

**Nature of Dynamic Relationships Between
Farm Real Estate Values
and Federal Farm Program Payments**

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Abstract

The objective of this study is to test the dynamic relationships among variables including farm real estate values, farm returns, farm program payments, and real interest rates in an income capitalization model. Our analysis is unique in multiple ways: (1) it covers the period beginning with the introduction of the first farm bill in 1933 through 2006; (2) assumes endogeneity of the variables, and (3) develops a dynamic modeling framework. Endogeneity is assumed among farm real estate values, farm program payments, and farm receipts since the direction of causality is unclear from a theoretical standpoint. Results indicate that policy makers are reactive rather than pro-active in making transfers to farmers. Once farm program payments are implemented, payments have positive impacts only in the short run on the value of farm real estate. However, considering endogeneity, the model suggests that it is possible that farm program payments have a lasting positive indirect impact (via farm returns) on the value of farm real estate.

JEL classification: Q18, H50; C32

Keywords: *Dynamics; Farm programs payments; Farm real estate values; Vector error correction model; U.S. data, 1933-2006.*

Nature of Dynamic Relationships between Farm Real Estate Values and Federal Farm Program Payments

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1. Introduction

Policy may be viewed as a guiding principle leading to a course of action pursued by the government. Specifically, agricultural policies have traditionally been driven by the instability of farm production, commodity prices and income. Due to these agricultural policies the U.S. government transfers large sums of money to the agricultural sector, relative to its importance as an industry in the general economy.¹ The most visible of those transfers are producer and landowner subsidies. Other public transfers include investments in research and development, and extension. In addition, investments in public infrastructure are presumed to increase the efficiency of agricultural production. Finally, individuals who receive income from agriculture benefit from a variety of tax features that result in a smaller personal tax burden than they would otherwise incur. While agricultural policies may be driven by the desire to stabilize farm production, prices, and income, the consequences of farm program payments on the structure of U.S. agriculture has often been a concern to economists (*e.g.*, Gardner, 1987, 1990, 1992; Hennessy, 1998; Sumner, 2003; Miljkovic, 2004; Miljkovic, Jin, and Paul, 2008). These agriculture policies stabilize farm income when the producer is faced with a shortfall in production by providing payments under commodity programs and other farm programs, disaster payments, and crop insurance².

Earlier studies (see the next section) have examined the effect of these farm program payments on farm real estate values. To summarize, these studies have analyzed farm real estate values to identify the principal factors explaining agricultural land values using cross-sectional or time-series data at the farm level or aggregate state or national level and concluded farm program payments are capitalized into the value of farm land. However, previous research examining the importance and effect of farm program payments on farm real estate values has two caveat. First, the extension of the model to include farm program payment faces identification issues introduced by the counter-cyclical or inverse relationship between farm receipts and farm program payments as indicated by Shaik, Atwood, and Helmers (2005) and Goodwin *et al.* (2003). Second, studies examining the importance of farm program payments in a static framework fail to address the short-run and long-run dynamics of farm program payments and other variables on farm real estate values.

Ideally, including additional variables is possible, and even desirable, when dealing with farm rather than national models. For instance, the impact of urban development on rural-urban fringes may be relevant for 3-4 percent of the total of agricultural land; similarly, alternative farm land uses (for recreation or hunting, for instance) is applicable to farms in certain regions. Yet the four variables identified in our research are the only variables with potential to impact all 932 million acres of farm land. In addition, it is unlikely that historical values for farm specific variables for the period of study are available.

The objective of this study is to test the dynamic relationships among farm real estate values, farm returns, farm program payments, and real interest rates in the income capitalization model using U.S. aggregate data. The analysis covers the period from the introduction of the first farm bill in 1933 through 2006. In this paper, we address the second caveat present in previous studies by assuming endogeneity of the farm real estate values, farm program payments, and farm receipts variables in a dynamic modeling framework.

In the next section, we review the literature addressing farm program payment impacts on farm real estate values. In the third section, we present the income capitalization model and its corresponding econometric vector autoregressive specification. U.S. data and pretesting of data and model are presented in the fourth section. Next, we present and discuss the empirical results. Finally, the conclusions and policy implications of the results are presented.

2. Earlier Literature on Farm Real Estate Values

Farm real estate is a measure of the value of all land and buildings on farms. Farm real estate is an important indicator of the financial condition of the farm sector and comprises approximately 85% of the asset portfolio of farm households (USDA, 2007b). In addition to being the largest single investment item in a typical farmer's portfolio, farm real estate is the principal source of collateral for farm loans, enabling farm operators to finance the purchase of additional farmland and equipment or to finance current operating expenses. Wide swings in farm real estate values alter the equity positions, creditworthiness, and borrowing capacity of those farm operators and landowners who hold large percentages of assets in the form of farmland.

