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Did 1933 New Deal Legislation Contribute to Farm Real Estate: Temporal and Spatial Analysis

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Abstract

The proportions of land values generated by farm program payments and farm returns are examined using an extended income capitalization model. The extended income capitalization model addresses the identification issue introduced by the counter-cyclical nature of farm program payments and farm returns. Procedures are presented that allow the estimation of agriculture land value shares without requiring explicit knowledge or assumptions with respect to the net land rental shares of farm returns or farm program payments. Results from the panel recursive or triangular-structure simultaneous equation model applied to 48 states in the U.S. for the period 1938 to 2006 indicate on average 41-45.6 percent and 54.4-59 percent of the agricultural land values can be identified with farm program payments and farm returns respectively. Spatially, at the resource regional level the contribution of farm program payments was as low as 16.8 percent in Eastern Upland region compared to a high of 51 percent in the Southern Plains region.

JEL classification:

Keywords: Farm *programs payments; Land values; Extended income capitalization model; Panel recursive/triangular structure simultaneous equation model; Resource regional analysis; U.S. State-level data, 1938-2007*.

Did 1933 New Deal Legislation Contribute to Farm Real Estate: Temporal and Spatial Analysis

Saleem Shaik[1], Joseph A Atwood, Glenn A. Helmers

I. Introduction

In the last century, American agriculture aided by federal farm programs has undergone an impressive transformation with much debate about structural changes. Among the first pieces of New Deal legislation proposed by incoming President Franklin D. Roosevelt in 1933 was a farm program designed to address declines in farm prices and net farm income. Since 1933, the design of federal farm policies changes or remain status quo approximately every five years with the authorization of a new farm bill. Aside from the domestic policy implications, considerable interest can be found among our trading partners regarding the impacts U.S. farm programs have on world production and international markets. Given this context, interest has grown in understanding how past federal farm programs have affected the structure of agriculture and how future policies could be designed to achieve preferred social outcomes. For example, concern has grown about how to design federal farm programs so as to minimize federal program outlays and production impacts for domestic and trade purposes, while at the same time strengthening the survivability or preventing the demise of family farms.

Although federal farm programs in the U.S. are rarely intended to alter the structure of U.S. agriculture, the effect of these programs on the structure has long been an economic as well as a political concern. Farm commodity programs, once viewed as temporary and supplementary to agricultural earnings, and are increasingly considered as permanent and of major proportion. Literature (Gardner; Sumner) has examined the causes and effects of U.S. farm commodity programs on U.S. farm structure. Apart from technology the widely-held view that a major, if not the most significant, mechanism for structural change in agriculture is the effect of federal farm programs on land values or farm real estate.

Farm real estate comprises approximately 80 percent of farm assets and it is hypothesized that a large share of the farm program payments is capitalized into these values. Reliably estimating the magnitudes of the effects farm program payments have on land values is an empirically challenging task. Both statistical and budgetary-based methodologies have been used to estimate the share of land prices generated by farm program payments and farm returns. Statistically-based methods are complicated by the fact that both real per acre farm returns and per acre farm program payments have drifted in the same direction over time but tend to be inversely correlated within any given year. Thus, this extension has the potential problem of identification introduced by the counter-cyclical relationship between expected farm returns and expected farm program payments. To address the identification issue, the econometric estimation uses a recursive/triangular structure simultaneous equation model. This assumption means that unobserved factors can affect both land value and farm program payments, and farm program payments can affect land value directly, but land value cannot affect farm payments directly.

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An additional complication affecting both the statistical and budget-based approaches is the fact that the net land rental shares of farm returns and farm program payments are unknown and may differ over time. If an income capitalization approach is to be utilized to *directly* estimate land values, the net land rental proportions of both farm returns and farm program payments must be assumed or computed. With usual budgeting procedures, erroneous assumptions with respect to the net rental proportions may lead to serious errors in estimates of the shares of land values generated by farm program payments. We circumvent this complication by demonstrating that elasticities of the land value regression equation provide our desired estimates of land value shares without having to explicitly identify the proportions of gross crop returns and government payments that accrue as land rent. The Appendix demonstrates procedures that enable the estimation of agricultural land value shares without having to a priori assume or identify the net rental shares of farm returns and farm program payments.

Finally, it is clear that some resource regions in the U.S. are more dependent on farm program payments than others due to differences in the type of agriculture, supported commodities, and the effects of program features. A marginal dollar payment is not expected to affect each resource region's land values in the same magnitude. In addition, given the difference in land values, program payments and crop receipts (Table 1), the contribution of farm returns and farm program payments to agricultural land values is expected to be different across nine U.S. resource regions. We attempt to examine for such divergent regional effects by estimating the contribution or share of the expected farm returns and farm program payments for each of the nine resource regions using historical data from 1938-2006.

Our contribution in this paper is three-fold. We propose an extended income capitalization model that addresses the identification difficulties introduced by the counter-cyclical relationship between farm program payments and farm returns. Second, we present procedures that enable estimation of the shares of land values generated by farm returns and farm program (Appendix) without having to explicitly identify or assume crop return or government payment land net rental proportions. Finally, we estimate the proportion of agriculture land values generated by farm returns and farm program payments across nine U.S. resource regions. These are obtained from partial elasticity estimates of the farm returns and farm program payments variables from the panel recursive/triangular structure simultaneous equation econometric model.

