millions of dollars, and

$(y/P_B)_{t-1}$ = net farm income to farm operators deflated by the building cost index lagged to the i-th year in millions of dollars.

Results for National Models

The regression equations used in predicting demand functions for farm buildings at the national level included several profit models, with variations relative to deflated data, weighted income and autocorrelation corrections. These equations were estimated in the original observations of the data as simple linear relationships. Also some power functions, with observations transformed to logarithms, were used. The results of the several models will be presented in the following section along with a summary of the implications of the statistics. The variables indicated for each equation are those listed and defined in the immediately preceding section.

PROFIT MODEL: UNDEFLATED DATA

This model includes the net income variable and a dummy variable for the World War II period. A deflator is not used. The model estimated is:

$$(1) \quad I_t = b_o + b_w + \sum_{i=1}^{3} b_i y_{t-i} + b_4 r_{t-1} + b_5 ER_{t-1} + b_6 T + u_t$$

The second model estimated (also without deflator) is the same as model 1 except that gross income, Y_{t-i}, is substituted for net income, y_{t-i},

$$(2) \quad I_t = b_o + b_w + \sum_{i=1}^{3} b_i Y_{t-i} + b_4 r_{t-1} + b_5 ER_{t-1} + b_6 T + u_t$$

Initially, models 1 and 2 were estimated with three lags $(t-1, t-2, t-3)$. Five lags of both gross income and net income in models that were the same as 1 and 2, except for these additional lags, were also estimated. The five lags were less successful statistically than the three lags, probably partly because of multicollinearity, and are not reported.

The quantitative results for models 1 and 2 with three lags each are reported in table 1. Equation 3 in table 1 is the estimate for model 1 with the net income variable. Equations 4, 5 and 6 in table 1 parallel model 2 with gross farm income replacing net farm income. Each line reports the statistical data for one regression equation. The equation number is given in the first column, and the $\bar{R}^2$ in the second column.[2] The third column reports the Durbin-Watson d statistic, the fourth column reports the autocorrelation coefficient, ρ, when used (non-zero value) for that equation, and the fifth and all following columns report the regression coefficients for the variables in the column headings. All following tables reporting regression coefficients and their associated statistics follow this same order.

All coefficients reported in table 1 are significant at a probability level of 0.05 or lower. The R^2's for equations 3, 4, 5 and 6 are 0.9698, 0.9829, 0.9795 and 0.9827, respectively, and the F ratios are 197.6, 421.0, 300.2 and 393.1, respectively.

The results reported in table 1 correspond with prior hypotheses. The signs of all coefficients are in the direction suggested by theory, except for the negative signs on Y_{t-2} and y_{t-2} in all equations in table 1 and the positive sign on r_{t-1} in equation 3 in table 1.

As an example of a specific complete equation, equation 4 from table 1 is as follows for the years 1910-41 and 1946-63 inclusive:

$$(4a) \quad I_t = -288.9462 + 0.05162\, Y_{t-1} - 0.03910\, Y_{t-2} + 0.03053\, Y_{t-3} - 53.7697\, r_{t-1} + 46.6204\, (ER)_{t-1}$$

and for the years 1942-45 inclusive:

$$(4b) \quad I_t = -701.9809 + 0.05162\, Y_{t-1} - 0.03910\, Y_{t-2} + 0.03053\, Y_{t-3} - 53.7697\, r_{t-1} + 46.6204\, (ER)_{t-1}$$

This difference arises because of the values given the dummy intercept variable in war and other years.

[2] The formula for calculation of $\bar{R}^2$ is given by Goldberger (15) as: $\bar{R}^2 = R^2 - [K/(N-K-1)]\,(1-R^2)$; where K is the number of independent variables and N is the number of observations. $\bar{R}^2$ is an adjustment of the R^2 to account for the number of variables and the number of observations.

Table 1. Regression equations and related statistics for profit models with lagged income, undeflated national data.

Equation number	$\bar{R}^2$	d	ρ	Constants		Regression coefficients for:		
				b_o	b_w	y_{t-1}	y_{t-2}	y_{t-3}
3	0.9649	0.8862	—	−1390.36**	−464.58**	0.06819**	−0.05126*	0.03795*
4	0.9806	1.6744	—	−288.95*	−413.03**	—	—	—
5	0.9767	1.9770	0.16	−239.41	−443.64**	—	—	—
6	0.9792	1.3628	—	−634.18**	−405.88**	—	—	—

Equation number	Regression coefficients for:					
	Y_{t-1}	Y_{t-2}	Y_{t-3}	r_{t-1}	ER_{t-1}	T
3	—	—	—	84.8391**	71.7034**	17.9182**
4	0.05162**	−0.03910**	0.03053**	−53.7697**	46.6204**	—
5	0.04818**	−0.03179**	0.02612**	−52.1518*	48.5138**	—
6	0.04725**	−0.03595**	0.02430**	—	57.3210**	5.1416*

** indicates coefficients with probability level $0 < p \le 0.01$.

* indicates coefficients with probability level $0.01 < p \le 0.05$.

The elasticities, determined with all variables at their mean, for these equations are reported in table 2.[3]

The wrong sign on the rate of interest is also obtained in equation 7, table 3, where results for the profit model with weighted income are reported. A positive sign is obtained for the rate of interest only in equation 3, table 1, and equation 7, table 3. Both these equations included time as a variable. Evidently the sign reversal results from intercorrelation between time and the rate of interest and from the use of undeflated data.

Negative coefficients for the second lag on both net income and gross income in all equations in table 1 are difficult to explain other than as the result of multicollinearity. The simple correlations of the first five lags of income with investment are positive, suggesting further that the negative coefficient on the second lag is due to multicollinearity. The intercorrelation matrices for investment and three lags of income are:

$$(11) \quad \begin{array}{c} Y_{t-1} \\ Y_{t-2} \\ Y_{t-3} \end{array} \begin{bmatrix} I_t & Y_{t-1} & Y_{t-2} \\ 0.9552 & & \\ 0.9499 & 0.9837 & \\ 0.9441 & 0.9528 & 0.9829 \end{bmatrix}$$

$$\begin{array}{c} y_{t-1} \\ y_{t-2} \\ y_{t-3} \end{array} \begin{bmatrix} I_t & y_{t-1} & y_{t-2} \\ 0.8834 & & \\ 0.8971 & 0.9581 & \\ 0.9093 & 0.8679 & 0.9516 \end{bmatrix}$$

[3] The elasticities are calculated in the following way: $e = b_i \bar{x}_i / \bar{I}_t$ (15, page 214).

These correlations suggest that an arbitrary distributed lag can be used.

PROFIT MODEL WITH WEIGHTED INCOME: UNDEFLATED DATA

This model is suggested by the results of models 1 and 2. The reversal of the sign on the second income lag and the correlation of lagged income with the dependent variable indicate that an arbitrary weighting scheme should give as good or better results. Based on learning theory and observation, heavier weights are placed on the most recent incomes. Therefore, the following weighting scheme is used: $y_w = (3y_{t-1} + 2y_{t-2} + y_{t-1})/6$. Model 12, with weighted net income, is estimated and reported as equation 7 in table 3.

$$(12) \quad I_t = b_o + b_w + b_1 y_w + b_2 r_{t-1} + b_3 (ER)_{t-1} + b_4 T + u_t$$

y_w is not only an arbitrary substitution for lagged net income or profit, but it also may be considered as a logical proxy variable for income expectation (assuming that expectations are based on experienced income). Gross income weighted in the same way is substituted for y_w to obtain model 13:

$$(13) \quad I_t = b_o + b_w + b_1 Y_w + b_2 r_{t-1} + b_3 (ER)_{t-1} + b_4 T + u_t$$

The statistical results for model 13 with several modifications are reported as equations 8, 9 and 10 in table 3.

All coefficients of equations in table 3 are statistically significant at probability levels of 0.05 or lower. The

Table 2. Elasticities calculated at the means for equations reported in table 1.

Equation number	y_{t-1}	y_{t-2}	y_{t-3}	Y_{t-1}	Y_{t-2}	Y_{t-3}	r_{t-1}	ER_{t-1}	T
3	0.7800	−0.5739	0.4161	—	—	—	0.5719	0.8320	0.9367
4	—	—	—	1.4399	−1.0537	0.7963	−0.3625	0.5410	—
5	—	—	—	1.3422	−0.8567	0.6813	−0.3516	0.5629	—
6	—	—	—	1.3163	−0.9862	0.6338	—	0.6651	0.2688

Table 3. Regression equations and related statistics for profit models with weighted income, undeflated national data.

Equation number	$\bar{R}^2$	d	ρ	Constants		Regression coefficients for:				
				b_0	b_w	y_w	Y_w	r_{t-1}	ER_{t-1}	T
7 ....0.9596		0.8105	—	−1382.99**	−439.15**	0.04435**	—	78.5629*	79.2715**	19.1328**
8 ....0.9724		1.1304	—	− 688.71**	−384.73**	—	0.03144**	—	64.4815**	7.3385**
9 ....0.9718		—	—	− 202.89	−349.49**	—	0.04221**	−58.3567*	48.6338**	—
10 ....0.9463		1.1800	0.40	− 205.09	−509.17**	—	0.04059**	−60.1342	55.1543**	—

** indicates coefficients with probability level $0 < p \leq 0.01$.
* indicates coefficients with probability level $0.01 < p \leq 0.05$.

R^2's range from 0.9506 to 0.9746. The F ratios for the equations are all highly significant.[4]

The signs for all coefficients of the same variable reported in table 3 (except for interest rate in equation 7, previously noted) are in the same direction and consistent with economic theory. The magnitude of all coefficients for the same variable is in a small numerical range among equations.

The signs and magnitudes of the coefficients for the equity ratio are consistent in all equations in both tables 1 and 3. The signs for $(ER)_{t-1}$ in all cases are positive as postulated by economic theory, and the t test for the coefficients of this variable shows significance at the 0.01 probability level in all equations. Time has a significant coefficient in all equations in which it is included as a variable, and the sign is consistently positive. In most of the following estimates, where data are deflated by a price index, the time variable has a negative coefficient. Most price indexes are closely correlated with time. It appears that the time variable for equations reported in tables 1 and 3 thus serves partly in place of a price deflator.

The elasticities for all coefficients of equations reported in table 3 are calculated at the means and are reported in table 4.

PROFIT MODEL WITH AN INDEX OF INCOME

Another method used in an attempt to avoid multicollinearity among the lagged income variables was to form an index from the first principal component of the lagged variables (46). An equation comparable to equation 9 in table 3 thus is estimated with the following results for the years 1910-41 and 1946-63 inclusive:

$$(14) \quad I_t = 612.7715 + 804.9196 \, J + 52.9435 \, (ER)_{t-1} - 61.9408 \, (r/P_B)_{t-1}$$

[4] The F values for equations 7, 8, 9 and 10 in table 3 are 238.7, 440.5, 443.1 and 195.4, respectively.

Table 4. Elasticities calculated at the means for equations reported in table 3.

Equation number	y_w	Y_w	r_{t-1}	ER_{t-1}	T
7 ....0.5002		—	0.5296	0.9199	1.0001
8 .... —		0.8570	—	0.7482	0.3836
9 .... —		1.1506	−0.3934	0.5643	—
10 .... —		1.1065	−0.4054	0.6400	—

and these results for the years 1942-45 inclusive:

$$(15) \quad I_t = 612.7715 - 354.3442 + 804.9196 \, J + 52.9435 \, (ER)_{t-1} - 61.9408 \, (r/P_B)_{t-1}$$

where J is the principal component index of lagged income. All coefficients are significant at the 0.01 probability level or lower. The $\bar{R}^2$ is 0.9718, and the F ratio is 387.7. The coefficients for the equity ratio and the interest variable are almost identical to those of equation 9, table 3. The $\bar{R}^2$ and over-all F ratios are also quite comparable. In this particular case, at least, there seems to be no advantage, compared with the arbitrary weighting scheme used in equation 9, in using the first principal component to form an index.

AUTOCORRELATION OF EQUATIONS USING UNDEFLATED DATA

Equation 5 in table 1 contains the same variables as equation 4 in table 1, but equation 5 is corrected for autocorrelation. Likewise, equation 10 in table 3 is corrected for autocorrelation and contains the same variable as equation 9 in table 3. The first-order autocorrelation scheme was hypothesized:

$$(16) \quad u_t = \rho \, u_{t-1} + e_t$$

where ρ is the autocorrelation coefficient, u_t are the errors from the equation to be corrected, and e_t are the errors of equation 16: $E(e_t) = 0$, var $(e_t) = \sigma^2_e$, and $E(e_t e_{t-1}) = 0$. The Durbin-Watson statistic (hereafter called the d statistic) is used to judge whether an equation has been satisfactorily corrected for autocorrelation. The correction for autocorrelation causes slightly lower significance levels for all explanatory variables and a lower R^2 for the autoregressive equation. All variables in the corrected equations remain significant, however, at the 0.05 probability level or lower. The autoregressive equations are estimated by least squares. The counterpart of equation 9, table 3, with correction for autocorrelation becomes:

$$(17) \quad (I_t - \rho \, I_{t-1}) = b^0 \, (1-\rho) \, x_1 + b^0_w \, (1-\rho) \, x_2 + b_1 \, (Y_{w,t} - \rho \, Y_{w,t-1}) + b_2 \, (r_{t-1} - \rho r_{t-2}) + b_3 \, [(ER)_{t-1} - \rho (ER)_{t-2}] + v_t$$

In both equation 5, table 1 and equation 10, table 3 ρ is substantially closer to zero than one; therefore, the

older method of correction by fitting first differences (37) would be worse than doing nothing.[5]

The prediction equation can be obtained from equation 17 by transposing the lagged endogenous variable with its coefficient, ρI_{t-1}, to the right as follows:

$$(18) \quad \hat{I}_t = \rho I_{t-1} + b^0 \ (1-\rho) \ x_1 + b^0_w \ (1-\rho) \ x_2 + b_1$$
$$(Y_{w,t} - \rho Y_{w,\,t-1}) + b_2 \ (r_{t-1} - \rho r_{t-2}) + b_3$$
$$[(ER)_{t-1} - \rho(ER)_{t-2}]$$

In addition to the equations corrected for autocorrelation, several power functions were estimated on national and undeflated data. The statistics indicated much lower R^2's and regression coefficients that were inconsistent with theory and known facts. None of these results is reported.

PROFIT MODEL: DEFLATED DATA

In estimating these regression equations, national data were deflated by the price index for the cost of building materials. (All variables measured in dollars were divided by the deflator.) The interest rate was also divided by the deflator, thus providing a price ratio of the interest rate to the cost of buildings. Dummy intercept variables for the World War II and pre-World War II years are included. The full model is:

$$(19) \quad (I/P_B)_t = b_0 + b_w + b_{pw} + b_1 \ (y/P_B)_{t-1} +$$
$$b_2 \ (r/P_B)_{t-1} + b_3 \ (ER)_{t-1} + b_4 \ T + u_t$$

Gross income deflated by the building materials price index, $(Y/P_B)_{t-1}$, is substituted for net income in another formulation:

$$(20) \quad (I/P_B)_t = b_0 + b_w + b_{pw} + b_1 \ (Y/P_B)_{t-1} +$$
$$b_2 \ (r/P_B)_{t-1} + b_3 \ (ER)_{t-1} + b_4 \ T + u_t$$

The results of model 19 with modifications are reported by equations 21, 22, 23 and 24 in table 5, and the results of model 20, with modifications, are reported by equations 25, 26, 27 and 28 in table 5.[6] Initially, lagged

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[5] The original equation where ρ is disregarded, implicitly postulates $\rho = 0$. The method of first differences implies that $\rho = 1$.

[6] The values of F for equations in table 5 in the order presented are: 112.7, 30.2, 154.4, 61.0, 119.7, 86.2, 165.6 and 83.6.

income models similar to models 1 and 2 in a previous section were estimated. Problems of multicollinearity and sign reversals of the regression coeffiicents also were encountered with the deflated data. Arbitrary weighted income variables similar to those used in models 12 and 13 were also tried. However, $(Y/P_B)_{t-1}$ has the highest correlation with I_t of any lagged income or weighted income variable, and therefore $(Y/P_B)_{t-1}$ was used for the explanatory income variable. All variables except the time trend are significant at the 0.05 probability level or lower in all equations reported in table 5, except the equations corrected for autocorrelated errors.

The coefficient for the equity ratio is highly significant in all equations reported thus far, whether using undeflated or deflated data. This supports the hypothesis of the close relationship between long-term capital investment and the long-term equity position of the entrepreneur. The long-term equity position of many farmers, especially since the Korean conflict, has been almost independent of net income. Farm land values have continued to rise despite a stable or slightly declining net farm income. Income alone is not the sole source of capital for long-term investment such as the investment in farm buildings. In long-term investment, equity becomes a more important criterion, and the major part of equity is not obtained from savings of current income. Most farmers obtain a major share of their equity from personal inheritance and inheritance through marriage. Inflation of land values in the last 2 decades, as previously noted, has also contributed substantially to the equity position of farmers. The higher equity position makes it possible to incur greater long-term debt for investment in long-term assets such as buildings.