Research on farm real assets, especially land values, was mainly geared towards examining the factors affecting land values in the 1980s and 1990s. These empirical analyses were based on income capitalization models and 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 farm land values increased rapidly during the late 1970s followed by a significant decline in values after 1981. Models developed to explain changes in the farm land values include income capitalization models (e.g., Alston, 1986; Burt, 1986), hedonic models (Palmquist and Danielson, 1989; Shonkwiler and Reynolds, 1986; and Xu, Mittelhammer, and Barkley, 1993), urban-rural expansion using non-farm factors (e.g., Shi *et al.*, 1997; Plantinga and Miller, 2001), and urban and environmental influences on land values (Freeman, 1974; Gardner and Barrows, 1985; and Miranowski and Hammes, 1984). Featherstone and Baker (1987) examined the simultaneous impact of farm real estate values, real interest rates, and farm returns using U.S. data from 1910 to 1985 in a vector autoregressive regression framework. Falk (1991), using value of land and difference between value of land and rents as endogenous variables, indicates farmland price and rent movements are highly correlated and the price movements are not consistent with the income capitalization model. He also argues the failure of farmland values to cointegrate with agricultural returns may be attributed to changes in the farm discount rate over time.

Previous studies rely on the income capitalization model in which farm factors affecting net returns are used in conjunction with other exogenous variables including real interest rates,

inflation, and rents (Just and Miranowski, 1993). More recent literature on farm land values focused on the effect of government payments on farm land values. In the last two decades studies of government payment impacts have also included those of specific crops and specific programs (Goodwin and Ortalo-Magne, 1992; and Vantreese *et al.*, 1989). Payments linked to program bases and the resulting impact on agricultural land values was examined by Duffy *et al.* (1994). The elimination of government payments and the resulting impact on agricultural land values was analyzed by Barnard *et al.* (2001). They used a cross-sectional examination by county of government payment effects on land values using the United States Department of Agriculture's 2000 Agricultural Resource Management Survey. Based on their analysis for eight U.S. agriculture production regions, eliminating government programs would reduce agricultural land values 12 to 69 percent. The overall positive impact of government payments in increasing agricultural land values was concluded by Weersink *et al.* (1999) and Gardner (1987) using county data. Goodwin *et al.* (2003) and Lence and Mishra (2003) also concluded the positive effect of government payments on cash rents.

Shaik, Helmers, and Atwood (2005) cited problems with earlier studies due to the identification issue introduced by the counter-cyclical nature of farm program payments and farm returns. The issue of identification is due to the use of farm program payments as an exogenous variable in the land value equation and also as an endogenous variable. To overcome the identification issue Shaik, Helmers, and Atwood (2005) analyzed the contribution of farm program payments and crop returns to agricultural land values with an empirical application to 48 U.S. states from 1940 to 2002 using a recursive-simultaneous equation model. Their conclusion indicates the contribution of farm program payments and crop receipts to agricultural land values were 30 and 70 percent, respectively. Furthermore, they found the contribution of farm program payments to land values has actually declined from a high of 30 to 40 percent during the 1938 to 1980 period to about 15 to 20 percent during subsequent farm bill periods. The results provide implications only at the aggregate U.S. level. Using data from 1938-2005, the positive contribution of farm program payments to farm real estate values was suggested by Shaik, Helmers, and Atwood (2006) and Shaik (2007) using regional data and employing four alternative panel estimators respectively.

To summarize, previous research examined the importance and effect of farm program payments in a static framework. To address the short-run and long-run dynamics of farm program payments and other variables of income capitalization model on farm real estate values we propose the use of vector autoregressive models.

3. Specification of Income Capitalization and Vector Autoregressive Model

A normative approach to examine the returns to an asset is to use an infinite life capitalization equation

$$(1) \quad V = A/r$$

where V is the present value of an asset, or in this case farm real estate value, A is the annual return, and r is the discount rate³ or in this case real interest rate. For the returns to an asset, A can be decomposed into the farm returns, x from the asset, and farm program payments z .

Extending the capitalization model to explicitly incorporate the individual components of annual returns - expected farm returns to assets and farm programs can be represented as

$$(2) \quad V = (x, z)/r$$

This model could be implemented in a static framework and thus, increases in A resulting from changes in farm returns and farm program payments, could be analyzed. This model assumes the exogeneity of farm return, farm program payments, and real interest rates, and examines their effects on farm real estate values. While land capitalization models typically ignore farm program payment endogeneity, microeconomic literature on policy evaluation or economic growth have long considered the biases introduced by policy endogeneity (*e.g.*, Rosenzweig and Wolpin, 1986; Rodrik, 2005). Standard solutions to the endogeneity problem are instrumental variable estimations or randomized trials. However, neither of these strategies is promising when we are concerned with the country-level impact of program payments due to economic policies (Rodrik, 2005). Farm program payments endogeneity requires an alternative modeling approach to interpret results of the income capitalization model defined in equation (2). For example, a significant increase in farm real estate values may change the amount and the direction of farm program payments to farmers. The dynamics of change in farm payments on the variables of the income capitalization model, as well as the impact of changing farm real estate values and farm receipts on farm program payments, cannot be captured in a static capitalization model.