Next the extended income capitalization model is proposed. Procedures that enable the estimation of the share contribution of farm returns and farm program payments to land values are presented in the appendix. In the data section, the details on the sources and construction of the regression variables along with means are discussed. This is followed by the panel recursive/triangular-structure simultaneous equation econometric model to estimate the extended income capitalization model. Results of empirical applications to the nine resource regions and U.S. based on state-level data for the period 1938 to 2006 are presented in the following section. Finally, general and policy implications are presented.

Table 1. Means of the Variables by Regions, 1938-2006

Regions \ Variables	N	Farm Real Land Value ($/acre)	Expected Farm Crop receipts ($/acre)	Expected Farm Program Payments ($/acre)
Basin Range	325	293.43	29.54	3.04
Eastern Uplands	325	697.94	86.85	8.83
Fruit Rim	195	1,069.70	235.85	6.34
Heartland	195	1,154.82	141.00	15.66
Mississippi Seaboard	520	808.17	137.18	11.79
Northern Crescent	715	748.35	104.58	13.22
North Eastern Crescent	260	1,671.79	253.84	6.97
Northern Plains	195	388.13	50.50	9.31
Southern Plains	260	471.24	38.90	6.78
US	**3312**	**916.33**	**137.04**	**8.60**

Regions \ Variables	Urbanization (Number)	Farm size (acres)	Herfindahl Index of Farm Revenue	Herfindahl Index of program acres
Basin Range	45.63	2,229.74	43.65	32.46
Eastern Uplands	120.82	153.62	40.11	21.95
Fruit Rim	359.88	365.58	35.49	17.20
Heartland	211.65	209.22	31.50	26.45
Mississippi Seaboard	210.81	167.72	27.33	20.96
Northern Crescent	237.11	197.43	28.30	23.92
North Eastern Crescent	2,716.39	138.31	65.97	29.34
Northern Plains	15.16	784.09	29.36	34.34
Southern Plains	60.78	477.94	29.92	27.97
US	**741.58**	**590.43**	**41.42**	**26.73**

II. Extended Income Capitalization Model

Early empirical research in explaining land values involved the use of individual farm data (Haas, Ezekiel) and county data (Wallace). These early studies were followed by a large number of analyses (Alston; Barry; Boehlji and Griffin; Brigham; Featherstone and Baker 1987 and 1988; Goodwin et al 1992 and 2003; Lance and Mishra; Lintner; Roberts et al; Roberts and Key; Ryan et al; Sharpe; Shoemaker; Shertz and Johnston; and Vantreese et al) directed at quantifying the variables that impact agricultural land values. These studies have emphasized the capitalization of expected long run changes in farm returns into agricultural land values. The impacts of inflation, debt financing, and financial speculation received considerable attention as agricultural land values increased rapidly during the late 1970s but experienced a significant decline after 1981. Others addressed increasing urban and environmental influences on land values. Previous analyses have indicated positive effects from farm program payments on land values (Reynolds and Timmons; Harris; Duffy, et al.; Herriges, et al.; Barnard, et al.; Gardner, 2002; Gertel, K; Weersink, et al.; and Shaik et al.), but the magnitude of these effects over time is often debated.

The structural factors explaining agricultural land values have centered on the income capitalization model (Burt). The basic representation of the income capitalization model is derived from discounting expected future returns over an infinite life:

(1) $$V = f\left(A, r^{-1}\right)$$

where V is agricultural land value, A represents the present value of expected future returns, and r is a discount rate or real interest rate.

With the increased role of farm program payments in agricultural returns, extensions to explicitly incorporate the components of the expected returns A provide a mechanism for policy analysis. The individual components include expected farm returns (*fcr*) and expected farm program payments (*fpp*) along with urbanization variable (*urban*). Following Weersink et al., the extended model can be represented as

(2) $$V = f\left(\frac{fcr, fpp}{r}, urban\right)$$

However, this extension has the potential problem of identification introduced by the counter-cyclical relationship between expected farm returns and expected farm program payments (Goodwin, et. Al., and Shaik, et al.). Due to their counter cyclical-nature, annual expected farm program payments are inversely related to expected annual farm returns. This can be represented as:

(3) $$fpp = f\left(fcr\right)$$

Due to the endogeneity of the explanatory variables—i.e., one or more of the explanatory variables (farm program payments) is jointly determined with the dependent variable (land value)—a need exists for simultaneous estimation of the income capitalization model. Jointly estimating equations (2) and (3) overcomes the identification issue and provides for a more accurate construction of the income capitalization model.

The entire system then can be represented as:

$$fpp = f\left(fcr,\ fsize,\ HIacre, ,\ HIrev \right)$$

(4)
$$V = f\left(\left(\frac{fcr, fpp}{r} \right), urban \right)$$

In addition to the variables described above, the Herfindahl index of crop and livestock revenue ($HIrev$), the Herfindahl index of planted acreage ($HIacre$) and the farm size ($fsize$) are included in the farm program payment equation.

Both expected farm returns and expected farm program payments are anticipated to be positively related to agricultural land values. Due to their counter-cyclical nature, realized farm program payments are hypothesized to be negatively related to farm returns in the farm program payments equation. The real interest rate is expected to be negatively related to agricultural land values. To account for the growing nonfarm demand for agricultural land and nonfarm economic influence, urbanization is included in the land value equation. Urbanization is hypothesized to increase the demand for agricultural land and therefore increase land values.