The gross income coefficient has higher t values than do net income coefficients in all corresponding equations. This suggests that farm output has a greater influence on investment than net income. Hence, another form of a capacity model would seem justified. A capacity variable, the ratio of gross income to value of buildings, was tried without success. Although a number of capacity adjustment models in the nonagricultural sector have been successful (2, 16, 29), similar formulations have not proved successful for farm buildings. Farm buildings are a longer-term investment than is

Table 5. Regression equations and related statistics for profit models, deflated national data.

Equation number	$\bar{R}^2$	d	ρ	Constants			Regression coefficients for:				
				b_0	b_w	b_{pw}	$(y/P_B)_{t-1}$	$(Y/P_B)_{t-1}$	$(r/P_B)_{t-1}$	ER_{t-1}	T
21	0.9306	0.9885	—	357.78*	−243.29**	−185.08**	0.01430	—	−23.3672*	19.6037**	−3.0150
22	0.8080	2.0923	0.50	351.71	−370.92**	−275.66*	0.03054**	—	− 1.0141	11.9288	−2.6357
23	0.9247	0.8788	—	108.09**	−237.20**	−142.84**	0.02309**	—	—	20.9561**	—
24	0.8621	1.9131	0.40	115.43	−298.29**	−160.29**	0.03076**	—	—	18.7022**	—
25	0.9344	1.0989	—	252.96	−234.69**	−152.73*	—	0.01417*	−21.3517*	19.7838**	−2.8400
26	0.8958	1.7913	0.30	257.23	−293.91**	−196.81*	—	0.01939**	−11.9260	15.3949*	−3.0638
27	0.9295	1.0505	—	−20.93	−218.40**	− 94.97**	—	0.02050**	—	21.8556**	—
28	0.8943	1.8291	0.30	−35.69	−251.85**	− 96.40**	—	0.02319**	—	21.0626**	—

** indicates coefficients with probability level $0 < p \leq 0.01$.
  * indicates coefficients with probability level $0.01 < p \leq 0.05$.

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the investment in plant and equipment in industry (especially when aggregated and when equipment is a large part of the aggregate). Thus, although capacity adjustment very well may be operable on the demand for farm buildings, the time lag of adjustment is apparently too long to be estimated accurately by available econometric techniques.

CORRECTION FOR AUTOCORRELATION OF EQUATIONS USING DEFLATED DATA

While all the original equations had autocorrelated errors, they were corrected with only varying degrees of success. The "goodness of correction" used for autocorrelated errors was the proximity of the d statistic of the corrected equation to the expected value of d = 2.0. The tabular values for d (10, 36) were also used as a criterion.

The predicted values from equation 25, table 5, are shown in fig. 1, and the predicted values from equation 26, table 5 (the autoregressive correction equation for equation 25), are shown in fig. 2 along with the actual values. (Building investment is deflated by the cost-of-building-materials index for both equations.) Predicted values from both equations compare favorably with the actual values. Predictions from the autoregressive equation shown in fig. 2 are better than those of fig. 1 when the criterion is one of comparing turning points and phase plane shifts. The error variance from the predicted values of the autoregressive equation is less than the error variance of the original equation, that is:
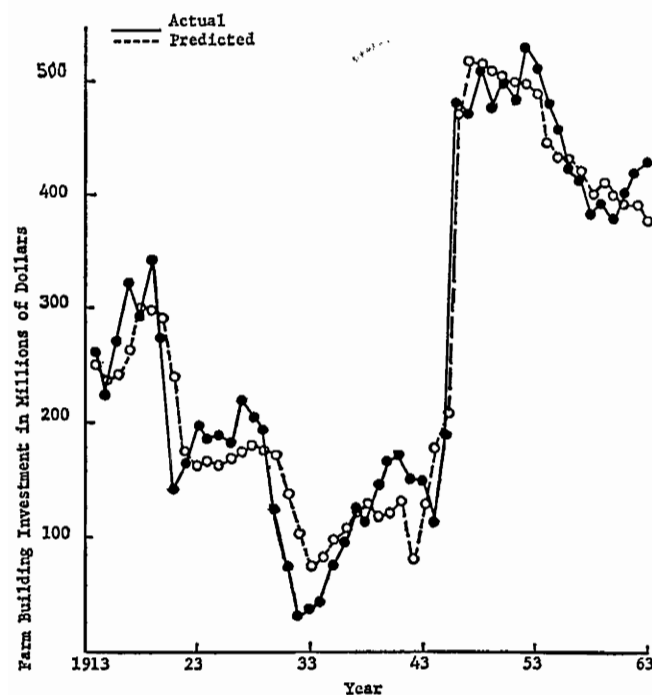

Fig. 1. Actual and predicted farm building investment for the United States (equation 25, table 5).
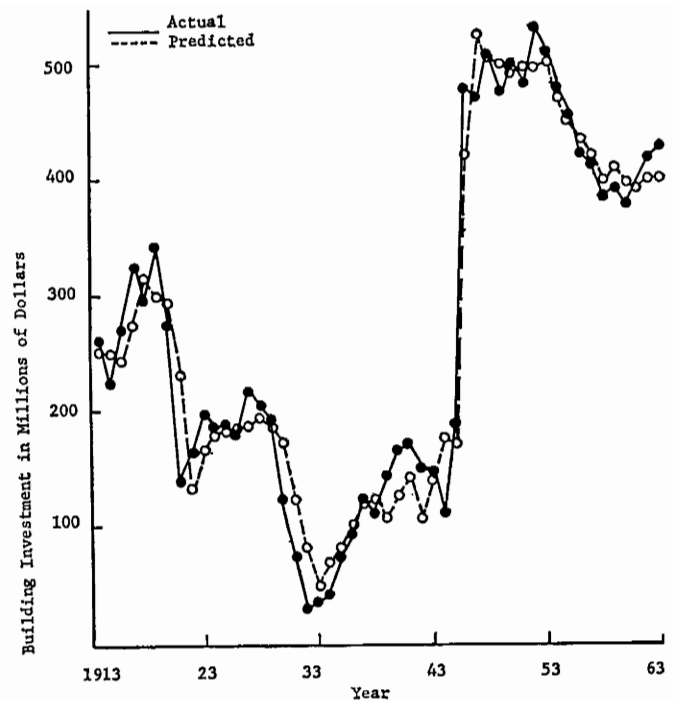

Fig. 2. Actual and predicted farm building investment for the United States (equation 26, table 5).

$$(29) \quad \sum_{i=2}^{n} \frac{(\widetilde{I_t} - I_t)^2}{n\text{-}k\text{-}2} < \sum_{i=2}^{n} \frac{(\hat{I} - I_t)^2}{n\text{-}k\text{-}2}$$

where $\widetilde{I_t}$ is the predicted investment from the autoregressive equation 26, $\hat{I_t}$ is the predicted investment from the original equation 25 and I_t is the actual value of investment. The $\overline{R}^2$, 0.9510, for the prediction equation derived from the autoregressive equation 26 is higher than that for the original equation. It is evident that if equations are autocorrelated, an attempt should be made to correct these equations to improve the predictive ability of the equation. The improvement affects both the sampling variance and the turning point values.

Table 6 shows the elasticities calculated at the mean for all variables of the equations reported in table 5. The values obtained for elasticities of given variables are very consistent and range only slightly in magnitude.

Table 6. Elasticities calculated at the means for equations reported in table 5.

Equation number	$(y/P_B)_{t-1}$	$(Y/P_B)_{t-1}$	$(r/P_B)_{t-1}$	ER_{t-1}	T
21	.....0.2020	—	−0.2382	0.6028	−0.4177
22	.....0.4304	—	−0.0103	0.3668	−0.3651
23	.....0.3254	—	—	0.6444	—
24	.....0.4335	—	—	0.5751	—
25	..... —	0.4829	−0.1986	0.5943	−0.3987
26	..... —	0.6352	−0.1216	0.4734	−0.4244
27	..... —	0.6634	—	0.6721	—
28	..... —	0.7597	—	0.6477	—

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The consistency of the outcome of all coefficients gives rise to confidence in the quantitative results obtained in the investigation of the aggregate national data.

POWER FUNCTIONS WITH NATIONAL DEFLATED DATA

Several Cobb-Douglas or power functions were fitted to the national deflated data by transforming the original observations into logarithms. The results of these estimates are presented in table 7.[7] Equations 29 and 31 are the same except for interchange of the net income and gross income variables, respectively. The $\bar{R}^2$ values for these equations are somewhat lower than for similar equations 21 and 25 estimated in linear form. Both equations include a dummy variable to allow "shift of the origin" during the war. However, according to the d statistic, both equations have high autocorrelation.

Accordingly, corrections for autocorrelation were attempted. Correction for equation 31 was unsuccessful because of multicollinearity in the transformed data and near-singularity of the coefficient matrix. Equation 30 in table 7 is the autoregressive counterpart of equation 29.

The elasticities reported in table 6 may be compared directly with the regression coefficients reported in table 7, since the regression coefficients of the Cobb-Douglas equations are the elasticities. The elasticities from equation 25, table 6, can be compared with the regression coefficients of equation 31, table 7. The elasticities of building investment with respect to income, interest rate and time are higher for the Cobb-Douglas models than for the linear models. However, the elasticities for the equity ratio from the two types of equations are almost indentical. The linear models have substantially higher R^2's. Consistency of the elasticities among equations also is greater for the linear models. Therefore, the linear regression models presented in table 5 are used for inference and for interpretations presented later.

LINEAR MODELS FOR FARM DWELLINGS AND SERVICE BUILDINGS, NATIONAL DEFLATED DATA

Data for investment expenditures are available

[7] The F values, in order, for equations in table 7 are 48.8, 9.8 and 48.9.

(only on a national basis for the years 1913 through 1963) separately for farm dwellings and farm service buildings. Based on the foregoing national aggregate results and economic theory, the following models were formulated and estimates obtained. Regression estimates for annual investment expenditures on farm dwellings were:

(30a) $(I^D/P_B)_t = -76.0130 + 0.02044 \ (y_w/P_R) + 6.2419 \ (ER)_{t-1} + 0.4877 \ (I^D/P_B)_{t-1}$

for the nonwar years; and for the war years:

(30b) $(I^D/P_B)_t = -127.2363 + 0.02044 \ (y_w/P_R)_t + 6.2419 \ (ER)_{t-1} + 0.4877 \ (I^D/P_B)_{t-1}$

Regression estimates for annual investment expenditures on farm service buildings were:

(31a) $(I^S/P_B)_t = 52.0738 + 0.01491 \ (Y_w/P_R)_t - 29.3706 \ (r/P_B)_{t-1} + 18.9248 \ (ER)_{t-1} - 3.7005 \ T$

for the nonwar years; and for the war years:

(31b) $(I^S/P_B)_t = 17.5145 + 0.01491 \ (Y_w/P_R)_t - 29.3706 \ (r/P_B)_{t-1} + 18.9248 \ (ER)_{t-1} - 3.7005 \ T$

Where: P_R is the index of prices received by farmers with 1910-14 = 1. All coefficients in equations 30a through 31b were significant at the 0.01 probability level or lower. The R^2 for equations 30a and 30b was 0.9706 and for equations 31a and 31b, 0.9196, and the F values were 242.2 and 102.9, respectively.

Weighted net income and equity ratio were included in the model for dwellings by assuming that personal preferences and the ability to realize these preferences play an important part in housing investment decisions. Lagged housing investment was included as an explanatory variable by assuming that custom and experience are very important for investment in dwellings. Housing expenditure may be considered a part of consumption; thus, lagged housing investment expenditure was included just as lagged consumption is used as an explanatory variable in most aggregate consumption functions.

Gross income was included as an explanatory variable for service buildings because of results of prior models and the hypothesis that output has a greater effect on service buildings than net income. The interest rate variable also was used (it was not used in the

Table 7. Regression equations and related statistics for power functions, deflated national data.

Equation number	$\bar{R}^2$	d	ρ	Constants		Regression coefficients for:				
				b_o	b_w	$(\bar{Y}/P_B)_{t-1}$	$(y/P_B)_{t-1}$	$(r/P_B)_{t-1}$	ER_{t-1}	T
29	..0.7928	0.8927	—	−0.9582	−0.3108**	—	0.7601**	−0.3808**	0.8665**	—
30	..0.4808	1.9292	0.6669	−0.5992	−0.5347**	—	0.6148*	−0.2880	1.0322**	—
31	..0.8273	0.6662	—	−1.9897	−0.2886**	1.3852**	—	−0.8872**	0.4901*	−0.7689**

** indicates coefficients with probability level $0 < p \leq 0.01$.
* indicates coefficients with probability level $0.01 < p \leq 0.05$.

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dwelling model), assuming that the marginal return on money is a more important criterion for investment decision on service buildings than on housing.

Results for Regional and State Models

Data on building investment are available for only eight of the 10 production regions in the United States. Data are not available for the Mountain and Pacific regions. (A map outlining the production regions is shown in fig. 3.) Data for income variables are available on a regional and state basis annually only from 1924 to 1963, rather than from 1910 inclusive as for the national data.

Time-series data on a state basis are available for all states within the three central production regions: the Corn Belt, including Illinois, Indiana, Iowa, Missouri and Ohio; the Lake States, including Michigan, Minnesota and Wisconsin; and the Northern Plains, including Kansas, Nebraska, North Dakota and South Dakota. The variables available on a regional basis for the production regions are also available for these 12 states. The length of the time series available is also the same for the states and regions.

The method ordinarily used for regression analysis of regional or state data is to estimate separate regression equations for each area, then to analyze each equation, and finally to compare the equations from each

area. If this procedure were used for the current study, the length of the time series available would reduce the total degrees of freedom (with reduction due to lags) to approximately 36. Hence, the procedure adopted is a single-equation technique that simultaneously includes all regions in one equation (each region and each year providing an observation). This approach provides an immediate statistical test for differences among regions.[8]

The same general procedure is followed for the analysis of state data. Although a separate equation is calculated for each of the three regions for which state data are available, all states within a region are included in the equation for that region. Thus, for individual state analysis, there are three basic equations: one each for the Corn Belt, the Lake States and the Northern Plains (within each region, each state and each year provide an observation).

The following aggregate time-series data for the years 1924 to 1963 inclusive are available from U. S. Department of Agriculture sources for the eight regions and 12 states previously mentioned:

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[8] Inclusion of all regions in one equation increases the number of observations for the equation. Although the number of independent variables also is increased because of the addition of dummy variables, differences among variables and regions are not always significant. Hence, the increase in the degrees of freedom associated with the residual sum of squares is relatively greater than the increase in the number of explanatory variables.

An underlying statistical assumption in following this procedure requires that observations from all regions are drawn from some common population. Certain assumptions must also be made if separate equations are estimated in the usual way and statistical tests are performed between regression equations.

Fig. 3. A map of the United States showing the 10 production regions.

I = annual investment expenditures on new and remodeled farm buildings in millions of current dollars from unpublished sources in the Farm Production Economics Division of the U. S. Department of Agriculture.

Y = gross farm income (total cash sales and government payments) in millions of current dollars from the Farm Income Situation (41).

Y^L = gross cash receipts for livestock sales in millions of dollars, from the Farm Income Situation (41).

r = the rate of interest on new farm mortgages. This is the same rate used in national data. There are no separate data available by region or state. The rate is a percentage and is taken from Agricultural Finance Review (39) and Farm Mortgage Credit Facilities in the United States (23).

ER = the ratio of the total value of land and buildings in millions of current dollars (from unpublished data in the Farm Production Economics Division of the U. S. Department of Agriculture) to the value of farm mortgage debt outstanding in millions of dollars, reported in the Agricultural Finance Review (39).

P_B = the price index of building materials with 1910-14 = 1. This is the same index used for national data. There is no separate index available by regions or states; from Prices Paid by Farmers (40).

P_R = the index of prices received by farmers with 1910-14 = 1. There is no separate index available by regions and states; from the Farm Income Situation (41).

F_s = average size in acres of farms in the geographic region or state.