Alternatively, we can examine the importance of farm returns, farm program payments, and real interest rates to farm real estate values in a vector autoregressive (VAR) process framework. VAR modeling has become popular due to its flexibility and it is a natural extension of the univariate autoregressive model to multivariate time series. The use of VAR in financial time series and forecasting, for example, is due to its ability to describe conditional and unconditional dynamic behavior. The VAR model can also be used for inference of farm program payment analysis based on the structural model, as in this case. In the structural analysis, unlike the VAR modeling, the causal impacts of expected or unexpected innovations or shift of variables cannot be examined. The vector autoregressive approach sidesteps the need for structural modeling by treating every endogenous variable in the system as a function of the lagged values of all of the endogenous variables in the system. Since income capitalization model theory employed offers an idea about variables that may be correlated, but tells us little about the appropriate lag structure and the direction of causality among variables, the use of the VAR model seems to be an inviting methodology to use in testing the income capitalization model.

The mathematical representation of a vector autoregressive model for equation (2) is:

$$\begin{aligned}
 V_t &= \alpha_1 + \sum_{i=1}^n \beta_{1i} V_{t-i} + \sum_{i=1}^n \gamma_{1i} r_{t-i} + \sum_{i=1}^n \delta_{1i} x_{t-i} + \sum_{i=1}^n \lambda_{1i} z_{t-i} + \varepsilon_{1t} \\
 x_t &= \alpha_2 + \sum_{i=1}^n \beta_{2i} V_{t-i} + \sum_{i=1}^n \gamma_{2i} r_{t-i} + \sum_{i=1}^n \delta_{2i} x_{t-i} + \sum_{i=1}^n \lambda_{2i} z_{t-i} + \varepsilon_{2t} \\
 z_t &= \alpha_3 + \sum_{i=1}^n \beta_{3i} V_{t-i} + \sum_{i=1}^n \gamma_{3i} r_{t-i} + \sum_{i=1}^n \delta_{3i} x_{t-i} + \sum_{i=1}^n \lambda_{3i} z_{t-i} + \varepsilon_{3t} \\
 r_t &= \alpha_4 + \sum_{i=1}^n \beta_{4i} V_{t-i} + \sum_{i=1}^n \gamma_{4i} r_{t-i} + \sum_{i=1}^n \delta_{4i} x_{t-i} + \sum_{i=1}^n \lambda_{4i} z_{t-i} + \varepsilon_{4t}
 \end{aligned}
 \tag{3}$$

where t is years; $i=1, \dots, n$ is the number of lags; β , γ , δ and λ are estimated parameters associated with farm real estate values, real interest rates, farm returns, and farm program payments respectively; and ε_1 , ε_2 , ε_3 and ε_4 are errors for each of the equations and innovation that may be contemporaneously correlated but are uncorrelated with their own lagged values and uncorrelated with all the right-hand side variables. Since only lagged values of endogenous variables appear on the right-hand side of the equations, simultaneity is not an issue and ordinary least square yields consistent estimates. Moreover, even though the innovations may be contemporaneously correlated, ordinary least square is efficient and equivalent to generalized least squares since all equations have identical regressors (Enders, 1995; Hamilton, 1994).

The vector autoregressive approach is appropriate if the time series under consideration are stationary. However, the analysis in levels is inappropriate with nonstationary series that are known to be cointegrated. The vector error correction (VEC) model is appropriate in this case because it has cointegration relations built into the specification so it restricts the long-run behavior of the endogenous variables to converge to their cointegrating relationships while allowing for short-run adjustment dynamics. The cointegration term is called the error correction term since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments. The VEC model in our case consists of a four variable system (V , x , z , and r) with one cointegrating equation (based on results of cointegration tests reported in the following section) and lagged difference terms:

$$\begin{aligned}
\Delta V_t &= \alpha_1 + \alpha_{1,0} (V_{t-1} - \delta x_{t-1} - \lambda z_{t-1} - \gamma r_{t-1}) \\
&\quad + \sum \alpha_{1,1}(i) \Delta V_{t-i} + \sum \alpha_{1,2}(i) \Delta x_{t-i} + \sum \alpha_{1,3}(i) \Delta z_{t-i} + \sum \alpha_{1,4}(i) \Delta r_{t-i} + \varepsilon_{1,t} \\
\Delta x_t &= \alpha_2 + \alpha_{2,0} (V_{t-1} - \delta x_{t-1} - \lambda z_{t-1} - \gamma r_{t-1}) \\
&\quad + \sum \alpha_{2,1}(i) \Delta V_{t-i} + \sum \alpha_{2,2}(i) \Delta x_{t-i} + \sum \alpha_{2,3}(i) \Delta z_{t-i} + \sum \alpha_{2,4}(i) \Delta r_{t-i} + \varepsilon_{2,t} \\
(4) \quad \Delta z_t &= \alpha_3 + \alpha_{3,0} (V_{t-1} - \delta x_{t-1} - \lambda z_{t-1} - \gamma r_{t-1}) \\
&\quad + \sum \alpha_{3,1}(i) \Delta V_{t-i} + \sum \alpha_{3,2}(i) \Delta x_{t-i} + \sum \alpha_{3,3}(i) \Delta z_{t-i} + \sum \alpha_{3,4}(i) \Delta r_{t-i} + \varepsilon_{3,t} \\
\Delta r_t &= \alpha_4 + \alpha_{4,0} (V_{t-1} - \delta x_{t-1} - \lambda z_{t-1} - \gamma r_{t-1}) \\
&\quad + \sum \alpha_{4,1}(i) \Delta V_{t-i} + \sum \alpha_{4,2}(i) \Delta x_{t-i} + \sum \alpha_{4,3}(i) \Delta z_{t-i} + \sum \alpha_{4,4}(i) \Delta r_{t-i} + \varepsilon_{4,t}
\end{aligned}$$

Again, $\varepsilon_{1,t}$, $\varepsilon_{2,t}$, $\varepsilon_{3,t}$, and $\varepsilon_{4,t}$ and all terms involving ΔV_{t-i} , Δx_{t-i} , Δz_{t-i} , and Δr_{t-i} are stationary. Thus, the linear combination of four variables $(V_{t-1} - \delta x_{t-1} - \lambda z_{t-1} - \gamma r_{t-1})$ must also be stationary. In this simple model the only right-hand side variable is the error correction term, and in long-run equilibrium this term is zero. However, if V , x , z , and r deviate from the long-run equilibrium, the error correction term will be nonzero and each variable adjusts to partially restore the equilibrium relation. Finally, the coefficient α_i measures the speed of adjustment of the i -th endogenous variable towards the equilibrium.

4. U.S. Data and Tests of Unit Roots and Cointegration

To be consistent with farm real estate values per acre, farm returns and farm program payments are standardized to a per acre basis using land in farms and converted into real 2000 dollars using the implicit gross domestic product price deflator. Land in farms is all land operated by farms and ranches during the year and includes crop and livestock acreage, wasteland, woodland, pasture, land in summer fallow, idle cropland, and land enrolled in the conservation reserve program, wetland reserve program, and other set aside or commodity acreage programs. Farm real estate is the value of all land and buildings on farms. Farm returns are the value of crop and livestock produced during the calendar year, not including any kind of farm program payments. Farm program payments include all program payments except disaster payments and crop insurance indemnities. Even though the crop insurance program was initiated in 1938, the importance in terms of payments can be observed with the major revisions introduction in 1980. Hence it was not included as part of farm program payments. 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. Data on farm receipts, farm program payments, farm real estate values, and interest rates are available from U.S. Department of Agriculture. Table 1 provides the summary statistics of the variables. The average value of farm real estate for the period 1933 to 2006 is \$743 per acre with a standard deviation of \$342. The average real interest rate for the same period is 3.6 percent. On average

U.S. agricultural producers produced \$173 per acre of gross farm receipts for the period, 1933 to 2006. The average farm program payment received by agriculture producers for the same period is \$8.30 with a standard deviation of \$6.20 per acre.

Table 1. Summary Statistics of the variables, 1933-2006

	Farm real estate values ¹	Real interest rates	Farm receipts ¹	Farm program payments ¹
Mean	742.7	3.6	172.9	8.3
Maximum	1,630.0	12.1	254.8	24.6
Minimum	301.5	-3.7	61.8	1.0
Std. Dev.	342.1	3.0	48.6	6.2

¹Data is available from <http://www.ers.usda.gov/Data/farmincome/finfidmu.htm>

The augmented Dickey-Fuller test (Dickey and Fuller, 1979) is used to test for the stationarity of farm real estate values, real interest rates, farm receipts, and farm program payments. We were unable to reject the null hypothesis of nonstationarity for farm receipts, farm real estate values, and real interest rates at either the 1% or 5% significance levels. However, the first differences of these variables are stationary, *i.e.*, the variables are I (1). Finally, the lag length for each of the time series was determined based on the Schwarz Information Criterion (SIC), and the optimal lag length is one for real interest rate and farm returns, and zero for farm program payments and farm real estate values for stationarity tests.