The Herfindahl index of crop and livestock revenue and the Herfindahl index of crop program acreage are included to account for the heterogeneity among states with respect to differences in the type of agriculture, supported commodities, farm program features, and farm size. The Herfindahl index of revenue reflects variations in the crop and livestock mixes across states over time. The Herfindahl index of planted acreage is included to account for the spatial variation of program crop acreage. Similarly, changes in farm size are included in the government payments equation to account for the temporal changes of farm consolidation.

Finally, if the entire system (equation 4) can be identified, appendix demonstrates: (1) the estimated partial elasticities of agricultural land values with respect to *fcr* and *fpp* are estimates of the agricultural land value shares contributed by expected farm returns and expected farm program payments, respectively; and (2) the sums of these elasticities should be less than or equal to unity.

III. U.S. State Data and Construction of the Variables

To be consistent with the agricultural land value per acre, all the variables are standardized to a per acre basis using acres in farms. Additionally the variables expressed in nominal dollars were converted into real 2000 dollars using the implicit gross domestic product price deflator. Agricultural land value and farm returns are reflected by farm real estate and farm receipts per acre, respectively. We use the conventional real interest rate definition where the rate of inflation (Consumer Price Index) is subtracted from the observed Federal land bank nominal interest rate[2]. Farm returns, farm program payments, and the inflation component of the real interest rate are in expectation form.

[2] If the nominal interest rate is less than 4 percent, we truncate the real interest rate at 4 percent Alternative truncation at 2 or 3 percent did not change the elasticities estimates of farm returns and farm program payments indicating the robustness of the model and results.

The expectations of the variables for farm returns, farm program payments and real interest rates were estimated by an autoregressive process in each state rather than using an ad hoc lag length. The order of the autoregressive model is selected by a stepwise autoregression. The stepwise autoregression method initially fits a high-order model with many autoregressive lags and then sequentially removes autoregressive parameters until all remaining autoregressive parameters have significant *t*-tests. One the lag length is estimated for farm returns, farm program payments and inflation component of real interest rates for each in each state, the expected farm returns, expected farm program payments and expected inflation are computed as moving average. The moving average is computed based on past information of the variables using the lag length estimated from the stepwise autoregressive model.

To reflect the importance of nonfarm demand for agricultural land and nonfarm economic influence on the value of land, urbanization is defined as urban population per acre. The Herfindahl index also referred to Herfindahl-Hirschman Index is a commonly accepted measure of concentration. The value of the index is the sum of the squares of the shares of all firms (or in our case crop and livestock variables) in an industry (or in our case farm). The index takes a value of 100 percent when it is totally concentrated and zero percent when it is fully diversified. The Herfindahl index of crop and livestock revenue reflects variations in the crop and livestock mixes across resource region over time. The Herfindahl index of crop program acreage accounts for the spatial variation of program crop acreage across resource region over time. Farm size is computed as the land in farms divided by the number of farm.

Regional means of the variables for the period 1938-2006 are presented in Table 1. The state composition of the nine U.S. resource regions is as follows: the *Basin Range* includes Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming; the *Eastern Uplands* includes Arkansas, Kentucky, Tennessee, and West Virginia; the *Fruit Rim* includes California, Florida, Oregon and Washington; the *Heartland* includes Illinois, Indiana, Iowa, Missouri, and Ohio; the *Mississippi Seaboard* includes Alabama, Georgia, Louisiana, Mississippi, North Carolina, South Carolina and Virginia; the *Northern Crescent* includes Michigan, Minnesota and Wisconsin; the *North Eastern Crescent* includes Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont; the *Northern Plains* consists of Kansas, Nebraska, North Dakota and South Dakota; and finally, Oklahoma and Texas represent the *Southern Plains*.

The mean U.S. farm real land value of $916 per acre is lower than two (Heartland and North Eastern Crescent) of the nine resource regions. The Basin Range farm real land value of $293 per acre was the lowest and the North Eastern Crescent was the highest with a value of $1,672. Four regions (Basin Range, Fruit Rim, Southern Plains and North Eastern Crescent) received lower farm program payments per acre compared to the U.S mean of $8.60 per acre with the Basin Range ($3.04) and the Heartland ($15.66) being the two extremes. Mississippi Seaboard, Heartland, Fruit Rim, and North Eastern Crescent regions realized higher expected crop receipts than the U.S. average of $137 per acre. The North Eastern Crescent region realized the highest expected farm receipts of $253 per acre compared to $26.53 per acre for the Basin Range region. In terms of the percentage of farm program payments relative to expected crop receipts per acre, the Fruit Rim region with 2.7 percent and the Northern Plains with 18.4 percent realized the lowest and highest levels, respectively. With the exception of North Eastern

Crescent, all of the resource regions had lower urbanization than the U.S. on average of 711 urban residents per acre.

These Southern plains, North Eastern Crescent, Basin Range and Northern Plains regions had higher program crop acreage Herfindahl indexes than the U.S. average of 26 percent indicating more specialized program crop acreage. The Northern Plains region with a Herfindahl index value of 34 percent was relatively less diversified. Fruit Rim with a Herfindahl index value of 17 percent was relatively more diversified.

The crop-livestock revenue Herfindahl index for two of the nine resource regions had a value greater than the U.S. average of 41 percent. This indicates the revenue is realized more from either crop or livestock and relatively less from combined crop and livestock. In contrast, the Mississippi Seaboard region with a Herfindahl index of 27 percent had more diversified crop-livestock revenue compared to the more specialized crop-livestock revenue of the North Eastern Crescent region (66 percent).