BASIC LINEAR MODEL FOR REGIONS AND STATES

The following basic model is used to obtain regression equations for the eight production regions and for states within production regions listed in the foregoing section:

$$(32)\ (I/P_B)_t = b_0 + b_w + b_{pw} + \sum_{i=1}^{m-1} b_i + c\,(Y_w/P_R)_t$$

$$+ \sum_{i=1}^{m-1} d_i\,(Y_w/P_R)_{t,i} + e\,(r/P_B)_{t-1} +$$

$$f(ER)_{t-1} + \sum_{i=1}^{m-1} g_i(ER)_{t-1,i} + hF_s +$$

$$k(Y^L/Y)_{t-1} + \sum_{i=1}^{m-1} p_i\,(Y^L/Y)_{t-1,i} +$$

$$qT + \sum_{i=1}^{m-1} s_i\,T_i + u_t$$

where:

$(I/P_B)_t$ = building investment deflated by building cost index for the year t.

b_0 = the over-all intercept in millions of dollars.

b_w = the difference between the intercept for the war years and the over-all intercept.

b_{pw} = the difference between the intercept for the prewar years and the over-all intercept.

b_i = the difference in intercept in millions of dollars between the i-th area and the over-all intercept where i = 1, 2, . . . m, and m is the number of areas included in the regression equation.

$(Y_w/P_R)_t$ = gross farm income deflated by the index of prices received by farmers and weighted in the following way: $[3(Y/P_R)_{t-1} + 2(Y/P_R)_{t-2} + (Y/P_R)_{t-3}]/6$.

$(Y_w/P_R)_{t,i}$ are m-1 dummy variables. $(Y_w/P_R)_t$ is entered for all observations for the i-th area, and zeroes are entered for all other observations for that variable. Thus, c, the coefficient of $(Y_w/P_r)_t$, will give the over-all effect of $(Y_w/P_R)_t$ on investment; and the coefficient, d_i, will give the slope difference between the i-th area and the area for which no dummy variable is constructed.

$(r/P_B)_{t-1}$ = the price ratio of the interest rate to cost of buildings lagged 1 year.

$(ER)_{t-1}$ = the equity ratio lagged 1 year.

$(ER)_{t-1,i}$ = the i-th dummy variable for equity ratio. The equity ratio is entered for all observations on the i-th area and zeroes for all other observations.

F_s is previously defined.

$(Y^L/Y)_{t-1}$ = the ratio of gross livestock sales to gross farm sales lagged 1 year.

$(Y^L/Y)_{t-1,i}$ = the i-th dummy variable for $(Y^L/Y)_{t-1}$.

T = the variable for trend and is the last two digits of the year of observation.

T_i = the i-th dummy variable for trend for area i.

Model 32 combines analysis of covariance (32, pages 437-465) with multiple regression (4). With algebraic recombination of certain intercept and slope variables, the model becomes multiple covariance analysis with additional regression variables. Slopes and differences for slopes as well as intercept differences

are obtained for testing. The entire model can be estimated and reported most easily as a multiple regression equation.

Model 32 is more nearly a capacity-price ratio model, as compared with the national profit-price ratio models presented earlier. Farm income was deflated by the price index of building materials in the national models. By deflating gross farm income by prices received by farmers, we provide a physical measure of output.

The problems associated with multicollinearity are increased in model 32 by the use of a large number of dummy variables. The use of lagged income variables to replace the weighted income variables in model 32 proved impossible. A number of equations representing various subsets of variables in model 32 are presented. Equations for presentation were selected on the following several criteria: (a) the F test for the regression as a whole, (b) the t tests for individual coefficients, (c) the specific variables and combinations of variables included in the equation, (d) the proportion of included variables that were statistically significant, (e) the signs of the coefficients in the direction postulated by economic theory, and (f) the proportion of variance of the dependent variable explained by regression.

BASIC POWER-FUNCTION MODEL FOR REGIONS AND STATES

Two power-function models are tried for regional and state analysis. The first model includes income lagged 3 years:

$$(33) \quad (I/P_B)_t = b_0 \ (Y/P_R)_{t-1}^b \ (Y/P_R)_{t-2}^c \ (Y/P_R)_{t-3}^d$$
$$(r/P_B)_{t-1}^e \ (ER)_{t-1}^f \ F_s^g \ T^h \ u_t$$

where all variables have been previously defined. The second model replaces lagged income with the arbitrary weighted income used in the linear model:

$$(34) \quad (I/P_B)_t = b_0 \ (Y_w/P_R)_t^b \ (r/P_B)_{t-1}^c \ (ER)_{t-1}^d \ F_s^e$$
$$T^f \ u_t$$

The variables are transformed to logarithms, and the functions are then estimated by ordinary least squares. Dummy intercept variables are also included for the World War II and the pre-world war periods.

REGIONAL RESULTS FROM THE LINEAR MODEL

Equations representing various subsets of model 32 for the eight production regions are given in table 8. Only those equations that have all variables statistically significant (at the 0.05 probability level or lower) are included in table 8.

Two usual statistical criteria for equations in table

8 are all excellent.[9] The variable $(Y^L/Y)_{t-1}$, which is the ratio of gross livestock income to total gross farm income, lagged 1 year, was tried but proved nonsignificant at the 0.05 probability level or lower.

The proportion of livestock output, it was postulated, should have a positive effect on farm building investment. This effect should result, not only from the greater shelter and feedlot requirements of a larger amount of livestock, but also from the higher requirements for on-the-farm feed storage for the livestock produced. The failure of this variable to show up as statistically significant does not necessarily eliminate the hypothesis. A lag of only 1 year may be too short to show the influence of this variable. The two variables, livestock income and gross farm income, are also multicollinear, which affects the results.

All coefficients for the same variables for equations reported in table 8 have the same signs as postulated by economic theory. The coefficients for the same variables between equations vary in a small absolute range. All equations in table 8 show that investment in farm buildings during the war period was the lowest of the three periods investigated, but only slightly lower than the prewar period. The postwar period has had by far the highest volume of farm building investment, as shown by the intercept b_0, even when deflated by the building cost index (as is done with the regional and state data). Two of the eight regions, the Appalachian and Northeastern, have building investment substantially below the over-all average. Both these regions are among the most mature where there are small farms and buildings on each farm. Farm consolidation has been occuring, and there has been an excess of existing buildings. Farm income has not expanded in these two regions as it has in others.

The over-all coefficients for income are positive in all equations in table 8, and all are significant at the 0.01 probability level or lower. Although the absolute value of the coefficients for gross income is relatively small, this variable has the greatest influence on investment of any variable included in the equations because of the magnitude of its mean and variance. As indicated earlier, the gross income variable deflated by the index of prices received by farmers results in a capacity variable. The coefficient of this variable indicates the influence of the variation of physical output on farm building investment. The Corn Belt is the only region with an income coefficient significantly different from the over-all coefficients. The Corn Belt income coefficient is at least twice as large as the over-all coefficient, indicating a much greater response to variation in output than any other region. The Corn Belt produces more livestock than any other region, in a climate requiring extensive shelter and feeding facilities. Livestock output is certainly a strong influence in the Corn Belt, even though the variable specified for

[9] The R²'s for the equations in table 8 in order are 0.9706, 0.9031, 0.9701, 0.9691, 0.9637 and 0.9604, and the F values are 540.2, 139.9, 565.5, 596.4, 626.0 and 691.2.

Table 8. Regression equations and related statistics from the linear model, deflated national data.

Equation number	R̄²	d	ρ	Constants						
				b_o	b_w	b_{pw}	b_i^a	b_3	b_4	b_5
35	0.9555	1.0992	—	71.5422**	-19.6204**	-17.5242**	-26.0578***	-2.7339*	-9.7822**	-27.5706**
36	0.8532	1.9703	0.48	69.4101**	-25.0668***	-23.6898**	-26.7702***	-2.4668	-8.5138	-29.0686**
37	0.9560	—	—	71.3846***	-19.5172***	-17.3645***	-25.2097***	—	-9.6376***	-28.6122**
38	0.9559	—	—	71.5830**	-19.4194**	-17.7155**	-24.5737	—	-9.5619***	-28.7788**
39	0.9522	—	—	75.0769**	-21.3672***	-20.5299***	-19.1020**	—	—	0.01347***
40	0.9505	—	—	70.5938**	-21.0133*	-19.9419***	—	—	—	0.01399***

Table 8. (Continued)

Equation number	Regression coefficients for:										
	$(Y_w/P_R)_t$	$(Y_w/P_R)_{t,2}$	$(r/P_B)_{t-1}$	$(ER)_{t-1,1}$	$(ER)_{t-1,2}$	$(ER)_{t-1,4}$	$(ER)_{t-1,5}$	T	T_1	T_2	T_5
35	0.01175**	0.02025**	-7.7376**	1.1905**	6.4880**	4.7988***	4.6876***	-0.8343***	0.6166**	-1.5699**	0.3033**
36	0.01169**	0.01203	-5.5399***	1.3000*	6.0555**	4.45933***	4.5379***	-0.83522***	0.6168**	-1.0646*	0.3610
37	0.01472**	0.01707**	-7.8662**	1.1902**	6.4619**	4.7694***	4.7149***	-0.8923***	0.6101**	-1.4876***	0.3172***
38	0.01607***	—	-7.8559***	1.1770**	6.3877**	4.7097***	4.6975***	-0.9182**	0.5986***	-0.6205***	0.3154***
39	0.01347***	—	-8.2643***	0.9738**	6.0087**	3.4490**	3.0173**	-0.9092**	0.5388**	-0.4450**	—
40	0.01399***	—	-8.1684***	1.4702**	5.9434**	3.4140**	2.9937**	-0.8303**	—	-0.4521**	—

[a] A numeral subscript associated with a variable indicates that it is a dummy variable for a region as follows: 1 is Appalachian, 2 is Corn Belt, 3 is the Delta, 4 is the Lake States, 5 is Northeastern, 6 is Northern Plains and 7 is the Southeastern region.

** indicates coefficients with significance levels of $0 < p \leq 0.01$.

* indicates coefficients with significance levels of $0.01 < p \leq 0.05$.

the influence of livestock showed no significant econometric result.

The interest-rate-to-building-cost price ratio is included in all equations in table 8 and is statistically significant at the 0.01 probability level or lower, and the signs in all equations are negative as postulated by economic theory. Since no data were available to differentiate interest rate on mortgages or building costs among regions, the national variables were used.

The equity ratio was not significant in all regions. Therefore, there is no over-all coefficient for this variable. The Appalachian, Corn Belt, Lake States and Northeastern regions did have significant positive coefficients for the equity ratio. In all equations in table 8 for these four regions, the coefficients were significant at the 0.01 probability level or lower, except for the Appalachian region in equation 36, which corrects for autocorrelated errors. Here, as with the national data, the equity ratio or ability to acquire long-term debt has a strong effect. This effect, however, shows up quite differently by regions.

The Corn Belt region has the largest coefficient for equity ratio, ranging for different equations from 5.9434 to 6.4880. The effect of equity ratio is almost the same for the Lake States (4.7988 in equation 35) and the Northeastern region (4.6876 in equation 35). For regions where the equity-ratio effect is significant, it is smallest for the Appalachian region, ranging from 1.1770 in equation 38 to 1.4702 in equation 40. The range of value of coefficients is very small for the same variable among the many equations. This criterion of the range of coefficients among equations added to the other usual statistical criteria (the F test, the R^2 and the t values) helps to establish the reliability of the results obtained.

Farm size in acres was tried unsuccessfully as a variable. Farm size and the time trend are highly correlated. The time trend proved significantly negative in all regional equations. The coefficient for the time trend ranged from -2.3 to -0.2, depending on the region. A number of factors, including farm consolidation and changes in technology or building design, are associated with the time trend. Quite drastic changes in building design (such as one-floor livestock barns, clear-span construction and pole construction) have increased the building space available for livestock and storage per dollar invested. The number of animals housed in a given area has increased because of the design and use of slotted floors. Improvement in building design contributes to the downward trend in building investment required for the physical output being produced. Thus, technology does play an important role in building investment as well as do the changes in physical farm output, changes in farm organization and consolidation of farms.

To illustrate application of regression results, an equation is presented with its coefficients and variables. It provides estimates for farm building demand functions in each of three time periods (pre-World War II

years, World War II years and post-World War II years) and for each of eight production regions in the United States. Thus, one regression equation may be used to derive 24 different and complete equations for the various regions and time periods. Equation 35 appears as follows for region 1, the Appalachian region, with a different equation for each of the three time periods:

(41a) Prewar years $(I/P_B)_t = (71.5422 - 17.5424 -$
$$26.0578) + 0.01175$$
$$(Y_w/P_R)_t - 7.7376$$
$$(r/P_B)_{t-1} + 1.1905$$
$$(ER)_{t-1} + (0.6166 -$$
$$0.8343) \text{ T.}$$
$$= 27.9602 + 0.01175$$
$$(Y_w/P_R) - 7.7376$$
$$(r/P_B)_{t-1} + 1.1905$$
$$(ER)_{t-1} - 0.2177 \text{ T}$$

where:

71.5422 is the intercept common to all regressions, −17.5242 is the difference common to all regressions to be subtracted in the prewar period, −26.0578 is the difference to be subtracted for the Appalachian region, 0.01175 is the coefficient for gross income, 1.1905 is the coefficient for equity ratio, −7.7376 is the coefficient for the rate of interest, −0.8343 is the coefficient for the over-all time trend, and 0.6166 is the dummy coefficient for time trend difference for the Appalachian region.

(41b) War period $I_t = (71.5422 - 19.6204 -$
$$26.0578) + \ldots$$
$$+ (0.6166 - 0.8343) \text{ T.}$$
$$= 25.8640 + 0.01175$$
$$(Y_w/P_R) - 7.7376 \ (r/P_B)$$
$$+ 1.1905 \ (ER)_{t-1} - 0.2177 \text{ T}$$

There is no coefficient (i.e., it is zero to be subtracted from the over-all intercept, 71.5422, for the postwar period.

This example illustrates the derivation of the specific equations, by region as well as the calculation of any specific equation. Three time period equations can be calculated in the same way for all remaining regions, resulting in a total of 24 investment functions from the single over-all regression equation. The complete elaboration of equation 35, table 8, with the 24 specific functions for regions and time periods is shown in table 9.

Also, equation 35 is used for the set of predictions in fig. 4 through fig. 11. These predictions, along with the actual values, suggest the "goodness of fit," the phase plane shifts and the turning points obtained by the multiple-covariance-regression model used for regional analysis. Although some regression analyses exclude the war period, including the war period evidently does not (a) impair the fit of the over-all equation or (b) generally misdirect predictions for individual regions. The comparisons of actual and predicted data

Table 9. Coefficients for regions and time periods using equation 35, table 8.

Region and period	Constant b_o	Regression coefficients for: (Y_w/P_R)	$(r/P_B)_{t-1}$	ER_{t-1}	T
Appalachian					
Prewar	27.9602	0.01175	−7.7376	1.1905	−0.2177
World War II	25.8640	0.01175	−7.7376	1.1905	−0.2177
Postwar	45.4844	0.01175	−7.7376	1.1905	−0.2177
Corn Belt					
Prewar	54.0180	0.03200	−7.7376	6.4880	−2.3942
World War II	51.9218	0.03200	−7.7376	6.4880	−2.3942
Postwar	71.5422	0.03200	−7.7376	6.4880	−2.3942
Delta States					
Prewar	51.2841	0.01175	−7.7376	—	−0.8343
World War II	49.1879	0.01175	−7.7376	—	−0.8343
Postwar	68.8083	0.01175	−7.7376	—	−0.8343
Lake States					
Prewar	44.2358	0.01175	−7.7376	4.7988	−1.1376
World War II	42.1397	0.01175	−7.7376	4.7988	−1.1376
Postwar	61.7600	0.01175	−7.7376	4.7988	−1.1376
Northeastern States					
Prewar	26.4474	0.01175	−7.7376	4.6876	−0.8343
World War II	24.3512	0.01175	−7.7376	4.6876	−0.8343
Postwar	43.9716	0.01175	−7.7376	4.6876	−0.8343
Northern Plains					
Prewar	54.0180	0.01175	−7.7376	—	−0.8343
World War II	51.9218	0.01175	−7.7376	—	−0.8343
Postwar	71.5422	0.01175	−7.7376	—	−0.8343
Southeast					
Prewar	54.0180	0.01175	−7.7376	—	−0.5310
World War II	51.9218	0.01175	−7.7376	—	−0.5310
Postwar	71.5422	0.01175	−7.7376	—	−0.5310
Southern Plains					
Prewar	54.0180	0.01175	−7.7376	—	−0.8343
World War II	51.9218	0.01175	−7.7376	—	−0.8343
Postwar	71.5422	0.01175	−7.7376	—	−0.8343

in the figures suggest that only the Delta region might need a seperate regression equation. Even then, including some additional variables not in equation 35 might be necessary to improve the results. The range and variance of data in the Delta region are much less than in other regions, giving credence to use of a separate regression. The predicted turning points approach the actual turning points for all regions.

The Durbin-Watson statistic was calculated for equation 35, table 8, and the errors were autocorrelated. The correction equation, 36, with $\rho = 0.48$, results in

a d statistic very close to the expected value of d = 2. The t values declined on all coefficients. Of the 18 coefficients included in the regression, however, 13 remain statistically significant at 0.01 probability level or lower and one is significant at 0.05 probability level or lower. It would be reasonable to apply the one-tailed t test on the assumption that the direction of a coefficient is known a priori; on this basis, only two of the 18 coefficients would be statistically nonsignificant at the 0.05 probability level.