We next test for cointegration of all four variables. The Granger representation theorem (Enders, 1995) asserts that for any set of I (1) variables, error correction and cointegration are equivalent representations. After establishing that all four time series under consideration are I(1), we could pursue the cointegration analysis. The multivariate cointegration test (Johansen, 1991, 1995) was carried out with one lag in differences. Based on the results of both trace statistics and maximum eigenvalue statistics, we can conclude that the four variables are cointegrated with p-values being below 0.01 considering one cointegrating vector.

Given the presence of unit roots and variables being cointegrated, we proceed with the vector error correction estimation. According to Hall (1994), using only the model selection criteria to choose the optimal lag structure may not be the most appropriate way to proceed in vector error correction analysis due to the presence of the long-run adjustment parameters from the cointegration analysis. Hall suggested that a reasonable starting point be the maximum number of lags based on economic theory, prior expectations, or common sense. One may then decrease the number of lags by simultaneously considering the model selection criteria and maintaining the original rationale (*i.e.*, economic theory, prior expectations, or common sense) until the most satisfactory model is selected. Following this procedure, we started out with a lag

length of 5 in all equations to account for the typical duration of the farm bill. However, lags 3 through 5 were insignificant both separately and jointly and were therefore deleted, and the model with 2 lags was selected. The two lag model was also consistent with the lowest values of both SIC and the Akaike Information Criterion (AIC).

**Table 2. Unit Root and Unrestricted Cointegration Rank Tests
Based on First Differences, 1933-2006**

Variables	Lag length¹	Exogenous Variables	ADF Statistic	Prob.²
Farm real estate values I(1)	0	None	-2.559	0.011
Real interest rates I(1)	1	Constant	-6.237	0.000
Farm returns I(1)	1	Constant and trend	-6.761	0.000
Farm Program payment I(0)	0	Constant and trend	-3.525	0.044

Hypothesized No. of CE(s)	Eigenvalue	Trace / Max-Eigen Statistic	Critical Value (0.05)	Prob.⁴
Unrestricted Cointegration Rank Test (Trace)⁵				
None ³	0.4428	76.1201	63.8761	0.0033
At most 1	0.2274	34.0030	42.9153	0.2883
At most 2	0.1055	15.4250	25.8721	0.5394
At most 3	0.0977	7.40108	12.5180	0.3045
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)⁶				
None ³	0.4429	42.1170	32.1183	0.0022
At most 1	0.2274	18.5781	25.8232	0.3345
At most 2	0.1055	8.02392	19.3870	0.8194
At most 3	0.0977	7.40109	12.5180	0.3045

¹ Lag length was automatically selected based on SIC

² MacKinnon (1996) one-sided p-values

³ denotes rejection of the hypothesis at the 0.05 level

⁴ MacKinnon, Haug, and Michelis (1999) p-values

⁵ Trace test indicates 1 cointegrating equation(s) at the 0.05 level

⁶ Max-eigenvalue test indicates 1 cointegrating equation(s) at the 0.05 level

5. Results of Vector Autoregressive Income Capitalization Model

Before analyzing the short-run parameters from the vector error correction model, we test for long run relationships among the variables. Specifically, the variables are tested for weak exogeneity and speed of adjustment coefficients (Johansen and Juselius, 1994). With one cointegrating vector, the null hypothesis of weak exogeneity is $H_0: \alpha_{i1} = 0$, for all i , where i is, respectively, farm real estate values, farm returns, real interest rates, and farm program payments. The tests are distributed as chi-squared with 1 degree of freedom and are reported in Table 3. The null hypotheses of weak exogeneity are clearly rejected for farm real estate values, real interest rates, and farm program payments, while we cannot reject the null hypothesis that farm returns are weakly exogenous. Hence in the long run, farm returns determine farm real estate values and farm program payments.

Table 3. Weak Exogeneity Test of the Variables, 1933-2006

Variables	Farm Real Estate values	Farm Returns	Real Interest Rates	Farm Program Payments
Cointegration Restrictions	A (1,1) = 0	A (2,1) = 0	A (3,1) = 0	A (4,1) = 0
Number of iteration required to converge	10	9	22	12
LR test for binding restrictions (rank = 1)				
Chi-square(1)	5.15688	1.5837	17.19909	9.782888
Probability	0.023154	0.2082	0.000034	0.001761

Next, an application of the vector error correction model to examine the dynamics of farm real estate values is modeled for the period 1933 to 2006. Estimated coefficients from the vector error correction model are presented in Table 4.

Results from the farm real estate values equation indicate the one time lagged farm real estate value is positively affecting farm real estate values. In other words, an increase in the previous period's farm real estate values carries over to the current period. This outcome is consistent with earlier research (*e.g.*, Featherstone and Baker, 1987; Burt, 1986). Changes in the real interest rate do not impact, in statistical terms, the farm real estate values. This might be due to the dominating effect of the general economy monetary and fiscal variables on the changes in the real interest rates (Just and Miranowski, 1993). Parameter coefficients on farm returns and farm program payments indicate a positive and significant effect on farm real estate values. The positive sign indicates that higher farm returns are expected to increase farm real estate values.