Finally, farm size in the Basin Range was the largest of the nine resource regions with an average of 2,229 acres per farm while the North Eastern Crescent region had the smallest average farm size with 138 acres per farm. The U.S. average was 590 acres per farm for the same period of 1938-2006.

IV. Empirical Model and Results

An application of the extended income capitalization model to examine the factors affecting farm land values simultaneously with the counter-cyclical relationship between farm program payments and farm returns is modeled for nine resource regions and U.S. using data from 48 states for the period 1938 to 2006. We estimate the contribution of expected crop returns, farm program payments and urbanization to agricultural land values for each of the nine resource regions and U.S. To accomplish this, the extended income capitalization model (equation 5) is estimated by recursive/triangular structure simultaneous equation model accounting for the panel structure of the data.

The recursive/triangular structure simultaneous equation model (for details refer to Kmenta pages 659-660) accounting for time-series and cross-section data can be represented as:

$$(5a) \qquad V_{it} = \alpha_2 + \beta_{2,r}\, rir_{it} + \beta_{2,fcr}\, fcr_{it} + \beta_{2,fpp}\, \hat{fpp}_{it} + \beta_{urban}\, urban_{it} + u_{2,i} + v_{2,t} + w_{2,it}$$

$$(5b) \qquad fpp_{it} = \alpha_1 + \beta_{1,fcr}\, fcr_{it} + \beta_{1,fsize}\, fsize_{it} + \beta_{1,HIrev} HIrev_{it} + \beta_{1,HIacre}\, HIacre_{it} + u_{1,i} + v_{1,t} + w_{1,it}$$

where u_i is the cross-section errors, v_t is the time-series errors, and w_{it} is the remainder random error term and $i = 1,\ldots.,N$ and $t = 1,\ldots.,T$ are defined above. The recursive/triangular structure simultaneous equation model is estimated in three stages. The first stage involves estimating and recovering the predicting farm program payments, fpp using equation (5b). In the second stage, the predicted farm program payments, $\hat{fpp}$ is used as an exogenous variable in equation (5a). Both stages in the recursive//triangular structure simultaneous equation model are estimated using two-way random effects accounting for temporal and spatial variation across states within each of resource regions. The validity the two-way random effects model was confirmed by the Hausman test. Further due to the presence of heteroskedasticity (White's test and the modified Breusch-Pagan test, for discussion see Greene), equation 5a and 5b are estimated with heteroskedasticity consistent-covariance matrix estimator (HCCME) for the two-way random effect panel model.

Due to the presence of nonconstant error variance, heteroskedasticity causes estimates to be inefficient. Generalized least squares can be used to make the estimator unbiased and efficient when the variances are known. White proposed a heteroskedasticity consistent-covariance matrix estimator (HCCME) when the variances are unknown and showed it is sufficient to estimate HCCME, $\Lambda = \mathbf{X}'\Omega\mathbf{X}$ where $\Omega = E\left(w_{i,t}w'_{i,t}\right)$ and $\mathbf{X}$ is the vector of exogenous variables from equation 5a and 5b. MacKinnon and White investigated three modified HCCME (HCCME=1, 2 and 3) including the original HCCME (=0) with improved finite sample properties and found the HCCME (=0) performed the worst followed by HCCME (=1), HCCME (=2) and HCCME (=3). The HCCME can be represented as

(6) $$\Lambda\left(HCCME = 3\right) = \frac{1}{N}\sum_{i=0}^{NT}\frac{\hat{w}_i^2}{\left(1-\hat{h}_i\right)^2}x_i x_i'$$

where $\hat{h}_i = X_i\left(X'X\right)^{-1}X_i'$

Results

Estimated coefficients for equation 5a and 5b of the panel recursive/triangular structure simultaneous equation model is presented in Table 2 by nine resource regions and the U.S. The associated elasticity estimates are presented in Table 3. Finally, Table 4 presents the two sets of normalized elasticities of farm program payments and farm crop receipts. One measure of elasticity is computed at the mean of the independent and dependent variables, and the second elasticity measure is computed as the average of the individual estimated elasticities. In the discussion of the results, we use partial elasticity measures for ease of interpretation.

Results indicate a negative sign on real interest rates for all the resource regions with the exception of the North Eastern Crescent. With respect to the magnitude of the real interest rate coefficient, Heartland had the highest and Basin Range the least effect on land values. Compared to the U.S., Heartland, Fruit Rim, Northern Plains, Northern Crescent and Southern Plains realized higher percentage reductions in land values for a one percent increase in interest rates.