Elasticities for the variables of the linear equations of table 8 were calculated at the means and are reported in table 10.[10] Since the range of regression coefficients among equations is small, the range of values for elasticities is also small. The elasticity of demand for farm buildings with respect to deflated gross income ranges from 0.3982 to 0.5473 for all regions except the Corn Belt. For the Corn Belt, the range is substantially larger, at 0.5138 to 0.6655. This shows, as stated earlier with the discussion of regression coefficients, the greater effect of output changes on capacity requirements in the Corn Belt region. The elasticities of demand with respect to the interest-rate/building-cost price ratio range from −0.4093 in equation 36 to −0.6106 in the autoregressive equation 39. For the four regions (Appalachian, Corn Belt, Lake States and Northeastern) where the equity ratio was significant, the elasticity of demand with respect to equity ratio ranges from 0.0440 in equation 39 for the Appalachian region to 0.2424 in equation 35 for the Corn Belt region.

The elasticity with respect to the time trend ranged from −1.1567 for the Northeastern region in equation 36 to −1.5786 for the Corn Belt region in equation 37. Assuming that technological change and improvements in building design, as discussed earlier, are at least partially the cause of the negative time trend, the elasticity of demand for investment in farm buildings with respect to time appears negative. This is contrary to the usual effects on investment assumed for technological changes. Here, however, the advances in building design and use have outweighed the usual replacement requirements, and the increase in output apparently has not advanced as rapidly as improvements in building technology.

[10] Elasticities under dummy variables in this and subsequent tables are calculated by including the difference resulting from the dummy variable and its over-all coefficient. If there is no area dummy variable, the over-all elasticity is appropriate. When there is neither a dummy nor an over-all variable for an area the elasticity is zero.

Table 10. Elasticities computed at the means for equations in table 8.

Equation number	$(Y_w/P_R)_t$	$(Y_w/P_R)_{t,2}$	$(r/P_B)_{t-1}$	$(ER)_{t-1,1}$	$(ER)_{t-1,2}$	$(ER)_{t-1,4}$	$(ER)_{t-1,5}$	T	T_1	T_2	T_5
35	0.4002	0.5948	−0.5717	0.0538	0.2424	0.1220	0.1402	−1.2215	−1.2190	−1.5088	−1.1660
36	0.3982	0.5138	−0.4093	0.0588	0.2263	0.1133	0.1358	−1.2228	−1.2203	−1.4176	−1.1567
37	0.5014	0.6655	−0.5812	0.0538	0.2415	0.1212	0.1411	−1.3064	−1.3039	−1.5786	−1.2483
38	0.5473	—	−0.5804	0.0532	0.2387	0.1197	0.1405	−1.3443	—	−1.4579	−1.2866
39	0.4588	—	−0.6106	0.0440	0.2245	0.0877	0.0903	−1.3312	—	−1.4126	—
40	0.4765	—	−0.6035	0.0665	0.2221	0.0868	0.0896	−1.2156	—	−1.2983	—
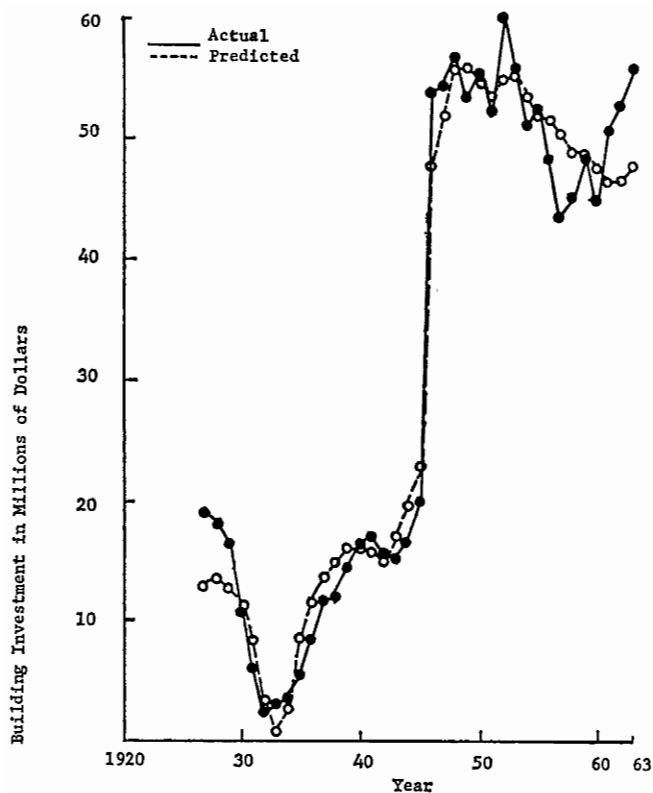
FIGURES 4, 5, 6 and 7 on this page show actual and predicted farm building investment in the Appalacian (left top), Corn Belt (left bottom), Delta (top below) and Lake (bottom below) states. Derived from equation 35, table 9.
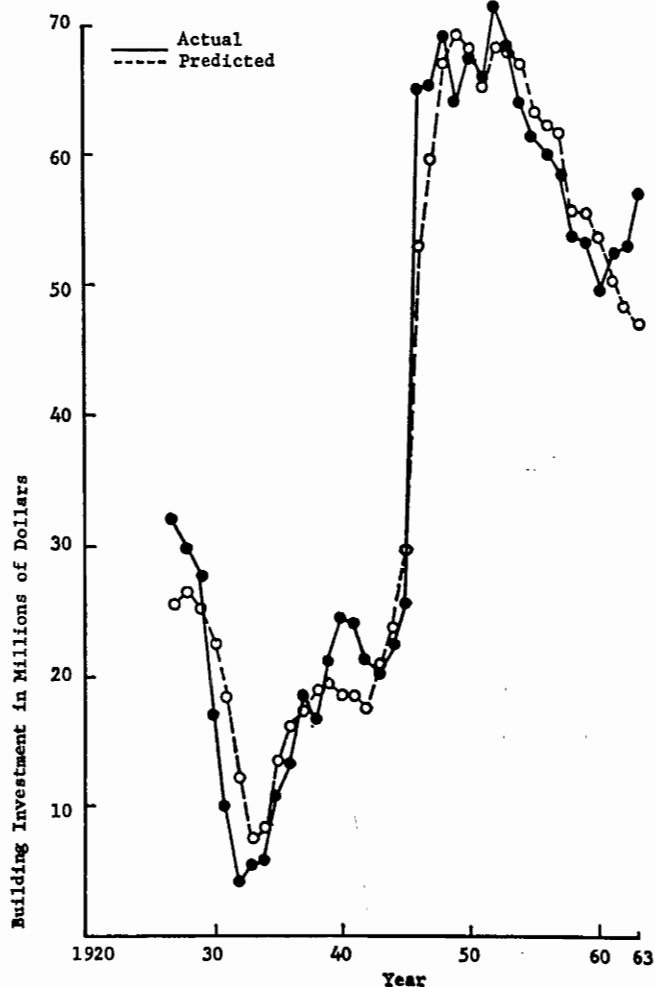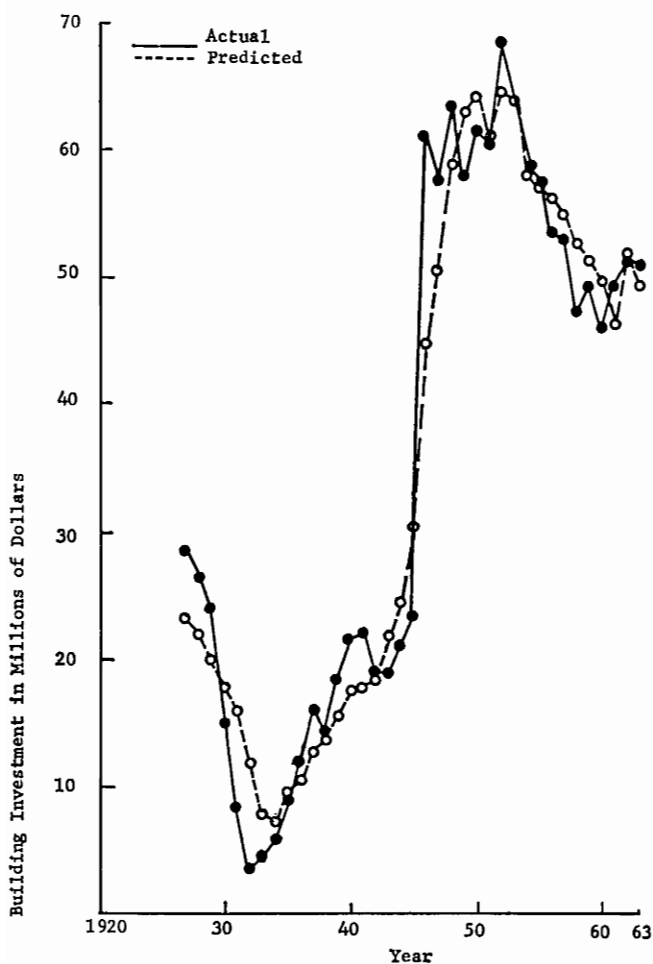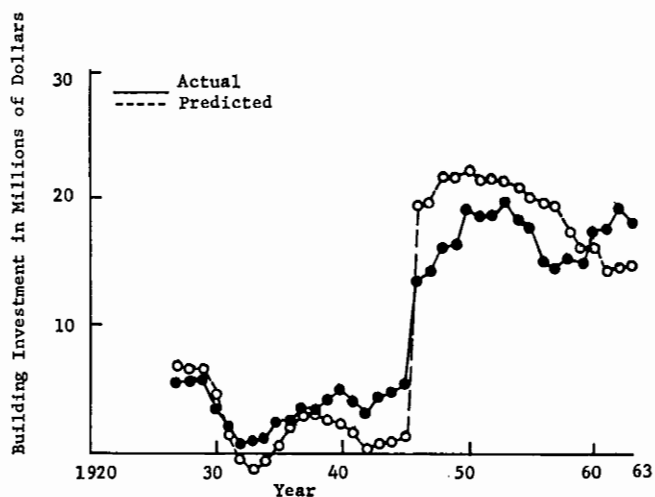
FIGURES 8, 9, 10 and 11 on this page show actual and predicted farm building investment in the Northeastern (top below), Northern Plains (bottom below), Southeastern (right top) and Southern Plains (right bottom) states. Derived from equation 35, table 9.
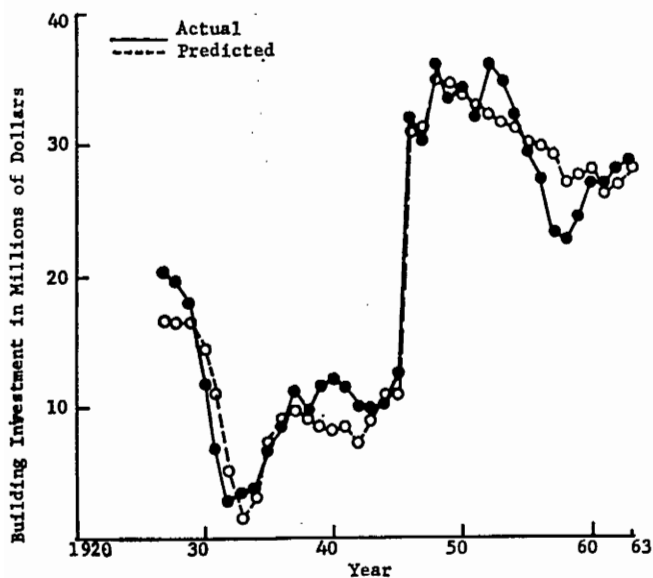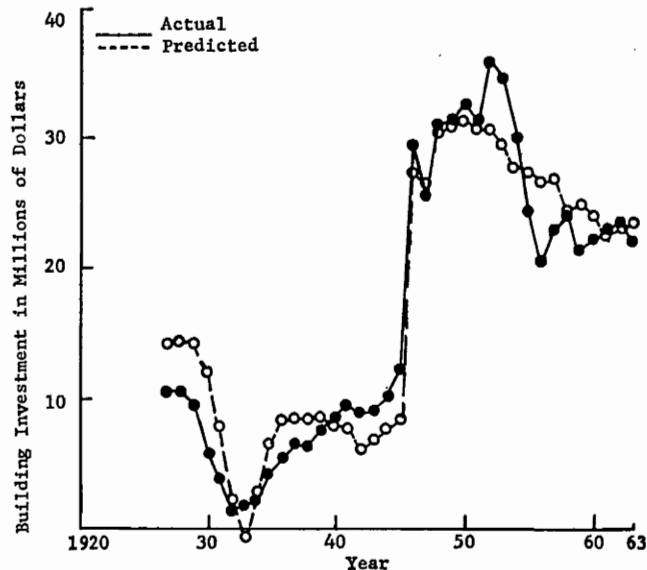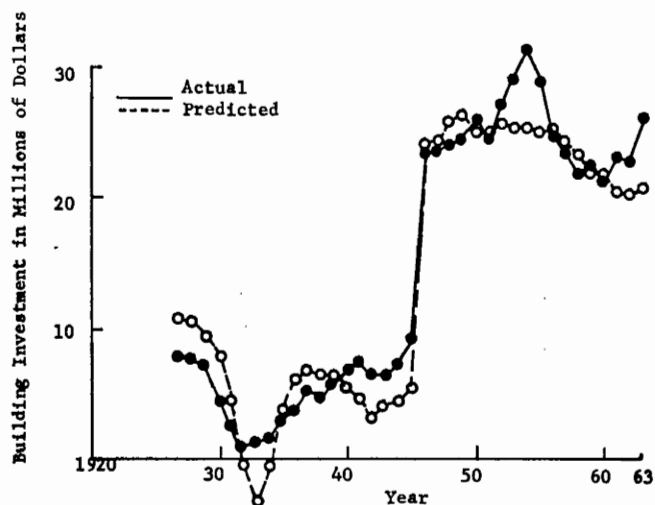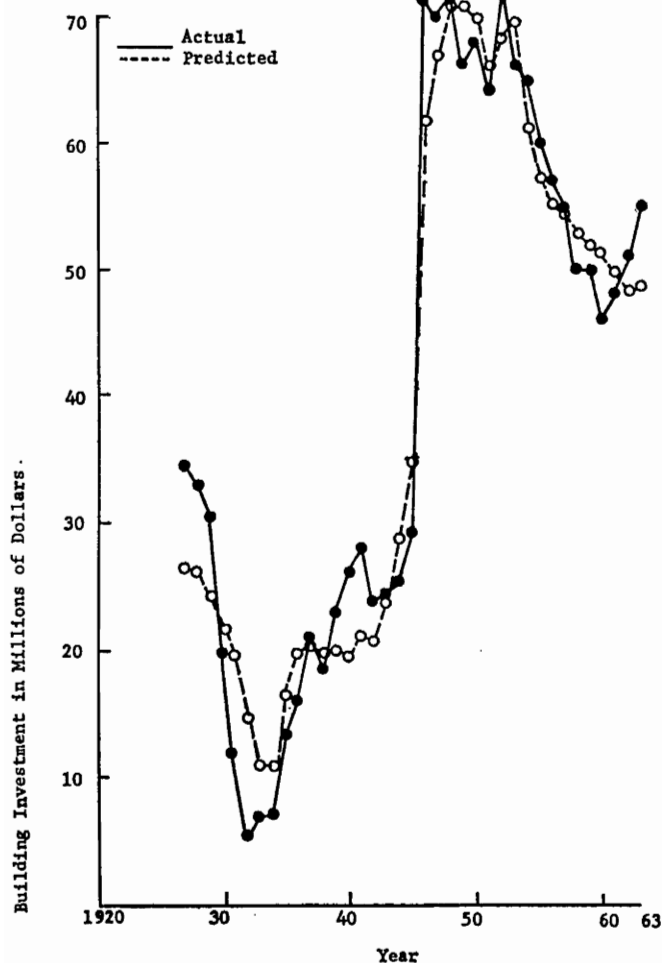
REGIONAL RESULTS FROM THE POWER FUNCTION

The power function, equation 33, with dummy variables added for the war and prewar periods, was estimated by transforming the regional data to logarithms; and the results are reported as equations 41 through 44, table 11.[11] The equity ratio variable and the third lag of income proved nonsignificant at the 0.05 probability level and, therefore, was dropped from the original equation. Farm size and time are correlated. This shows up especially in equation 42, table 11 (equation 41 corrected for autocorrelated errors), where the sign for the coefficient of the time trend not only is negative but also has a low t value. The coefficient values and the t values for the second lag of income are increased when equations 41 and 43 are corrected for autocorrelated errors. In all regressions, the interest-

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[11] The R^2's for the equations in the order reported in table 11 are 0.8779, 0.4859, 0.8436 and 0.5161, and the F values are 295.9, 33.1, 259.7 and 42.8. These values for the autoregressive equations 42 and 44 are for the generalized least-squares equations and not for the prediction equations which are higher. The R^2's for the prediction equations derived from equations 42 and 44, table 9, are 0.9551 and 0.9952, respectively.