Farm program payments had a positive influence on the value of farm real estate values, even though the primary intent of farm program payments was to provide stability of farm prices and incomes in times of adversity. This positive influence might be of consequence to the new

entrants to farming, and small and socially disadvantaged farmers who are faced with higher farm real estate values.

Table 4. Results of Vector Error Correction, 1933-2006

Error Correction	Farm Real Estate Values (V)	Farm Returns (x)	Real Interest Rates (r)	Farm Program Payments (z)
CointEq1	0.000375*	-0.000063	0.000016*	0.000046*
Diff (V (t-1))	0.5953*	0.0308	-0.0001	-0.0393*
Diff (V (t-2))	0.0186	-0.0250	-0.0057***	0.0124
Diff (x (t-1))	1.5364*	0.2488***	0.0015	-0.0583***
Diff (x (t-2))	0.2059	-0.3774*	0.0090	0.0893**
Diff (r (t-1))	-6.3671	-1.0386	0.5231*	0.0059
Diff (r (t-2))	0.3350	-1.3394	-0.2777*	-0.2176
Diff (z (t-1))	3.9313*	-0.1614	0.0947*	0.0789
Diff (z (t-2))	1.0713	-0.7230	0.0882**	0.2633***
Constant	2.6579	2.0699	-0.0337	0.4157
R-squared	0.6109	0.2133	0.5535	0.3667
Adj. R-squared	0.5535	0.0972	0.4876	0.2732
Sum sq. resids	79,802	9,097	43	564
S.E. equation	36.1694	12.2117	0.8424	3.0415
F-statistic	10.6436	1.8378	8.4028	3.9243
Log likelihood	-350.1	-273.0	-83.2	-174.3
Akaike AIC	10.1442	7.9725	2.6248	5.1925
Schwarz SC	10.4629	8.2912	2.9435	5.5111
Mean dependent	18.2417	2.0445	-0.0757	0.1196
S.D. dependent	54.1320	12.8525	1.1769	3.5677

Note: *, **, and *** indicate statistical significance at 1%, 5%, and 10% respectively.

Results from the farm returns equation indicate that past farm returns with positive parameter coefficients would lead to higher current farm returns from farming operations. Indeed, these are the only significant coefficients in the farm returns equation. Low explanatory value and only two significant coefficients in this equation come as no surprise since farm production decisions are excluded from this agricultural policy-political economy specification of the farm returns.

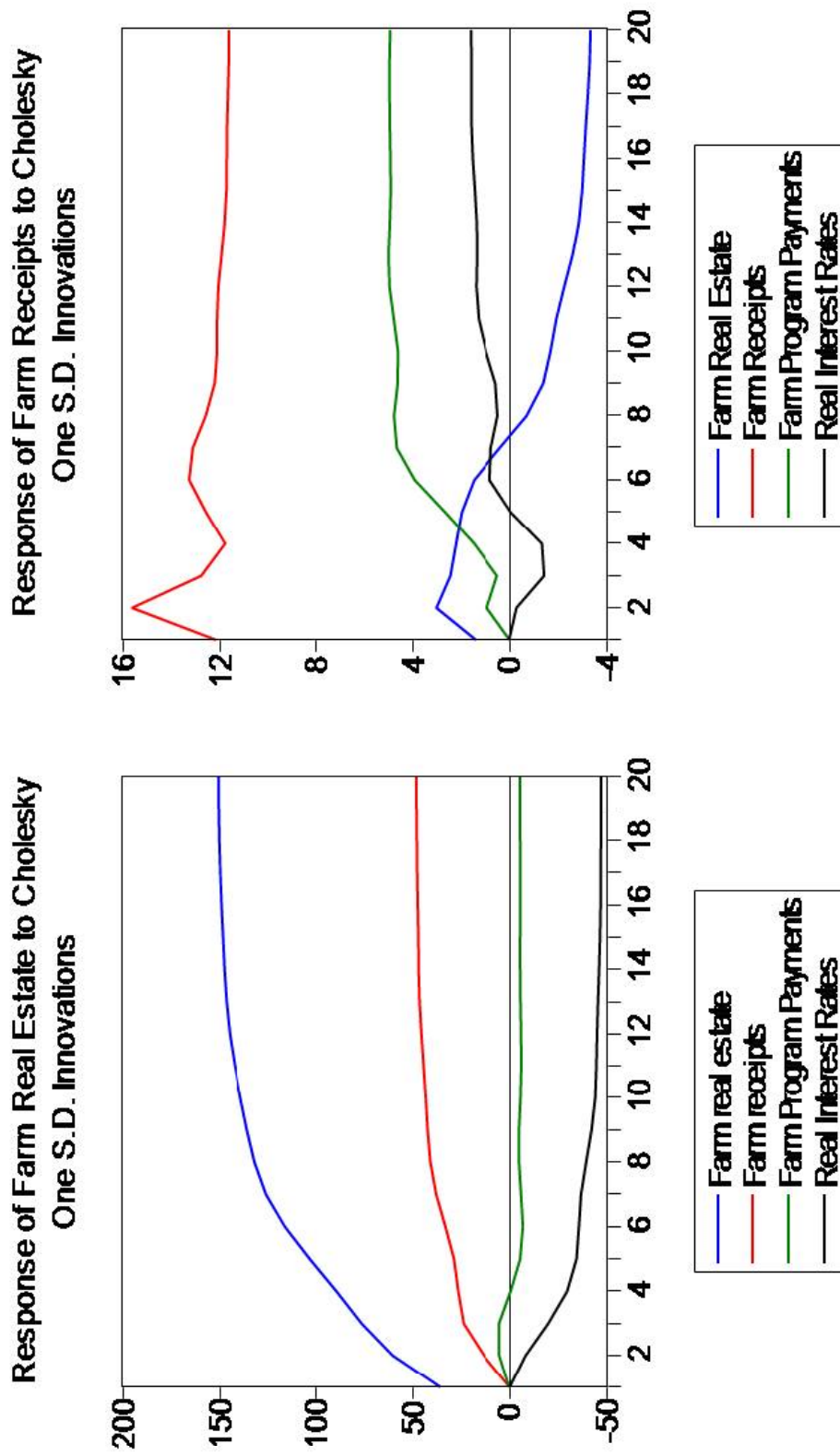
The farm program payment equation indicates the previous years' farm program payments are positively affecting current payments. First lagged values of farm real estate values and farm returns with negative parameter coefficients suggest that the declining value of