Table 2. Parameter Coefficients[3] of Panel Recursive/Triangular Structure Simultaneous Equation Model by Resource Regions, 1938-2006

	Basin Range	**Eastern Uplands**	**Fruit Rim**	**Heartland**	**Mississippi Seaboard**
Real Land Value Equation					
Intercept	**146.663**	-45.203	**604.920**	**615.359**	213.894
Real interest rates	-5.873	-17.661	-87.679	**-127.185**	-16.828
Farm crop receipts	**2.665**	**4.091**	1.255	**4.678**	**1.240**
Farm program payments	**23.256**	**8.104**	**29.377**	**14.390**	**9.410**
Urbanization	**0.544**	**3.304**	**1.097**	**1.193**	**1.859**
Farm Program Payment Equation					
Intercept	**3.930**	**16.365**	**-7.129**	**-25.049**	**9.564**
Farm crop receipts	**0.047**	**-0.149**	**0.018**	**-0.046**	0.003
Farm size	-0.00007	**0.139**	0.014	**0.103**	**0.063**
Herfindahl index of program acreage	**-0.080**	**-0.517**	0.142	**1.006**	**-0.216**
Herfindahl index of farm revenue	**0.041**	**0.216**	-0.052	-0.230	**-0.131**

	Northern Crescent	**North Eastern Crescent**	**Northern Plains**	**Southern Plains**	**US**
Real Land Value Equation					
Intercept	**537.007**	-227.462	**344.920**	-82.869	**285.078**
Real interest rates	-71.505	49.503	**-78.227**	**-63.568**	-59.719
Farm crop receipts	**2.282**	**1.889**	**4.738**	**10.185**	**2.603**
Farm program payments	**12.994**	53.425	**21.558**	**60.750**	**34.708**
Urbanization	**0.579**	**0.299**	-1.909	0.736	**0.345**
Farm Program Payment Equation					
Intercept	3.839	2.123	-1.475	3.833	**14.255**
Farm crop receipts	-0.001	0.002	0.009	**-0.084**	**-0.004**
Farm size	**0.105**	0.032	**0.006**	**0.006**	0.00009
Herfindahl index of program acreage	-0.282	-0.018	0.013	0.050	**-0.092**
Herfindahl index of farm revenue	-0.136	0.034	**0.149**	0.070	**-0.048**

[3] Values in bold indicated the variables are significant at less than 0.05 percent level of significance.

Table 3. Elasticity Estimates of Panel Recursive/Triangular Structure Simultaneous Equation Model by Resource Regions, 1938-2006

	Basin Range	Eastern Uplands	Fruit Rim	Heartland	Mississippi Seaboard
Real Land Value Equation					
Real interest rates	-0.094	-0.119	-0.385	-0.518	-0.098
Farm crop receipts	0.268	0.509	0.277	0.571	0.211
Farm program payments	0.241	0.103	0.174	0.195	0.137
Urbanization	0.085	0.572	0.369	0.219	0.485
Farm Program Payment Equation					
Farm crop receipts	0.462	-1.464	0.685	-0.414	0.030
Farm size	-0.049	2.422	0.787	1.379	0.893
Herfindahl index of program acreage	-1.146	-2.348	0.793	2.024	-0.501
Herfindahl index of farm revenue	0.440	0.536	-0.141	-0.389	-0.234

	Northern Crescent	North Eastern Crescent	Northern Plains	Southern Plains	US
Real Land Value Equation					
Real interest rates	-0.449	0.139	-0.948	-0.634	-0.307
Farm crop receipts	0.319	0.287	0.616	0.841	0.390
Farm program payments	0.230	0.223	0.517	0.875	0.326
Urbanization	0.183	0.487	-0.075	0.095	0.280
Farm Program Payment Equation					
Farm crop receipts	-0.010	0.081	0.050	-0.480	-0.070
Farm size	1.571	0.639	0.521	0.405	0.006
Herfindahl index of program acreage	-0.605	-0.169	0.040	0.220	-0.445
Herfindahl index of farm revenue	-0.246	0.144	0.548	0.289	-0.148

Table 4. Normalized Elasticities from Panel Recursive/Triangular Structure Models by Resource Regions, 1938-2006

	Basin Range	**Eastern Uplands**	**Fruit Rim**	**Heartland**	**Mississippi Seaboard**
Elasticity at Individual observations					
Farm crop receipts (FCR)	45.6%	84.7%	56.7%	74.5%	62.6%
Farm program payments	54.4%	15.3%	43.3%	25.5%	37.4%
Elasticity at the Mean					
Farm crop receipts (FCR)	52.7%	83.2%	61.4%	74.5%	60.5%
Farm program payments	47.3%	16.8%	38.6%	25.5%	39.5%

	Northern Crescent	**North Eastern Crescent**	**Northern Plains**	**Southern Plains**	**US**
Elasticity at Individual observations					
Farm crop receipts (FCR)	57.2%	41.1%	56.9%	51.5%	59.0%
Farm program payments	42.8%	58.9%	43.1%	48.5%	41.0%
Elasticity at the Mean					
Farm crop receipts (FCR)	58.1%	56.3%	54.4%	49.0%	54.4%
Farm program payments	41.9%	43.7%	45.6%	51.0%	45.6%

The expected farm crop receipts and expected farm program payment variables are positive and significantly related to real land value for all the nine resource regions and the U.S. The only exception was Fruit Rim with an insignificant coefficient. Based on the elasticities, a 10 percent decrease in expected farm crop returns would be expected to reduce real land values by 3.90 percent. Compared to the U.S., the Southern Plains (8.41 percent), Northern plains (6.16 percent), Heartland (5.71 percent) and Eastern Uplands (5.09 percent) realized higher percentage reductions in real land values for a 10 percent decrease in expected farm crop returns. This indicates the value of land in these regions is strongly driven by increases in farm crop returns. The Northern Crescent (3.19 percent), North Eastern Crescent (2.87 percent), Fruit Rim (2.77 percent), Basin Range (2.68 percent), and Mississippi Seaboard (2.11 percent) realized lower percentage reduction in real land values for a 10 percent decrease in expected farm crop returns compared to U.S. estimate. This indicates the value of land in these regions is driven by diversified farm returns and non-traditional commodity crops including fruit and vegetables, pulses and aquaculture. Our estimates are in the range estimated by Kastens and Dhuyvetter (7.4

percent to 79.9 percent across states using average rent-to-value ratios over the 1951-1972 time-period).