Equation number	$\bar{R}^2$	d	ρ	Constants			Regression coefficients for:				
				b_o	b_w	b_{pw}	$(Y_w/P_R)_{t-1}$	$(Y_w/P_R)_{t-2}$	$(r/P_s)_{t-1}$	T	F_s
41	0.8580	0.3832	—	3.1195**	−0.1388**	−0.1660**	0.7818**	0.6372*	−1.9567**	−2.1921**	−0.3399**
42	0.4022	1.8207	0.8364	−1.1207	−0.1841	−0.1185	0.3840**	0.8148**	−1.7152**	−0.5934	−0.3303*
43	0.8223	0.4234	—	3.0827**	−0.1246*	−0.1666*	0.7193*	0.5715	−1.9713**	−2.3874**	—
44	0.4501	1.6953	0.8070	1.2671*	−0.2246	−0.0778	0.3767**	0.7470**	−1.7606**	−1.0529*	—

** indicates coefficients with probability level $0.0 < p \leq 0.01$.

* indicates coefficients with probability level $0.01 < p \leq 0.05$.

rate/building-cost price ratio coefficient is negative as postulated by economic theory, and the coefficients are significant at the 0.01 probability level or lower. These results are consistent with the linear model for regions and with the power function and linear models using national deflated data. It is possible that the results pertaining to interest rate have some policy implications to be discussed later.

CORN BELT STATES RESULTS FROM THE LINEAR MODEL

The basic linear model 32 used for regional data is also used for state analysis. The Corn Belt region is presented and includes Illinois, Iowa, Indiana, Missouri and Ohio. Various regression equations using subsets of variables included in model 32 are given in table 12.[12]

The intercepts for the war years in all regressions in table 12 were substantially below the over-all intercept, as was the prewar period. The difference in intercepts between the war and prewar periods for the Corn Belt data is so small that it appears that the time periods 1927-45 and 1946-63, inclusive, could have been used instead of the three time period analysis ac-

[12] The R^2's for the regression equations in the order presented in table 12 are 0.9482, 0.8102, 0.9469 and 0.9457, and the F values are 222.3, 47.0, 234.5 and 249.8.

tually used. Income, equity and expectations contributed little to long-term building investment in the prewar period. Income and equity both increased during the war period, but expectations probably remained unchanged or lagged behind increasing income, thus limiting building investment. Another limiting factor during the war was the scarcity of labor and materials for construction of farm buildings. After the war, both income and equity continued to rise. Equity rose faster than income and continued to increase after the leveling-off of income. Expectations also apparently changed after the greater wartime income was extended into the postwar period. Too, the supply of building materials and labor was limited only by price in the latter period.

Intercept differences occur for all states in the Corn Belt. Iowa and Missouri have the highest intercept, while Ohio has the lowest.

There were no differences among states with respect to the effect of gross income on building demand. The over-all income coefficient ranged from 0.006362 to 0.01251 depending on the equation. Compared with the original equation 45, the income coefficient was no longer significant at the 0.05 probability level in the autoregressive equation 46, table 12. Thus, the influence of the income variable is not as great in the analysis of individual Corn Belt states as in analysis of the Corn Belt region as a whole. Except for the differences in

Equation number	$\bar{R}^2$	d	ρ	b_o	Constants					
					b_w	b_{pw}	$b^*_{Ill.}$	$b_{Ind.}$	b_{Iowa}	$b_{Mo.}$
45	0.9439	0.7378	—	35.7000**	−12.1396**	−12.0955**	10.1482**	5.0966*	14.6725**	14.7935**
46	0.7364	1.8195	0.54	36.1245**	−14.6179**	−15.6292**	7.3076	4.3848	7.5003	15.2565*
47	0.9429	—	—	40.2097**	−12.4957**	−12.7054**	6.4456**	—	11.4403**	12.0031**
48	0.9419	—	—	41.5543**	−12.6165**	−13.2929**	4.9126*	—	10.3010**	11.7463**

Equation number	Regression coefficients for:							
	$(Y_{\bar{w}}/P_R)$	$(r/P_s)_{t-1}$	$(ER)_{t-1}$	T	$T_{Ill.}$	$T_{Ind.}$	T_{Iowa}	$T_{Mo.}$
45	0.01251*	−4.5553**	0.3222**	−0.2197**	−0.3275**	−0.1900**	−0.4006**	−0.4977**
46	0.00636	−3.3808**	0.2310	−0.1769	−0.2221	−0.1706	−0.1978	−0.5087**
47	0.00886	−4.6622**	0.2621**	−0.2640**	−0.2230**	−0.0834**	−0.3041**	−0.4421**
48	—	−4.6522**	0.2250*	−0.2127**	−0.1351*	−0.0842**	−0.2059**	−0.4388**

* The variables subscripted with a state abreviation are the dummy variables applicable to that state. b_o, the over-all intercept, is also the intercept for Ohio and similarly for all other over-all variables.

** indicates coefficients with probability level $0.0 < p \leq 0.01$.

* indicates coefficients with probability level $0.01 < p \leq 0.05$.

Table 13. Elasticities calculated at the means for equations reported in table 12.

Equation number	(Y_w/P_R)	$(r/P_B)_{t-1}$	$(ER)_{t-1}$	T	$T_{Ill.}$	$T_{Ind.}$	T_{Iowa}	$T_{Mo.}$
45	0.4099	−0.7177	0.2114	−0.6861	−0.8906	−0.8048	−0.9363	−0.9969
46	0.2084	−0.5326	0.1516	−0.5524	−0.6911	−0.6590	−0.6759	−0.8701
47	0.2904	−0.7345	0.1720	−0.8244	−0.9637	−0.8765	−1.0143	−1.1004
48	—	−0.7330	0.1476	−0.6642	−0.7486	−0.7168	−0.7928	−0.9383

variables included in the regression equations and statistical variation, the reason for this difference is not known. However, the elasticities with respect to income for regression equations of the Corn Belt states (table 13) do not differ greatly from those of the region.

Consistent with prior regression equations of this study, the coefficients for the interest-rate/building-cost price ratio again are negative in all equations of table 12. Further, they are all significant at a probability level of 0.01 or lower. The range of the coefficients is small: from −3.3808 for equation 46 (the autoregressive equation) to −4.6622 in equation 47. The corresponding elasticities reported in table 12 range from −0.5326 in equation 46 to −0.7345 in equation 47.

As in all previous farm building demand functions, the equity ratio is an important variable for the Corn Belt states. Except for the autoregressive equation, the coefficient for the equity ratio is significant at the 0.05 probability level in all equations of table 12. Regression coefficients for the equity ratio were not significant for differences at the 0.05 probability level among the Corn Belt states. The coefficients for the over-all value ranged from 0.2250 in equation 48 to 0.3222 in equation 45. The t value for the coefficient of lagged equity ratio went above the 0.05 probability level when equation 45 was corrected for autocorrelation. The value of ρ, used to correct equation 45 in table 12 for autocorrelation, was 0.54. Corrected thus for autocorrelation, equation 45 then resulted in equation 46 with a d statistic of 1.8195.

Coefficients for time in all states differed significantly from the over-all regional trend. All time trend coefficients were negative and ranked in this order: Missouri, Iowa, Illinois, Indiana and Ohio. Part of this expressed trend effect is probably due to the more rapid increase in farm size in the central and western Corn Belt than in the eastern part of the region where there are more part-time farmers. In the eastern Corn Belt, with a greater dispersion of industry over the states, there is less pressure towards farm enlargement since part-time or full-time off-farm work is available within commuting distance. More small operators thus continue to farm, at least on a cash-crop basis.

Any equation of table 12 may be used to derive coefficients specific for the five states of the Corn Belt and for each of the three time periods: prewar, World War II and postwar. The complete elaboration of equation 45, table 12, for all states of the Corn Belt and for the three time periods is presented in table 14. The predicted values for farm building investment obtained

by use of equation 45, table 12, along with the actual values are graphed by states in figs. 12 through 16. A separate regression equation might give better results for Missouri, where the range of values is less than for other states. Equation 45 gives very good graphic results, including the very substantial phase-plane shift for the period following the second world war, for the other four Corn Belt states.

CORN BELT STATES RESULTS FROM THE POWER FUNCTION

The basic power function, model 33, was estimated for the Corn Belt states from data transformed to logarithms. Several variables contained in model 33 were nonsignificant at the 0.05 probability level. The equation found acceptable is equation 49, table 15.[13] It contains no time period intercepts, has variables for lagged deflated gross income, the interest-rate/building-cost price ratio and the equity ratio lagged 1 year. It has no farm size or time trend variables. The included variables are all significant at the 0.01 probability level

[13] The R^2's for equations 49 and 50, table 15, are 0.7618 and 0.5011, respectively, and the F values are 193.0 and 44.2.

Table 14. Regression coefficients by states and time periods for the Corn belt region derived from equation 45, table 12.

	b_o	(Y_w/P_R)	$(r/P_B)_{t-1}$	$(ER)_{t-1}$	T
Illinois					
Prewar	33.7527	0.01251	−4.5553	0.3222	−0.5472
World War II	33.7086	0.01251	−4.5553	0.3222	−0.5472
Postwar	45.8482	0.01251	−4.5553	0.3222	−0.5472
Indiana					
Prewar	28.7011	0.01251	−4.5553	0.3222	−0.4097
World War II	28.6570	0.01251	−4.5553	0.3222	−0.4097
Postwar	40.7966	0.01251	−4.5553	0.3222	−0.4097
Iowa					
Prewar	38.2770	0.01251	−4.5553	0.3222	−0.6203
World War II	38.2329	0.01251	−4.5553	0.3222	−0.6203
Postwar	50.3725	0.01251	−4.5553	0.3222	−0.6203
Missouri					
Prewar	38.3980	0.01251	−4.5553	0.3222	−0.7174
World War II	38.3575	0.01251	−4.5553	0.3222	−0.7174
Postwar	50.4935	0.01251	−4.5553	0.3222	−0.7174
Ohio					
Prewar	23.6045	0.01251	−4.5553	0.3222	−0.2197
World War II	23.5604	0.01251	−4.5553	0.3222	−0.2197
Postwar	35.7000	0.01251	−4.5553	0.3222	−0.2197
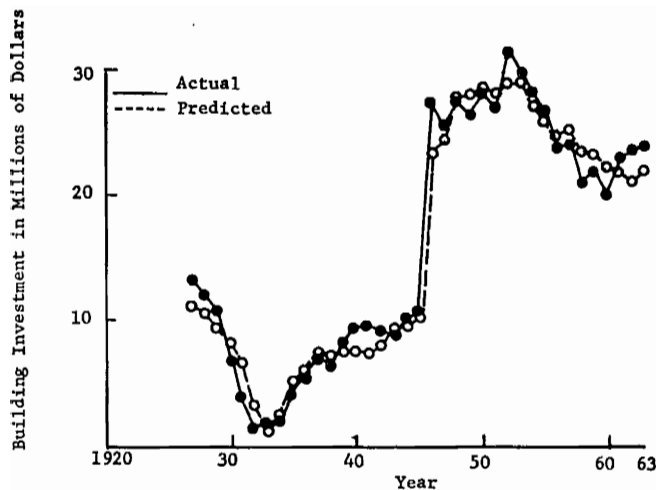
Fig. 12. Actual and predicted farm building investment in Illinois (equation 45, table 12).
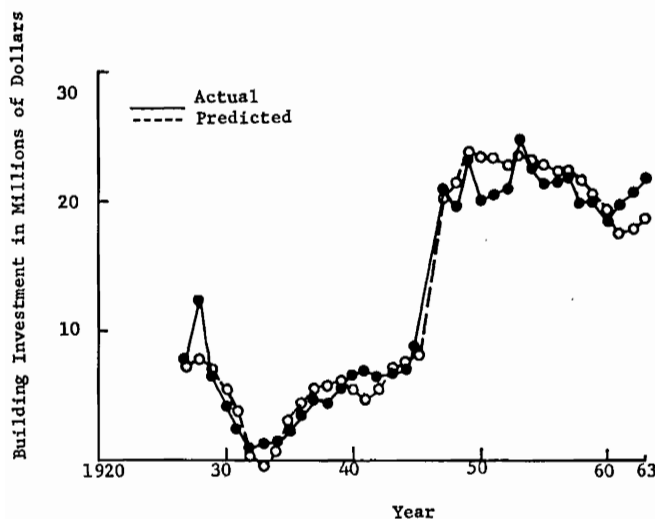
Fig. 13. Actual and predicted farm building investment in Indiana (equation 45, table 12).
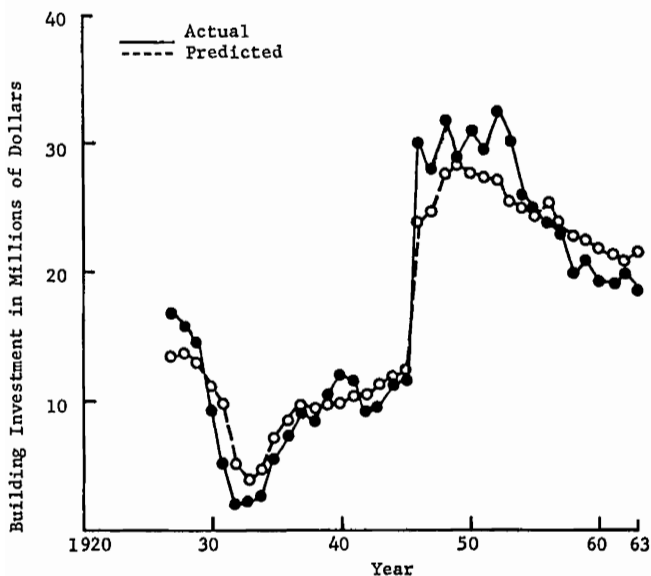
Fig. 14. Actual and predicted farm building investment in Iowa (equation 45, table 12).
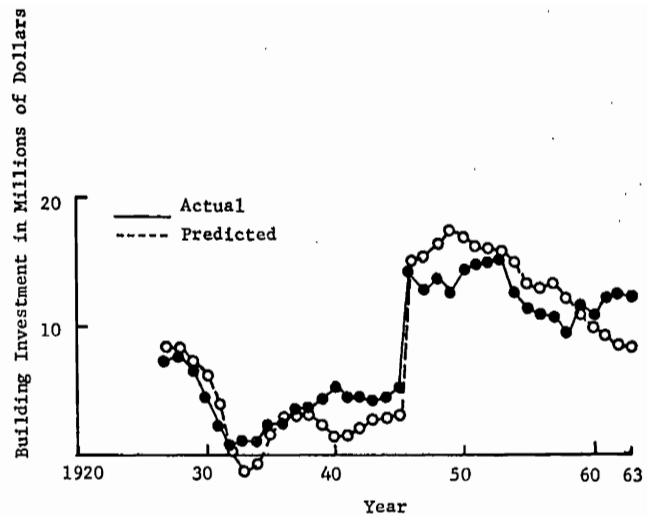
Fig. 15. Actual and predicted farm building investment in Missouri (equation 45, table 12).
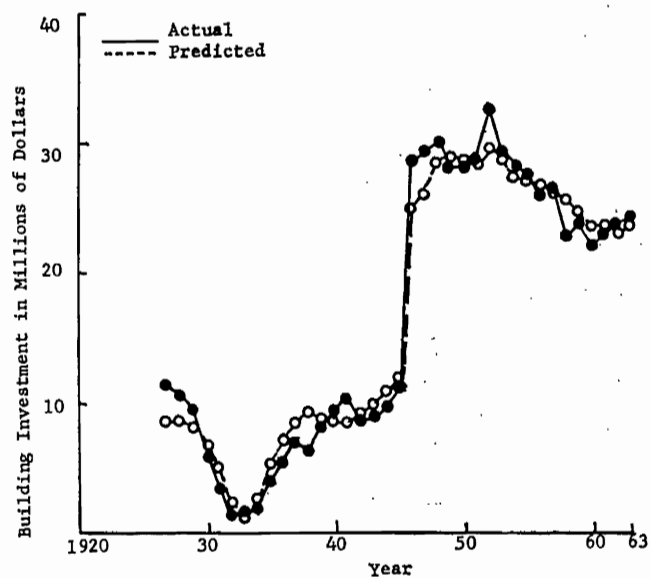
Fig. 16. Actual and predicted farm building investment in Ohio (equation 45, table 12).

Table 15. Regression equations and related statistics for the power function, deflated Corn Belt data.