farm real estate values and lower returns from farming would lead to higher current farm program payments. The counter-cyclical nature of farm program payments and farm returns has been indicated by Shaik et al, 2005, in the static framework. This is consistent with intended agricultural policies used to stabilize farm prices and income. However, the positive parameter coefficient on the second lagged farm returns suggest higher farm returns would lead to higher current farm program payments. This positive coefficient of farm program payments may be self-perpetuating since the omnibus legislation covers multiple years.

Next, we determine how a shock to the i^{th} variable affects all the endogenous variables through the lag structure of the vector error correction model. As in traditional vector autoregressive analysis, Lutkepohl and Reimers (1992) showed that innovation accounting (*i.e.*, impulse responses) in vector error correction can be used to obtain information concerning the interactions among the variables. As a practical matter, the two innovations ε_{y_t} and ε_{z_t} may be contemporaneously correlated if y_t has a contemporaneous effect on z_t and/or z_t has a contemporaneous effect on y_t . In obtaining impulse response functions, Choleski decomposition is used to orthogonalize the innovations. The impulse responses are sensitive to the ordering of variables. Economic theory sometimes provides the rationale for the ordering. Usually, there is no such a priori knowledge and only intuition with respect to the research questions being addressed determine the ordering of variables.⁴ In this case however, the farm real estate capitalization model suggests the ordering of the variables as follows: farm real estate values, farm returns, farm program payments, and real interest rates. In other words, the effects of a shock in farm returns and farm program payments on farm real estate values are the issues of primary interest. The graphs in Figure 1 trace out the effects of one-unit shocks to all ε_s on the time paths of the farm real estate values, farm returns, farm program payments, and real interest rates sequences. We are most interested in the effects of one unit-shocks in $\varepsilon_{z,t}$, $\varepsilon_{x,t}$ and $\varepsilon_{r,t}$ on farm real estate values as well as in the effects of one unit-shocks in $\varepsilon_{V,t}$ and $\varepsilon_{x,t}$ on farm program payments.⁵ Results from the impulse response analysis are presented in Figure 1.

All impacts of the innovations are considered in a 20-year timeframe. The most significant finding is that an innovation or a shock to farm program payments has little or no impact on farm real estate values considering its long run equilibrium path. In other words, sudden changes in farm policy and farm program payments do not affect the long run equilibrium values of farm real estate values. This result indicates the existence of efficient markets where farm program payment policy disturbances do not have a lasting impact on farm real estate values. On the other hand, a shock to farm returns has a lasting, significant (in terms of its size), and increasing effect on farm real estate values. For example, as returns from farming experience a sudden increase due to implementation of new technology (*e.g.*, increased use of chemicals and capital in 1940s and 1950s, or use of genetically modified seeds in the 1990s and 2000s), the mean long run equilibrium farm real estate values increase over time relative to the equilibrium path based on the no-impact scenario. This finding is consistent with capitalization model assumptions of returns from farming activities impacting capitalized farm real estate values. Finally, a shock in real interest rates due to sudden changes in macroeconomic or monetary policy would lead to permanent changes in long run equilibrium of farm real estate values. Again, after an adjustment period farm real estate values would stabilize at the levels significantly above the original equilibrium path. Here we see more potent impacts of the farm program payment policy on farm sector real estate values than in the case of farm program

Figure 1. Impulse Response Functions to Cholesky One Standard Deviation Innovations



payments. The farm sector inevitably reacts to (independent) macro-economic policies set forth by the government, while farm program payments may be considered more of the policy makers' reaction to the situation and performance of the agricultural sector. This point is validated further as we analyze the impact of sudden change in farm returns and farm real estate values on the levels of government transfers to agriculture.