Similarly, a 10 percent decrease in expected farm program payments implies a 3.26 percent decrease in average real land values for the U.S. Compared to the U.S., Northern and Southern Plains (8.41 and 6.16 percent) realized higher percentage increases in real land values for a 10 percent increase in expected farm program payments. This indicates the value of land in the two regions is strongly driven by farm program payments due to the availability of farm programs for traditional commodity crops grown in these regions. While the rest of regions realized lower percentage reductions compared to U.S. estimate. This indicates farm program payments contribute less to the increase in value of land in these regions. These results are in the range estimated by Barnard et al (16 percent to 69 percent across land resource regions using cross section data) and Kastens and Dhuyvetter (10.7 percent to 100 percent across states using average rent-to-value ratios over 1951-1972).

Urbanization is positive and significantly related to real land value with two exceptions. The parameter coefficient was positive (negative) and insignificant for Southern (Northern) Plains. A 10 percent increase in urbanization would be expected to increase real land values by 2.80 percent for the U.S. Compared to the U.S., the Heartland (2.19 percent), Northern Crescent (1.83 percent), Southern Plains (0.95 percent) and Basin Range (0.85 percent) realized less than the 2.8 percentage U.S impact. This indicates the value of land in these regions is relatively driven by the farm economy. While Eastern Uplands (5.72 percent) North Eastern Crescent (4.87 percent), and Mississippi Seaboard (4.85 percent) realized higher percentage increase in real land values for a 10 percent increase in urbanization compared to the U.S.

An inverse relationship between expected farm program payments and farm crop returns is observed at the U.S. level. A 10 percent increase in expected farm crop receipts implies a 0.70 percent decrease in expected farm program payments for the U.S. However, the relationship is mixed for regions with the coefficients significant in the Basin Range, Eastern Uplands, Fruit Rim, Heartland and Southern Plains. A positive relationship between expected farm program payments and farm crop returns were realized in the Basin Range, Fruit Rim, Mississippi Seaboard, North Eastern Crescent and Northern Plains. Expected farm crop receipts is negative and for a 10 percent increase in farm crop receipts would lead to a reduction in farm program payments in the Eastern Upland, Southern Plains, Heartland and Northern Crescent by 11.5 percent, 4.8 percent, 4.14 percent and 0.10 percent respectively. This negative relationship in these regions indicates producers receive farm program payments only if there is a shortfall in farm crop receipts. In contrast, a 10 percent increase in farm crop receipts would be expected to increase farm program payments in Fruit Rim, Basin Range, North Eastern Crescent, Northern Plains and Mississippi Seaboard by 6.85 percent, 4.62 percent, 0.81 percent, 0.50 percent and 0.30 percent respectively. The positive relationship in these regions indicates producers receive farm program payments even if there are high farm crop receipts. This might be due to the different kinds of farm programs. Here we did not identify the payments by different farm programs and hence would be hard justify.

Increased farm size is positively related to expected farm program payments for all the resource regions with the exception of the Basin Range. Farm size is positively related to expected farm program payments for the U.S. but at a significant level. In contrast, farm size in the Eastern Uplands, Northern Crescent, Heartland, Southern Plains, Fruit Rim and Northern

Plains are positive and significantly related to expected farm program payments with elasticities of 24.2 percent, 15.7 percent, 13.8 percent, 7.87 percent, 5.21 percent and 4.05 percent respectively. In these regions producers with larger farms tend to receive higher farm program payments.

The negative and significant coefficient for the Herfindahl index of program crops acreage indicates farm program payments are lower under greater crop specialization for the U.S. A 10 percent increase in specialization of program crops acreage is estimated to reduce expected farm program payments by 5.01 percent. For regions the relationship is mixed with positive signs in the Fruit Rim, Heartland, Northern Plains and Southern Plains with negative signs in the Basin Range, Eastern Uplands, Mississippi Seaboard, Northern Crescent, North Eastern Crescent and the U.S. The Eastern Upland, Basin Range and Mississippi Seaboard realized reductions (23.5 percent, 11.5 percent and 5.01 percent) in expected farm program payments for a 10 percent increase in specialization of program crops acreage. This indicates that expected farm program payments are driven by increases in the number of program crop acreages. The Heartland realized a 20 percent higher expected farm program payment for a 10 percent increase in the specialization of program crop acreage, however parameter coefficients of the remaining resource regions were insignificant.

The negative and significant farm revenue Herfindahl index variable indicates farm program payments are lower under greater specialization of farm revenue for the U.S. A 10 percent increase in specialization of program crops acreage would be expected to decrease expected farm program payments by 14.8 percent for the U.S. For the resource regions the relationship is mixed with positive signs in the Basin Range, Eastern Uplands, North Eastern Crescent, Northern Plains and Southern Plains, and negative signs in the remaining regions.

Contribution of Farm Program Payments and Farm Crop Returns

Next, two sets of normalized elasticity measures are presented in table 4, one measure of elasticity is computed at the mean of the independent and dependent variables, and the second elasticity measure is computed as the average of individual estimated elasticities. The proportions of agricultural land values attributable to expected farm program payments and expected farm crop returns varied across the nine U.S. production regions for the time period 1938-2006.