Equation number	$\bar{R}^2$	Constants			Regression coefficients for:		
		d	ρ	b^0	$(Y/P_R)_{t-1}$	$(r/P_B)_{t-1}$	ER_{t-1}
49	0.7466	0.5039	—	0.6872*	0.5094**	−1.0252**	0.3553**
50	0.4693	1.9307	0.7481	1.0901*	0.4098*	−1.4445**	0.2928

** indicates coefficients with probability level $0.0 < p \leq 0.01$.
* indicates coefficients with probability level $0.01 < p \leq 0.05$.

or lower. The d statistic shows that the errors of equation 49 are highly autocorrelated. Hence, the equation was corrected for autocorrelation by transforming the variables by using $p = 0.7481$. The resulting autoregressive equation 50 yields a satisfactory d statistic of 1.9307. The significance level for the coefficient of the interest-rate/building-cost ratio was improved in this autoregressive equation. The t values for the income and equity ratio variables both declined as compared with equation 49. The t value for the coefficient of the equity ratio fell below the 0.05 probability level of significance. However, the signs of all coefficients are in the direction postulated by theory, and the magnitude of the coefficients, which are elasticities, is in the range expected when comparing them with the corresponding elasticities (given in table 13) derived from the linear model. The value of $\overline{R}^2$, 0.7466, is relatively low compared with some of the previous power functions estimated. The high autocorrelation indicated by the d statistic in equation 49 suggests that another possible reason for the low R^2 is the omission of one or more significant variables from the equation. Other variables were tried in the power function with little success. As indicated earlier, however, other variables were significant in the linear formulation. A mathematical function other than the power function may be more appropriate as the results of the linear equations already suggest.

LAKE STATES RESULTS FROM THE LINEAR MODEL

Basic model 32 was used to estimate equations for the Lake States: Michigan, Minnesota and Wisconsin. The regression equations containing subsets of the variables in model 32 are reported in table 16.[14] A nonlinear function of the time trend, $T^{0.5}$, was added to the original model, 32, in estimating the equation for the Lake States. The regressions obtained proved to be very

consistent with the highest R^2's of any group of equations estimated in this study. With the exception of certain coefficients in autoregressive equation 52, all regression coefficients are significant at the 0.05 probability level or lower. The reasons for the better statistical results, compared with the Corn Belt and Northern Plains where state analysis is made, are: (a) There are fewer states involved in the over-all equation, (b) the three states are more homogeneous in general agricultural characteristics, and (c) the magnitude of the variables from each state is confined to a smaller range for corresponding years of observation. All coefficients of variables in table 16 are in the direction postulated by economic theory, except for the small negative equity ratio coefficient for Michigan.

The time period results for the Lake States region are similar to those obtained in the Corn Belt region; i.e., the differences between the dummy variables for World War II and for the prewar period are so small that an analysis of the two time periods 1927 through 1945 and 1946 through 1963 would have been adequate. The intercept for the period 1927 through 1945 is substantially lower than the intercept for the postwar years. However, there were significant intercept differences among time periods for all states. Michigan had the lowest intercept, and Minnesota the highest.

The over-all coefficient for deflated gross income, ranging from 0.01318 to 0.02967, was significant in all equations (except the autoregressive equation 52) at the 0.01 probability level or lower. In two equations, 51 and 54, the coefficients for the Michigan dummy income variable, with values of 0.02248 and 0.02829, were significant at the 0.01 probability level. These

[14] The R^2's for equations 51 through 55, table 16 are: 0.9790, 0.9506, 0.9779, 0.9769 and 0.9729, and the F values are 381.2, 112.2, 397.4, 423.1 and 458.4, respectively. As in previous tables containing autoregressive equations, the R^2 and $\overline{R}^2$ reported for equation 52 are for the generalized least-squares equation. The R^2 for the derived prediction equation is 0.9642.

Table 16. Regression equations and related statistics for the linear model, deflated Lake States data.

Equation number	$\overline{R}^2$	d	ρ'_1	ρ_2	Constants				
					b_0	b_w	b_{pw}	$b'_{Mich.}$	$b_{Min.}$
51	0.9724	1.1122	—	—	67.0353**	−12.5523**	−11.4620**	−5.1140**	7.2934**
52	0.9351	2.0398	0.48	−0.11	75.1870**	−17.5721**	−17.9278**	−5.6217	10.5531**
53	0.9754	—	—	—	133.8870**	−12.5089**	−12.6159**	−5.1807**	10.9735**
54	0.9746	—	—	—	49.4614**	−12.4073**	−11.7889**	−5.0769**	—
55	0.9708	—	—	—	48.4062**	−12.5780**	−12.5564**	—	—

Equation number	Regression coefficients for:								
	$(Y_w/P_R)_{Wisc.}$	$(Y_w/P_R)_{Mich.}$	$(Y_w/P_R)_{Minn.}$	$(r/P_B)_{t-1}$	$(ER)_{t-1}$ Wisc.	$(ER)_{t-1}$ Mich.	F_s	T	$T^{0.5}$
51	0.02967**	0.02248**	−0.008136*	−4.5995**	0.4778**	−0.5476**	−0.1453**	—	−4.5447**
52	0.01737	0.01437	−0.002720	−3.5416**	0.2563	−0.6480**	−0.1994**	—	−2.0482
53	0.01393**	—	—	−4.3666**	0.4228**	−0.4730**	−0.2736**	1.5983**	−21.9560**
54	0.01800**	0.02829**	—	−4.8362**	0.3930**	−0.5487**	−0.04422**	−0.4641**	—
55	0.01318**	—	—	−4.7080**	0.2526*	−0.3034**	−0.03302**	−0.4190**	—

*Variables with a state abbreviation subscript are dummy variables corresponding to that state. The over-all variable b_0 is the intercept for Wisconsin and similarly for other over-all variables.

** indicates coefficients with probability level $0.0 < p \leq 0.01$.

* indicates coefficients with probability level $0.01 < p \leq 0.05$.

results again indicate the importance of the gross farm output in farm building investment decisions.

When equation 52 was corrected for autocorrelation, it was found that a first-order scheme was not adequate. Hence, a second-order scheme of the following nature was used:

$$(56) \quad u_t = \rho_1 u_{t-1} + \rho_2 u_{t-2} + e_t$$

After a number of trials, the values of $\rho_1 = 0.48$ and $\rho_2 = -0.11$ gave good results based on a d statistic of 2.0398. The t values for all coefficients obtained in the autoregressive equation were lower than those for corresponding coefficients of the original equation, 51. The t values for the coefficients of the deflated gross income variables fell below the value required for significance at the 0.05 probability level in all states.

The equity ratio is an important variable in explaining building investment for both Minnesota and Wisconsin. The coefficient for the over-all equity ratio ranges from 0.2526 in equation 55 to 0.4778 in equation 51. In contrast, the coefficient for the equity ratio in Michigan is not significant at a 0.05 probability level.

Again, as postulated by economic theory, the coefficients of interest-rate-to-building-cost price ratio in all equations, including the autoregressive equation 52, were negative and also were significant at the 0.01 probability level in all regressions. The coefficients ranged from -3.5416 in equation 52 to -4.8362 in equation 54.

The Lake States region is the first of the three regions where significant coefficients were obtained for the farm size variable (i.e., the average number of acres per farm). The coefficients were negative and significant at the 0.01 probability level or lower in regressions for all states, ranging from -0.03302 in equation 55, where the time trend variable was also included, to -0.2736 in equation 53, where both the time trend and the square root of time were included. Again, it is likely that the greater homogeneity of the Lake States region is important in explaining the significance of farm size in the equations.

Two opposing forces affect farm building investment when farms are consolidated: (a) When a farm is enlarged, it also acquires existing buildings with the added land. Thus, the enlarged farm may need no increase in farm buildings. Also, with the initial increased capital outlay for land, other capital investments that can be postponed (such as farm buildings) are often minimized, resulting in a negative effect on new farm

building investment. (b) However, buildings added because of farm enlargement often are located inconveniently for efficient use by the new farming unit. Usually the two or more sets of buildings are of the same type. Taken together these buildings may have adequate physical capacity, but none may be adequate for use from a central location and none may be modern, judged in the light of technological change. These conditions could cause farm enlargement to have a positive effect upon farm building investment. However, the investment lag may be so extended that an econometric study cannot easily isolate the effect; or as previously noted, the rate of improvement and adaptation in building design may offset any positive effect of farm consolidation.

The time variable was tried successfully as both a linear and nonlinear function. When both T and $T^{0.5}$ were included, the coefficient for T was positive and that for $T^{0.5}$ was negative. When either T or $T^{0.5}$ was included without the other, the coefficients of both were consistently negative, affirming the results obtained for states in other regions.

Elasticities are calculated at the means for the equations of table 16 and are reported in table 17. The elasticities compare favorably with previous results for elasticities obtained from linear equations. The elasticity with respect to income for Michigan in equation 51 is unusually high compared with the values for other states.

Regression coefficients from equation 51, table 16, for states and time periods (making nine equations) are reported in table 18. Equation 51 also is used to obtain predictions for the years 1927 through 1963. These predicted values are graphed along with the actual values by states in figs. 17, 18 and 19. The graphic results indicate the goodness of fit already indicated by the R^2. Turning points and phase plane shifts are predicted with good accuracy. Equation 51 appears to give equally good predictions for each of the Lake States.

LAKE STATES RESULTS FROM THE POWER FUNCTION

The power function model 33 was tried on the transformed Lake States data without success. Multicollinearity of the lagged income variables resulted in a near-singular matrix. Model 34, where the lagged income variables are replaced with weighted income, was then tried. There was also difficulty in estimating this

Table 17. Elasticities calculated at the means for equations reported in table 16.

Equation number	(Y_w/P_R) Wisc.	(Y_w/P_R) Mich.	(Y_w/P_R) Minn.	$(r/P_B)_{t-1}$	$(ER)_{t-1}$ Wisc. & Minn.	$(ER)_{t-1}$ Mich.	F_s	T	$T^{0.5}$
51 ....0.7647	0.9023	0.6776	-0.7960	0.2322	0.1295	-1.5493	—	-2.3070
52 ....0.4481	0.5360	0.4190	-0.6129	0.1245	0.0030	-2.1261	—	-1.0397
53 ....0.3594	—	—	-0.7557	0.2054	0.1267	-2.9173	-0.0132	-11.1452
54 ....0.4644	0.6375	—	-0.8369	0.1910	0.0881	-0.4715	-0.0038	—
55 ....0.3400	—	—	-0.8147	0.1227	0.0658	-0.3521	-0.0035	—

Table 18. Regression coefficients by states and time periods for the Lake States derived from equation 51, table 16.

	b_o	(Y_w/P_R)	$(r/P_B)_{t-1}$	$(ER)_{t-1}$	F_s	$T^{0.5}$
Michigan						
Prewar	50.4593	0.05212	−4.5995	−0.0698	−0.1453	−4.5447
World War II	49.3690	0.05212	−4.5995	−0.0698	−0.1453	−4.5447
Postwar	61.9213	0.05212	−4.5995	−0.0698	−0.1453	−4.5447
Minnesota						
Prewar	62.8667	0.02150	−4.5995	−0.4778	−0.1453	−4.5447
World War II	61.7764	0.02150	−4.5995	−0.4778	−0.1453	−4.5447
Postwar	74.3287	0.02150	−4.5995	−0.4778	−0.1453	−4.5447
Wisconsin						
Prewar	55.5733	0.02964	−4.5995	−0.4778	−0.1453	−4.5447
World War II	54.4830	0.02964	−4.5995	−0.4778	−0.1453	−4.5447
Postwar	67.0353	0.02964	−4.5995	−0.4778	−0.1453	−4.5447

Table 19. Regression equations and related statistics for the power function, deflated Lake States data.

Equation number	R^2,F	d	Constants			Regression coefficients for:			
			b_o	b_w	b_{pw}	(Y_w/P_R)	$(r/P_B)_{t-1}$	T	F_s
57	0.8399	0.6769	4.5665**	−0.1355*	−0.1605	0.4912**	−2.0050**	−1.8755**	—
58	0.7989	0.5836	1.8816**	−0.1128*	—	0.8207**	−1.4204**	—	−0.6890*

** indicates coefficients with probability level $0.0 < p \leq 0.01$.
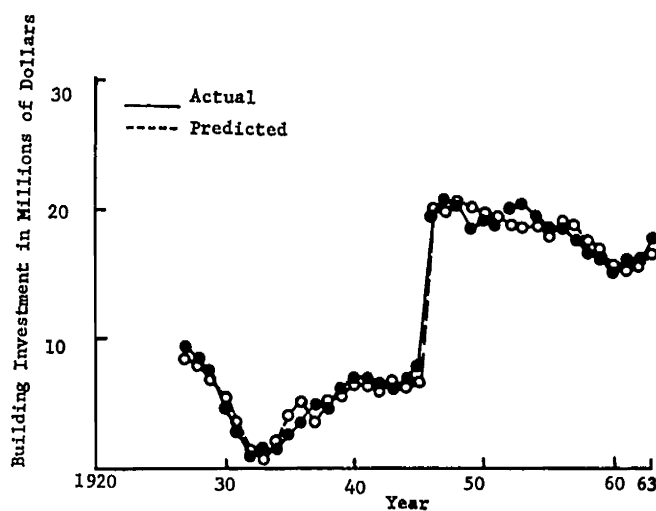* indicates coefficients with probability level $0.01 < p \leq 0.05$.

Fig. 17. Actual and predicted farm building investment in Michigan (equation 51, table 16).
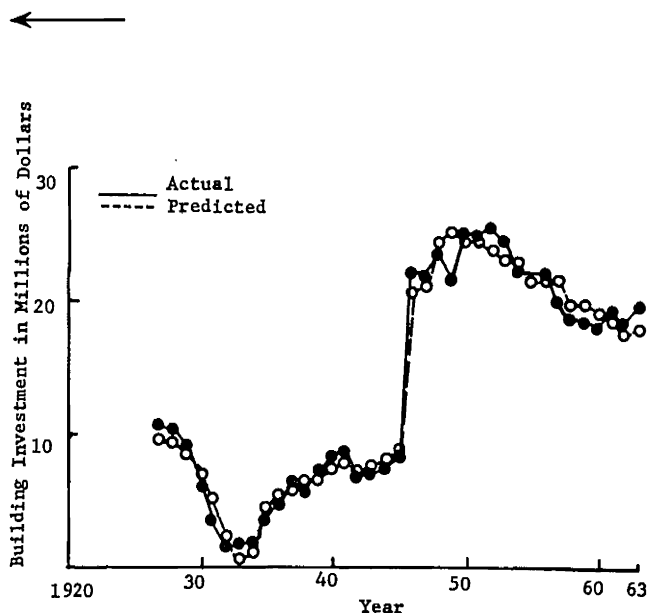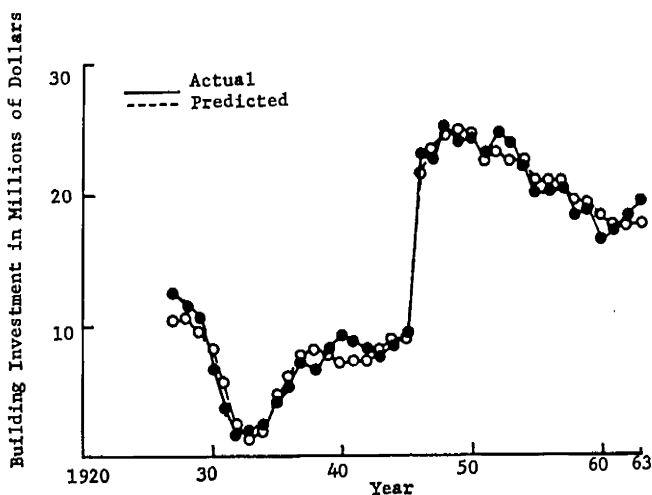

Fig. 19. Actual and predicted farm building investment in Wisconsin (equation 51, table 16).

Fig. 18. Actual and predicted farm building investment in Minnesota (equation 51, table 16).

model. The coefficients of the equations finally estimated are reported in table 19.[15] The regressions estimated from the power functions appear less satisfactory than the linear equations for the same data according to the usual statistical criteria. The signs of all coefficients are in the direction postulated by theory, and the magnitude of coefficients appears reasonable compared with the results of previous power functions. Correction for autocorrelation proved unsuccessful because of nonsingularity of the coefficient matrix for the transformed variables.

NORTHERN PLAINS STATES RESULTS FROM THE LINEAR MODEL

State data are also available for the Northern Plains states: Kansas, Nebraska, North Dakota and South Dakota. The basic linear model 32 with variations was estimated for these states. Based on statistcal comparisons, regression results for the Northern Plains states linear model are not as good as those for the Corn Belt and Lake States. The coefficients and associated statistics are reported in table 20. The R^2 values range from 0.7634 to 0.9176 for equations before correction for autocorrelated errors.[16] The F ratios are all highly significant, although lower than for regression equations for prior models.