The estimated shares or contribution of farm crop returns and farm program payments to agricultural land values in the U.S. is 59 percent and 41 percent respectively for the period 1938-2006 and is based on the elasticity measure computed as the average of individually estimated elasticities. The shares estimated here are different for two reasons. First, the estimates are based on historical data from 1938 to 2006 and accounts for spatial and temporal variation. Second the shares were computed as the average of individually estimated elasticity.

In contrast, the share or contribution of farm crop returns and farm program payments to agriculture land values is 54.4 percent and 45.6 percent respectively based on the elasticity computed at the mean of the independent and dependent variables.

Based on the elasticity computed at the mean of the independent and dependent variables, the contribution of farm crop returns to agricultural land values was approximately 49 percent in the Southern Plains followed in order of degree by the Basin Range (52.7 percent), Northern

Plains (54.4 percent), North Eastern Plains (56.3 percent), Northern Crescent (58.1 percent), Mississippi Seaboard (60.5 percent), Fruit Rim (61.4 percent), Heartland (74.5 percent) and Eastern Uplands (83.2 percent). Compared to the U.S., Basin Range and Northern Plains realized lower contribution of farm crop returns to value of land based on the elasticity computed at the mean of the independent and dependent variables. The Eastern Uplands, Heartland, Fruit Rim, Mississippi Seaboard, Northern Crescent and North Eastern Crescent resource regions realized higher contribution of farm crop returns to value of land than the U.S.

Farm program payment contribution to agricultural land values was only 16.8 percent in the Eastern Upland followed by the Heartland (25.5 percent), Fruit Rim (38.6 percent), Mississippi Seaboard (39.5 percent), Northern Crescent (41.9 percent), North Eastern Crescent (43.7 percent), Northern Plains (45.6 percent), Basin Range (47.3 percent) and the Southern Plains (51 percent) based on the elasticity computed at the mean of the independent and dependent variables. Compared to the U.S., the Northern Plains, Basin Range and Southern Plains realized higher contributions of farm program payments to the value of land. The remaining regions realized lower contributions of farm program payments to value of land compared to the U.S.

V. Summary and Conclusions

In this paper we investigate the role of farm program payments in altering the structure of U.S. agriculture with specific reference to agriculture land values. This research is unique and rich in the sense it use historical U.S. state level data from 1938-2006 to examine differential effects of farm program payments and far returns on value of land.

First, the proportions of agricultural land values generated by farm program payments and farm returns are examined using panel recursive/triangular structure simultaneous equation model of extended income capitalization model. The extended capitalization model addresses the identification issue introduced by the counter-cyclical nature of farm program payments and farm returns. Further, procedures are presented that enable the indirect estimation of the proportion of land values generated by farm returns and farm program (Appendix) without requiring explicit knowledge or assumptions with respect to the net land rental shares of farm returns or farm program payments. Second, we account for spatial variation across states within a resource region and temporal variation over time in the estimation of partial elasticities of farm returns and farm program payments variables from the panel recursive/triangular structure simultaneous equation econometric model.

Third, the regional analysis indicates the contribution of the farm program payments to agriculture land values varied substantially by region. Regional difference in the contribution of farm program payments might be due to the difference in the agricultural production systems and also due to non-availability of program payments for certain crops or livestock production or lower acreage under program crops. This analysis would provide domestic policy makers insights with respect to the introduction of new farm programs or re-allocation of funding for regions without program payments for crops and livestock production.

The share or contribution of farm crop returns and farm program payments to agricultural land values in the U.S. is 54.4 percent and 45.6 percent respectively for the period 1938-2006. Basin Range and Northern Plains realized lower contribution of farm crop returns to value of land compared to the U.S and the Eastern Uplands, Heartland, Fruit Rim, Mississippi Seaboard, Northern Crescent and North Eastern Crescent resource regions realized higher contribution of farm crop returns to value of land than the U.S. The Northern Plains, Basin Range and Southern Plains realized higher contributions of farm program payments to the value of land than the U.S. compared to other resource regions.

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Appendix

Estimating the contribution of expected farm crop returns and farm program payments to agricultural land values

We present procedures that enable us to estimate the shares of agricultural land values generated by expected farm crop returns and expected farm program payments, and relate these shares to elasticity estimates obtainable from econometric models. In developing these procedures we use the following definitions:

V(t) = the land's "agricultural value" at time t;
fcr(t) = expected annualized per acre farm returns at time t;

fpp(t) = expected annualized per acre farm program payments at time t
z(t) = expected annualized levels of "other" income accruing to land

r(t) = the effective annualized real discount factor at time t and

K_{fcr}, K_{fpp}, K_z = the land net rental proportions of gross fcr(t), fpp(t), and z(t), respectively.