All coefficients of regression equations (before correction for autocorrelation) are statistically significant at the 0.05 probability level or lower, based on the two-

tailed t test. All coefficients for the same variable have the same sign (that postulated by theory) and have a small range in value. This gives greater credence to the regression equations obtained.

As with previous state data, the time periods could have been divided into two periods, 1927 through 1945 and 1946 through 1963, instead of the three time periods used. Investment during the war years was least, and it was highest in the postwar period. South Dakota and Nebraska have the highest state intercept; Kansas and Nebraska the lowest.

No difference among states was found for gross farm income deflated by the prices received by farmers, but the coefficient was significant for all states as a whole. The coefficient ranges from 0.003662 in equation 61 (the autoregressive equation) to 0.009669 in equation 64. All these coefficients are significant at the 0.05 probability level, except for equation 61, corrected for autocorrelated errors, where the t value fell to 1.1551. Again, the results show the strong influence of farm output on investment requirements for farm buildings.

The equity ratio had no statistically significant effect in two states: North and South Dakota. The equity ratio had a significant positive effect in the other two states: Kansas and Nebraska. Except for the autoregressive equation, all equity ratio coefficients are significant at the 0.01 probability level or lower with coefficients ranging from 0.1761 in the autoregressive equation 61, to 0.2567 in equation 59 for Nebraska and 0.1344 to 0.2387 for Kansas.

The national rate of interest was used again and was one of the most significant variables in any regression including the autoregressive equations.

The farm size variable was included in several

[15] The R^2's for equations 57 and 58, table 19, are 0.8559 and 0.8150, and the F values are 124.8 and 116.8, respectively.

[16] The R^2's for equations in order reported in table 20 are 0.9176, 0.9111, 0.7634, 0.8882, 0.8867 and 0.8849, and the F values for the corresponding equations are 222.6, 124.8, 39.0, 138.1, 120.0 and 133.6. The R^2 for the prediction equation derived from the autoregressive equation 61 is 0.9848.

Table 20. Regression equations and related statistics for the linear model, deflated Northern Plains data.

Equation number	$\bar{R}^2$	d	ρ	Constants					
				b_o	$b_w°$	$b_{pw}°$	$b_{Kan.}°$	$b_{Neb.}°$	$b_{N.D.}°$
59 ....0.9135		—	—	14.9340**	−3.3272**	−2.2872**	—	—	—
60 ....0.8889		0.8300	—	14.7017**	−3.1613**	−2.2332**	−3.4877**	−2.0613**	−0.6138*
61 ....0.7042		1.9221	0.55	15.3637**	−4.2275**	−3.8739**	−3.0785**	−1.7046	−0.66185
62 ....0.8818		—	—	20.1211**	−4.5843**	−4.1581**	−3.9382**	—	—
63 ....0.8618		—	—	19.1307**	−3.8690**	−2.9668**	−4.7991**	−1.9966**	−0.6806*
64 ....0.8783		—	—	21.2540**	−4.4683**	−3.8762**	−4.7203**	—	—

Equation number	Regression coefficients for:							
	(Y_w/P_R)	$(r/P_B)_{t-1}$	$(ER)_{t-1}$ Kan.	$(ER)_{t-1}$ Neb.	F_s	T	$T_{Kan.}$	$T_{Neb.}$
59 ....0.00519**	−1.6788**	0.2387**	0.2567**	—	−0.1623**	—	—
60 ....0.006180**	−1.5012**	0.2117**	0.1870**	−0.01265**	—	—	—
61 ....0.003662	−1.1874**	0.1985**	0.1761*	−0.01278**	—	—	—
62 ....0.00574*	−2.0806**	—	—	—	−0.2449**	0.1431**	0.0543**
63 ....0.009489**	−1.8888**	0.1344**	—	−0.01893**	—	—	—
64 ....0.009669**	−2.1845**	—	—	−0.009513**	−0.1563**	0.09129**	—

° The variables subscripted with a state abreviation are the dummy variables applicable to that state.
  b_o is the over-all intercept and is also the intercept for S. Dakota, similarly for other over-all variables.
** indicates coefficients with probability level $0.0 < p \leq 0.01$.
 * indicates coefficients with probability level $0.01 < p \leq 0.05$.

Table 21. Elasticities calculated at the means for equations in table 20.

Equation number	(Y_w/P_R)	$(r/P_B)_{t-1}$	$D(ER)_{t-1}$ Kan.	$D(ER)_{t-1}$ Neb.	F_s	T	T $D_{Kan.}$	T $D_{Neb.}$
59	0.2805	−0.7593	0.1349	0.1205	—	−1.4551	—	—
60	0.3340	−0.6790	0.0120	0.0880	−1.2391	—	—	—
61	0.1979	−0.5371	0.1122	0.0829	−1.2518	—	—	—
62	0.3102	−0.9411	—	—	—	−2.1956	−1.8749	−2.0739
63	0.5128	−0.8543	—	—	−1.8542	—	—	—
64	0.5225	−0.9881	0.0760	—	−0.9318	−1.4013	−1.1967	—

formulations. All such coefficients of farm size, F_s, were significant at the 0.01 probability level. These coefficients were negative and ranged from −0.009513 in equation 64 to −0.01893 in equation 63. The coefficients for interest-rate/building-cost ratio ranged from −1.1874 in the autoregressive equation 61, to −2.1845 in equation 64. Only one equation (equation 64) includes both farm size and the time trend variable because of the difficulty encountered in estimating multicollinear variables. The coefficient of the over-all time variable was also negative and significant at the 0.01 probability level in all equations where it was included. The range of the coefficient for time was from −0.1563 to −0.2449. Trend differences were isolated for Kansas in equations 62 and 64 and for Nebraska in equation 62. These states have a smaller negative coefficient for time trend than the other Great Plains states.

The autoregressive equation 61, the counterpart of equation 60, is determined with $\rho = 0.55$ and is very acceptable based on d = 1.9221. As with several previous autoregressive equations, the t values declined for all regression coefficients; and for the deflated gross income coefficient, the t value did not show significance at the 0.05 probability level.

Equation 60, table 21, is used to show the use of an equation for the different states and time periods included in the over-all equations. These coefficients of regression are reported in table 22. Equation 60 also is used to obtain the predicted values for the years 1927 through 1963 by states. These predicted values along with the actual values are depicted in figs. 20 through 23. The predicted values are close to the actual values for all large changes. For Kansas, Nebraska and South Dakota, there is considerable divergence between the actual values and the predicted values for the years 1927, 1928 and 1929. No good explanation was found for this divergence. The error was shown previously to be greater, since the R^2's for these equations were less than for the previous two sets of states.

NORTHERN PLAINS RESULTS FROM THE POWER FUNCTION

Both power functions, models 33 and 34, were tried for the Northern Plains states by using least squares on the transformed data. Model 33 with lagged income gave unsatisfactory estimates, so model 34 with the arbitrary income weighting scheme was used. Also, the

equity ratio was not a significant variable in the power function. This is not surprising since the equity ratio shows up significantly on only two of the four states in the linear regressions. The pre-World War II intercept variable was not significant, whereas it was significant in all linear regressions where it was included. Time trend and farm size were significant in different regressions. The coefficients and associated statistics are reported in table 23. All coefficients are significant at the 0.05 probability level or lower. The R^2 is 0.8316 for equation 65 and 0.7947 for equation 66, and the F ratios are highly significant at 176.5 and 138.4, respectively. According to the d statistic, both equations have autocorrelated errors. Attempts were made to correct both equations for autocorrelation. However, the transformed data resulted in a near-singular matrix, and no results were obtained. The absolute value of the coefficients (which are elasticities) from the power functions in table 23 are larger than the corresponding elasticities calculated from the linear equations except for the elasticity with respect to time.

Projections of Farm Buildings for the year 1980

ASSUMPTIONS

Projections of investment in farm buildings were made for the year 1980.

Table 22. Regression coefficients by states and time periods for the Northern Plains states derived from equation 60, table 21.

	b_0	$(Y_R/P_R)_t$	ER_{t-1}	$(r/P_B)_{t-1}$	F_s
Kansas					
Prewar	8.9808	0.006180	0.2117	−1.5012	−0.01265
World War II	8.0527	0.006180	0.2117	−1.5012	−0.01265
Postwar	11.2140	0.006180	0.2117	−1.5012	−0.01265
Nebraska					
Prewar	10.4072	0.006180	0.1870	−1.5012	−0.01265
World War II	9.4791	0.006180	0.1870	−1.5012	−0.01265
Postwar	12.6404	0.006180	0.1870	−1.5012	−0.01265
North Dakota					
Prewar	11.8547	0.006180	—	−1.5012	−0.01265
World War II	10.9266	0.006180	—	−1.5012	−0.01265
Postwar	14.0879	0.006180	—	−1.5012	−0.01265
South Dakota					
Prewar	12.4685	0.006180	—	−1.5012	−0.01265
World War II	11.5404	0.006180	—	−1.5012	−0.01265
Postwar	14.7017	0.006180	—	−1.5012	−0.01265

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Table 23. Regression equations and related statistics for the power function, deflated Northern Plains data.

Equation number	$\bar{R}^2$	d	Constants		Regression coefficient for:			
			$\overset{\circ}{b}$	$\overset{\circ}{b_w}$	(Y_w/P_R)	$(r/P_B)_{t-1}$	F_s	T
65..............0.8251		0.6044	3.2172**	−0.0865*	0.8517**	−1.8708**	—	−1.8688**
66..............0.7867		0.8302	2.9615**	−0.1236**	0.4688**	−1.3915**	−0.7637**	—

** indicates coefficients with probability level $0.0 < p \leq 0.01$.
* indicates coefficients with probability level $0.01 < p \leq 0.05$.
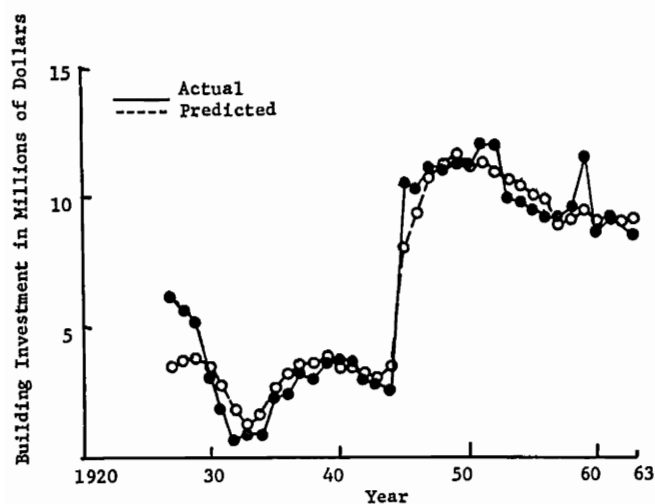

Fig. 20. Actual and predicted farm building investment in Kansas (equation 60, table 20).
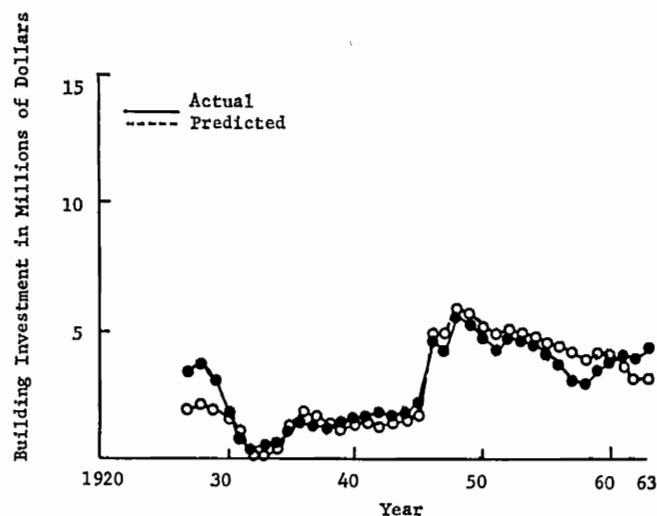

Fig. 22. Actual and predicted farm building investment in North Dakota (equation 60, table 20).
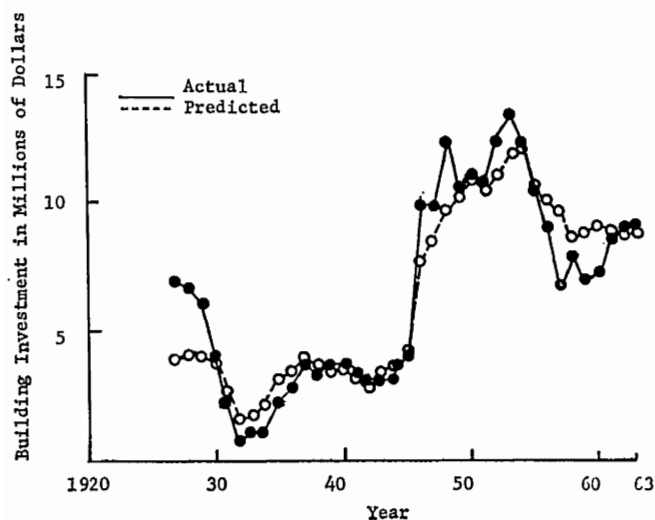
Fig. 21. Actual and predicted farm building investment in Nebraska (equation 60, table 20).
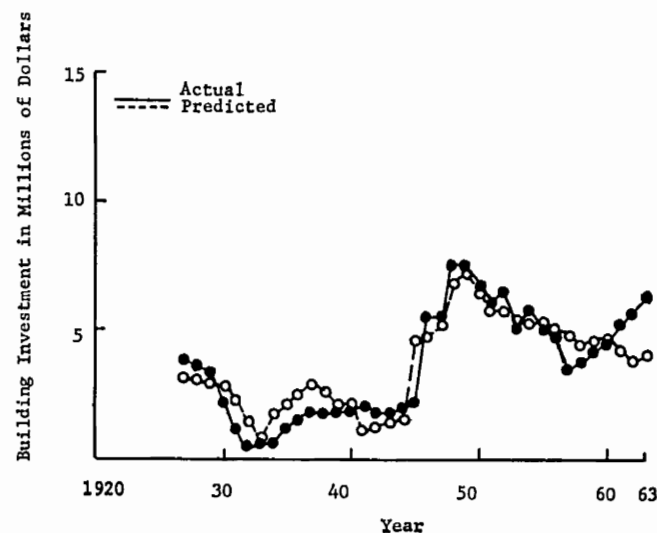
Fig. 23. Actual and predicted farm building investment in South Dakota (equation 60, table 20).

Certain basic assumptions about the national economy are necessary: It is assumed that (a) there will be no general war and no severe recession; (b) the past trends in productivity and technological development will continue, (c) a midpoint between the Census Bureau's high and low projections of population for 1980 (255 million) is assumed and (d) national economic growth is assumed to continue at approximately the same rate as the actual growth rate that occurred from 1940 to 1960.

Using these basic assumptions, Daly estimates the population will increase by 35 percent from 1962-63 to 1980, the gross national product will increase by 93 percent, and the disposable per-capita income will increase by 42 percent (8, p. 3).

Assuming the foregoing general economic environment, projections were made for certain variables that are helpful in making projections of farm building demand (8). Cash receipts from farm marketings (one of the important variables in the building investment

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demand equations) were projected to increase by 34 percent from 1962-63 to 1980. On the basis of the projected population increase and the continuing trend in foreign demand for agricultural products, the index of prices received by farmers is projected to decline by 1 percent from 1962-63 to 1980. Realized gross farm income (a variable in the national building investment demand equations) was projected to increase by 23 percent from 1962-63 to 1980. The realized net farm income (a variable in other national farm building demand equations) was projected to increase by 4 percent, and the number of farms (the farm-size variable was significant in two of the state models) to decline by 42 percent. No projections of the index of prices paid by farmers were made by the Daly study (8, p. 16).

It was necessary to project the following explanatory variables to the year 1980 to use the models estimated in this farm building demand study: (a) gross farm income and net farm income for the national models; (b) cash receipts from farm marketings for the regional and state models; (c) the index of prices received by farmers; (d) the index of prices paid for building materials; (e) the rate of interest; (f) the size of farm; and (g) the equity ratio.

The projections made by Daly (8) of the U. S. Department of Agriculture and reported here will be used where appropriate. The remaining variables that must be projected for this analysis are: (a) the index of prices paid for building materials, (b) the ratio of the rate of interest to the index price of building materials, (c) the size of farm in acres and (d) the equity ratio.

The price index for cost of building materials has gone up since the second world war in an approximate linear trend of 2 percent per year. Since the general policy guidelines are to hold price increases to 2 percent per year, the price index for cost of building materials was projected to increase at the rate of 2 percent annually on the base year 1962-63.