If land values represent discounted expected future cash flows, procedures similar to those presented by Watts and Helmers, can be used to demonstrate that land values for all t can be represented with the basic income capitalization formula:

$$\text{(A-1)} \quad \begin{aligned} V_0(t) &= \frac{K_c\, c_0(t) + K_g\, g_0(t) + K_z\, z_0(t)}{i(R) + p + d} \\ &= \frac{K_c\, c_0(t)}{r} + \frac{K_g\, g_0(t)}{r} + \frac{K_z\, z_0(t)}{r} \\ &= V_{0,C}(t) + V_{0,G}(t) + V_{0,Z}(t) \end{aligned}$$

where *r* is an effective discount rate and $V_{0,fcr}(t)$, $V_{0,fpp}(t)$ and $V_{0,z}(t)$ are the portions of land value $V_0(t)$ generated by expected farm returns, farm program payments, and other receipts, respectively. In the main body of the paper we utilize historical interest rates and inflation and estimate the expected net discount rate r directly as a moving average of the historical ex post realized real interest rates. However, since it is highly unlikely that markets expect negative real interest rates t continue indefinitely into the future, we truncate ex post real interest rates. As the results were not highly dependent upon the truncation threshold, we present the results when assuming a real net discount rate of at least 4 percent.

Differentiating equation (A-1) with individual elements of the equation gives
$\partial V_0(t)/\partial c_0(t) > 0;\ \ \partial V_0(t)/\partial g_0(t) > 0;\ \ \partial V_0(t)/\partial z_0(t) > 0;\ \ \partial V_0(t)/\partial i(R) < 0;$

$\partial V_0(t)/\partial p < 0;$ and $\partial V_0(t)/\partial d < 0$

Dividing (A-1) by $V_0(t)$ gives the land value share relationship:

(A-2) $$\frac{V_{0,C}(t)}{V_0(t)}+\frac{V_{0,G}(t)}{V_0(t)}+\frac{V_{0,z}(t)}{V_0(t)}=S_{0,C}(t)+S_{0,G}(t)+S_{0,z}(t)=1$$

where $S_{0,fcr}(t)$, and $S_{0,fpp}(t)$ and $S_{0,z}(t) \geq 0$ are the proportions or shares of the land's value generated by farm returns, farm program payments, and other receipts, respectively.

When considering only agricultural farm receipts and government payments, expression (A-2) reduces to

(A-3) $$\frac{V_{0,C}(t)}{V_0(t)}+\frac{V_{0,G}(t)}{V_0(t)}=S_{0,C}(t)+S_{0,G}(t)\leq 1$$

Estimating Agricultural Land Value Shares

While ex post historical realized farm returns and farm program payments are observable, neither expected *fcr(t)* or *fpp(t)* nor the net land rental shares K_{fcr}, or K_{fpp} are observable. In the paper we approximate expected *fcr(t)* and *fpp(t)* as a moving average of historical or realized values. The inability to observe K_{fcr} or K_{fpp} can introduce substantial difficulties when attempting to estimate the parameters of the land value capitalization formula if the magnitudes of the beta coefficients are to be interpretable. While the *signs* and *significance* of the parameters are unaffected by errors in assumed levels of K_{fcr} or K_{fpp}, the levels of the parameter estimates are not invariant to such assumptions.

Fortunately, estimates of the value shares $S_{0,fcr}(t)$ and $S_{0,fpp}(t)$, can be obtained that are invariant to the assumed values of K_{fcr} or K_{fpp}. This result arises because partial elasticities estimated from a regression model are invariant to the scales of the explanatory variables and K_{fcr} or K_{fpp} can be viewed as scale variables in our regression. The emphasis on elasticities is justified because the partial elasticities of the regression are the estimated value shares $S_{0,fcr}(t)$ and $S_{0,fpp}(t)$. To show this, we take the differential of equation (A-1) with respect to *fcr* and *fpp*:

$$dV_0(t)=\frac{K_C}{r}\,d\,c_0(t)+\frac{K_G}{r}\,d\,g_0(t)\quad\Leftrightarrow$$

(A-4) $$\frac{dV_0(t)}{V_0(t)}=\frac{\left(\frac{K_C\,c_0(t)}{r}\right)}{V_0(t)}\,\frac{d\,c_0(t)}{c_0(t)}+\frac{\left(\frac{K_C\,g_0(t)}{r}\right)}{V_0(t)}\,\frac{d\,g_0(t)}{g_0(t)}$$

Using Gardner's proportional change notation and our definition of land value shares we obtain:

(A-5) $$E(V_0(t)) = S_{0,C}(t)\;E(c_0(t)) + S_{0,G}(t)\;E(g_0(t))$$

Taking partial elasticities gives:

(A-12) $$\varepsilon_{V,C}=\frac{E(V_0(t))}{E(c_0(t))}=S_{0,C}(t)\quad and\quad \varepsilon_{V,G}=\frac{E(V_0(t))}{E(g_0(t))}=S_{0,G}(t)$$

Expressions (A-9) and (A-12) also imply that

(A-13) $S_{0,C}(t) + S_{0,G}(t) = \varepsilon_{V,C} + \varepsilon_{V,G} \leq 1$

The net result is that land value shares can also be interpreted as elasticities with respect to changes in land values. If we can estimate the partial elasticities of V(t) with respect to fcr(t) and fpp(t), the elasticities themselves become estimates of the land value shares generated by farm returns and farm program payments. Since elasticity estimates are unitless, we do not have to specify K_{fcr} and K_{fpp} a priori. Simulation results available from the authors, demonstrate that partial elasticities estimated for equation (5a) in the main text provide unbiased estimates of land value shares if land values are determined as the capitalized values of future expected net rental shares of crop receipts, government payments and non-farm income sources. The simulations also demonstrate that the elasticities approach to estimating land value shares does not require accurate *apriori* knowledge or assumptions with respect to the net land rental shares K.