The ratio of interest rate to the index of the price of building materials can be estimated for 1980 by projecting the two individual variables involved. The rate of interest for new farm mortgages was projected at 6 percent. The criteria used for this projection include: (a) the rates of interest on various maturities of Federal Land Bank bonds (especially those rates for bonds maturing close to the year 1980), (b) the difference between present rates being paid on Federal Land Bank bonds and the rate being asked on Federal Land Bank mortgages, and (c) the presumption that no drastic change will be made in recent government policies on rates of interest and availability of funds for investment purposes.

If the Daly estimate (8) for the decline in farm numbers were accepted for all regions, it would mean more than a 72-percent increase in the average size of farm (assuming approximately the same total acres in farms). This increase for the two regions where farm size is a significant variable is approximately 50 percent more than the simple linear trend. For these two

regions, the higher projection seemed large; therefore, the linear trend increase in farm size was used.

Projection of the equity ratio variable requires that either projection of the ratio or projection of the two parts of the ratio as separate variables must be made. In the case of the equity ratio, it seemed more logical to project the ratio itself. Based upon past trends and the substantial changes that are occurring in agriculture, the equity ratio (as formulated in the farm building investment demand models) is projected to follow the declining trend that has occurred since the second world war. As farms became larger and the investment in land and buildings and in machinery and operating capital increases, the possibility of entrepreneurs accumulating sufficient capital to maintain the existing equity ratio is remote.

A further general assumption is that a government policy of no greater restriction in agriculture will continue. A policy of no greater government restriction of agricultural output through the period to 1980 seems appropriate because of the increasing foreign demand for agricultural products either for dollars or by government foreign aid and the continuing increase in domestic population and income.

Regional and state projections are made comparable to the national estimates. The expected national income is allocated to the various regions and states assuming that their proportional share in 1980 will be approximately the same as it has been in the last 5 years. Considering the different demand elasticities for various agricultural products with respect to consumer income, the assumption of constant proportions between geographic areas may not be realistic; but present proportions were assumed to continue for the purpose of this study. Since the Pacific States are not included in the analysis, the assumption of constant proportions for the remaining regions is more creditable.

NATIONAL PROJECTIONS

Projected values of all variables for 1980 (as well as actual values for 1947 and 1963) for four of the national linear models are presented in table 24. The projected outcomes presented in table 24 are from national data deflated by the price index of building materials and from equations corrected for autocorrelation. When time is included as an explanatory variable, it is the last two digits of the year. The price indexes and interest rate variables are not different from one geographic area to another in the models used in this study. Therefore, the values of these variables are not repeated in later tables.

REGIONAL PROJECTIONS

Table 25 gives the projected values for the eight production regions studied. Values obtained by two different equations are presented. Equation 35 is an orig-

Table 24. Projections of variables for 1980 national data (deflated by price index of building materials).

Variable	Equation number	1947	1963	1980
$(I/P_B)_t$	Actual values	474.4	431.6	—
$(I/P_B)_t$	21	544.5	404.6	323.0
$(I/P_B)_t$	22	550.8	412.3	363.9
$(I/P_B)_t$	23	593.4	398.9	332.9
$(I/P_B)_t$	24	568.4	396.1	360.1
P_B	—	277	389	483
P_R	—	276	258	255
Y_{t-1}	—	34,352	41,737	54,944
$(Y/P_B)_{t-1}$	—	14,012.3	10,527.2	11,375.6
$(Y/P_R)_{t-1}$	—	12,514	17,813	21,547
y_{t-1}	—	17,304	12,611	16,282
$(y/P_B)_{t-1}$	—	7,180.7	3,241.9	3,371.0
r_{t-1}	—	4.00	5.96	6.00
$(r/P_B)_{t-1}$	—	1.89	1.53	1.24
$(ER)_{t-1}$	—	12.423	9.678	7.542

Table 25. Projection of building investment for eight production regions for 1980 (deflated regional data).

Year	(Y_w/P_R)	$(ER)_{t-1}$	Actual $(I/P_B)_t$	Equation 35 $\widehat{(I/P_B)}_t$	Equation 36 $\widehat{(I/P_B)}_t$
Region 1 Appalachian					
1946 874	15.478	54.20	—	—	
1963 1,328	9.962	56.10	—	—	
1980 1,779	7.074	—	48.54	47.69	
Region 2 Corn Belt					
1946 2,449	10.036	122.2	—	—	
1963 3,772	10.607	102.3	—	—	
1980 5,054	9.892	—	96.31	90.96	
Region 3 Delta States					
1946 474	10.337	13.98	—	—	
1963 838	7.455	18.50	—	—	
1980 1,202	5.798	—	6.60	6.71	
Region 4 Lake States					
1946 1,079	6.862	65.13	—	—	
1963 1,543	6.697	57.01	—	—	
1980 2,007	6.938	—	39.95	41.91	
Region 5 Northeast States					
1946 1,133	9.610	71.68	—	—	
1963 1,369	7.320	55.03	—	—	
1980 1,834	5.367	—	43.09	48.89	
Region 6 Northern Plains					
1946 1,172	9.431	32.00	—	—	
1963 1,808	11.864	28.69	—	—	
1980 2,457	9.624	—	24.08	23.82	
Region 7 Southeast States					
1946 638	13.432	23.92	—	—	
1963 1,166	9.300	26.34	—	—	
1980 1,562	6.278	—	13.57	13.43	
Region 8 Southern Plains					
1946 867	12.905	29.37	—	—	
1963 1,435	14.387	22.42	—	—	
1980 1,922	13.050	—	17.79	17.61	

inal equation, and equation 36 is the same corrected for autocorrelated errors.

For the nation as a whole and for all regions studied, the projections indicate a moderate decline in the real value of investment expenditures on farm buildings. This agrees in general with the more aggregated study on fixed assets by Heady and Tweeten (21). All dollar values of the variables presented in tables 24 through 28 are given in millions of dollars: investment in farm buildings is deflated by the building cost index, and gross farm income is deflated by either the building cost index or the index of prices received by farmers, depending on the equation used.

STATE PROJECTIONS

Table 26 gives the projected values for all states in the Corn Belt. The results of the original equation 45 and the respective autoregressive equation 46 are presented. Table 27 gives the projected values for the individual Lake States, and table 28 gives the projected values for the states of the Northern Plains.

In the case of the Lake States, the autoregressive equation gives projected values for Minnesota and Wisconsin substantially higher than the autocorrelated original equation and higher than the actual past expenditure.

Except for this one case of equation 52 giving apparent high values for Minnesota and Wisconsin, the sum of state projections within regions by using state

Table 26. Projection of building investment for the Corn Belt states for 1980 (deflated state data).

Year	(Y_w/P_R)	$(ER)_{t-1}$	$(I/P_B)_t$	Equation 45 $\widehat{(I/P_B)}_t$	Equation 46 $\widehat{(I/P_B)}_t$
Illinois					
1946 601	14.130	27.94	—	—	
1963 996	15.505	24.35	—	—	
1980 1,336	14.110	—	21.92	21.08	
Indiana					
1946 351	11.369	21.29	—	—	
1963 556	10.148	22.23	—	—	
1980 745	7.987	—	14.25	15.10	
Iowa					
1946 766	7.291	30.01	—	—	
1963 1,185	9.311	18.84	—	—	
1980 1,589	6.113	—	16.94	20.97	
Missouri					
1946 358	8.024	14.11	—	—	
1963 547	9.463	12.24	—	—	
1980 733	7.863	—	-2.19	-4.79	
Ohio					
1946 371	13.180	28.82	—	—	
1963 486	8.574	24.54	—	—	
1980 651	6.794	—	22.79	23.49	
Total for 1980 5,054	—	—	73.71	75.85	

Table 27. Projections of building investment for the Lake States for 1980 (deflated state data).

Year	(Y_w/P_R)	$(ER)_{t-1}$	F_s	Actual $(I/P_B)_t$	Equation 51 $(\hat{I}/P_B)_t$	Equation 52 $(\hat{I}/P_B)_t$
Michigan						
1946	273	11.144	106	19.88	—	—
1963	346	7.273	134	17.81	—	—
1980	418	5.179	162	—	23.47	26.64
Minnesota						
1946	436	6.298	176	22.31	—	—
1963	681	7.230	217	19.98	—	—
1980	929	5.550	258	—	11.14	23.80
Wisconsin						
1946	378	6.088	133	22.94	—	—
1963	515	5.583	168	19.22	—	—
1980	660	5.078	203	—	13.18	24.80
Total for 1980 ..2,007	—	—	—	47.79	75.24

Table 28. Projection of building investment for the Northern Plains states for 1980 (deflated state data).

Year	(Y_w/P_R)	$(ER)_{t-1}$	F_s	$(I/P_B)_t$	Equation 59 $(\hat{I}/P_B)_t$	Equation 60 $(\hat{I}/P_B)_t$
Kansas						
1946	387	12.570	340	10.80	—	—
1963	636	14.085	485	8.70	—	—
1980	861	9.415	630	—	8.69	7.78
Nebraska						
1946	351	8.627	428	10.84	—	—
1963	586	11.251	559	9.21	—	—
1980	794	6.810	690	—	8.23	7.48
North Dakota						
1946	233	8.648	591	10.29	—	—
1963	275	9.325	817	4.50	—	—
1980	378	6.464	1,043	—	1.40	1.29
South Dakota						
1946	199	8.372	632	5.51	—	—
1963	310	12.072	819	6.28	—	—
1980	424	9.321	1,006	—	2.74	2.58
Total for 1980 ..2,457	—	—	—	21.06	19.13

equations is approximately the same as the projected results for the respective regions using regional equations. This is further evidence supporting the reliability of the quantitative results obtained by the various equations and techniques used in this study.

Interpretation of Results

In all farm building investment demand equations, the most significant variables included gross farm income, net farm income, the price ratio of the rate of interest to building cost index, the equity-ratio, farm size and the time trend.

Several formulations of income variables were used. Gross income divided by the index of prices received by farmers gave the best statistical results. This formulation results in an aggregate farm output variable and suggests that farm building investment is influenced more by changes in physical output than by the net income produced by this output. In fact, the gross output variable has the largest positive effect of any variable used. This is shown by standardizing equation 35 for the Corn Belt region:

$$(67) \quad I_t = 0.2529 \ (Y_w/P_R) - 0.2683 \ (r/P_B)_{t-1} + 0.1662 \ (ER)_{t-1} - 0.0822 \ T$$

Using the aggregate farm output variable makes the demand function a type of capacity model. Such models also have been successful in nonagricultural investment demand studies (2, 16, 29).

The net income variable (where used instead of the gross income variable) also has a large positive effect upon investment in farm buildings. However, since gross output seems to have a greater effect than net income, investment in farm buildings may be based more on what is needed to increase output and based on the expected earning power of the increased output or the existing ownership equity rather than on recent or current net income. Thus, gross physical output is one of the most important variables to observe in predicting farm building investment. Even more important on the regional and state level is to observe changes in proportion and composition of output among areas. Gross livestock income was tried as a variable, and the ratio of gross livestock income to gross farm income was also tried unsuccessfully as a variable in aggregate analysis. Although both these attempts were unsuccessful in aggregate econometric analysis with the data available, it is still hypothesized that change in composition of farm products produced within an area and between areas should have an effect upon farm building investment. In the short run, the investment resulting from change in type of products produced may be a minimum remodeling of existing structures. After the change in composition of products produced appears to be permanent, more permanent investment may be made. The effect of the composition of farm production on the amount and type of farm building expenditure is an important area impossible to investigate with the time series data presently available.

The rate of interest and the interest-rate-to-cost-of-buildings price ratio had negative regression coefficients that were significant at the 0.01 probability level or lower in almost all equations. In prior investigations, few researchers found the rate of interest so consistently significant as in this study.

The consistent significance of the interest rate implies its possible use as a policy variable to affect the amount of investment in different economic sectors or for other purposes. A differentiation, for example of interest rates between the agricultural and nonagricultural sectors, could be made. Some present Federal Reserve Board regulations differ for country banks and city banks. The reserve requirements are usually lower

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for country banks than for city banks, and these requirements can be changed if such a change is warranted. If the rate of interest is a proxy variable for fund availability, as suggested by Gehrels and Wiggins (14), then a decrease (or increase) in reserve requirements for country banks would increase (or decrease) fund availability and lower (or raise) the rate of interest to farmers. If there is over-investment in one sector compared with another, a prolonged differentiation of fund availability between the two sectors should change the ratio of investment between the sectors.

Before this, most proponents of the use of the rate of interest as a policy variable have suggested its use in connection with the business cycle. Although the effect of the rate of interest as a policy variable for this purpose has been questioned by a number of writers (14), the Federal Reserve Board has continued to use the rate of interest as a policy tool to smooth out the business cycle since World War II. Even though change in the rate of interest appears to affect investment in farm buildings, the proportion of expenditures on farm building investment (compared with aggregate national investment activity) is so small that its effect on the business cycle is probably negligible.

It is suggested here that the rate of interest and fund availability be differentiated among economic sectors over a longer period than the usual length of the business cycle. Long-term differentiation among sectors should effectively change the ratio of investment among these sectors to be of greater benefit to society as a whole. (This is on the assumption that there is or could be a misallocation of investment funds among sectors.) Bankers, for example, may ration funds either in absolute amounts or by the rate of interest to individual customers—thus differentiating among their various customers. It is just as plausible for the monetary system of the government to do the same thing among economic sectors to effectively encourage or discourage different investment activities.

The federal government has already done this in a limited way. The Rural Electrification Administration has been able to borrow investment funds from the federal treasury at an interest rate of 2 percent for an extended period of time. This rate of interest has been substantially below the market rate for the entire period. Differentiation of the interest rate and fund availability between sectors could be done on a wider scale indirectly through the money market rather than as a subsidy from the treasury. The type of policy followed with REA, however, is much more specific than the policies proposed here which would affect all businesses of a sector in a less selective way.

In some ways, interest rate differentiation would be similar in effect to a tax and an offsetting subsidy. The tax would be imposed on a sector instead of raising the rate of interest, and the subsidy would be given in a sector instead of a lower rate of interest. This would be a tax and subsidy with no tax gain to the government, but the administration of a tax and subsidy would cost the government more than indirect interest rate differentiation.

Changes in the interest rate to counter the business cycle have been widely debated with no verdict. Differentiating interest rates among sectors and controlling fund availability for allocation of investment might have greater probability of success.

The equity ratio is another variable that had positive and highly significant coefficients in almost all formulations of building demand equations. Although a high equity ratio by itself does not sufficiently explain building investment, along with gross output and the rate of interest, it does add to building investment explanation. If equity is high when gross output signals an increase in building investment, the financial base to make the long-term investment expenditure is present. Thus, equity in most cases may not be the motivating force in building investment; but it does make the desired investment possible when other forces (a change in output or type of product produced, or an advance in technology) exert their influence. There are instances where personal preferences (whose realization is made possible by high equity) as contrasted with the actual capacity requirements of farm output have had a profound influence on building expenditures.

Both the farm size variable and the time trend variable have negative coefficients in all equations where either is included; and where included, one or the other of these variables has been significant at the 0.05 probability level or lower. Several forces affect building investment when farms expand. Ordinarily, as farms increase in size, one would expect the total capital services required from buildings to increase. However, as farm size increases in a well-developed agricultural area (no new land is being wrested from the wilderness and added to farms), the enlarging farm acquires existing farm buildings with the land. In the short run, therefore, investment is farm buildings is not expected because of farm consolidation. Nevertheless, an eventual increase in building investment resulting from increased farm size is expected. Enlarged farms add existing farmsteads that eventually are expected to fall into disuse because of labor time required in traveling from the main headquarters farmstead to a subsidiary farmstead. When farmsteads are added, there are additional buildings of each type for the farm— all probably inadequate for the enlarged farm. Eventually these additional buildings are expected to be abandoned or replaced with a single building for the larger unit.

Technological change and advances in design and use are often represented by the time variable. (The trend variable consistently had negative coefficients for demand equations wherever it was included in this study.) Thus, a further reason for building disuse and expectation of investment in new buildings is the rapid technological change in building materials, structure and design. Pole buildings are being built for livestock housing where two-story, stud and rafter type buildings

were previously used. Slotted floors and caged birds make possible housing more animals in less space. These and other changes in building design, however, may well make it possible to reduce the capital expenditure in buildings as time progresses while obtaining physical capital services from the investment in building of less quantity and better quality than older buildings.

New expenditures for investment in farm buildings are predicted to decline by the econometric models of this study even though the physical capital services demanded are expected to increase because of (a) continuing expansion of livestock and other farm production to keep up with the growing population and (b) changing patterns of production to larger, more specialized production units. The prediction of declining investment in farm buildings is possible despite the foregoing increase in demand for building services if advances in building design and use (including use of buildings more like a production line) more than offset the forces influencing an increase in building investment. Of course, not all the important questions can be clearly answered by a single econometric study based on aggregate time series data available.

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