A sudden positive shock or change in farm returns for example, due to widespread application of new technology, leads to (permanently) lowered government transfers to agriculture after a short 1 to 2 year lag period. On the other hand, a shock in farm real estate values, for instance a sudden increase, leads to an initially swift response by the government as evidenced by significantly decreased farm program payments. However, government transfers exhibit a level of "stickiness" and increase over time, returning to the initial equilibrium path level. These results may indicate two things: (1) in a productive sector like agriculture, government transfers are reduced since it seems that policy makers recognize the sector's high level of performance; and, (2) farm real estate values may not be considered by the policy makers as the sector's performance indicators but as the sector's "health indicators," and farm program payments will be adjusted to the pre-shock equilibrium levels in order to maintain the sector's structure.

All of our analysis is based on the assumption of the endogeneity of the variables in the model. However, we also try to identify causal relationships. Using Granger causality tests (Granger, 1969; Hamilton, 1994) we conclude the following - one way Granger causality exists between the farm real estate values and the farm program payments. In other words, farm real estate values Granger cause the farm program payments while the opposite is not true. Second, one way Granger causality exists between the farm returns and the farm program payments. Again, farm returns Granger cause the farm program payments while the opposite does not hold. Finally, one way causality exists between the farm returns and the farm real estate values, *i.e.*, the farm returns Granger cause the farm real estate values while the opposite does not hold. We recognize how the explanatory power of these tests is low and conclusions based on them are weak. Yet, they may serve as a starting point if one is to better understand the dynamic (reactive) nature and reasons for policy actions.

6. Conclusions

In this paper we investigate the role of farm program payments and farm returns in altering farm real estate values. This research is unique in the sense it uses historical U.S. data from 1933-2006 to examine not only the overall effect but also the dynamics of farm program payments, farm receipts, real interest rates, and farm real estate values accounting for the endogeneity among the variables. The outcome of this research has important policy implications.

Our results indicate how policy makers are reactive rather than pro-active in their decision making to make the transfer to farmers. Granger causality tests suggest that farm returns and farm real estate values both Granger cause farm program payments while the opposite is not true. Weak exogeneity test results point to farm returns determining the behavior of other variables in the model, including farm program payments, in the long run. Our results

from the VEC analysis, where negative signs for both farm returns and farm real estate values in the farm program payments equation, suggest rational government that will lower its transfers as farm returns and farm real estate values increase. Moreover, once farm program payments are implemented, they have a positive impact only in the short run (one year). Based on impulse response function analysis, they do not have a lasting impact on farm real estate values. This seems to be perfectly reasonable: government intervention through farm program payments may be prompted with the motive of maintaining the income and life style of people in rural America, but the value of farm assets, including farm real estate values, is ultimately a function of market success of farm operations expressed through farm returns.

A significant increase in farm program payments, on the other hand, has a positive and lasting impact on farm returns. This also seems reasonable since an infusion of additional revenue may serve not only to bridge current liquidity problems but to modernize and more widely disseminate new technologies into the farm sector. This would clearly lead to the sector's increased revenue in the longer run. Considering endogeneity of the variables in the model suggests it is possible that farm program payments have a positive indirect impact (via farm returns) on farm real estate values.

The results point to the relatively positive impact government transfers have had on farm real estate values. However, the true beneficiaries of these policies may not have always been the intended recipients since millions of family farmers vanished from the scene in the seventy plus years since the inception of the first farm bill, as previously pointed out (USDA ERS, 2007a).

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Footnotes

¹ Miljkovic, Jin, and Paul (2008) indicate how direct government payments to farmers peaked in 2000 at approximately US\$ 23 billion. This number does not include any price support payments or export enhancement program payments. They suggest how successful agricultural lobbying is due to: (1) rent dissipation, as defined in Baldwin and Robert-Nicoud (2002), and (2) the inability for free riding in agriculture due to limited or no entry into the industry caused by asset (land) fixity (following the argument by Grossman and Helpman, 1994; 1996).

² Crop insurance program started in 1938 but did not catch up till 1980s and later in 1996 with increased subsidies. Unlike farm programs, farmers do incur a cost (of paying premium) to purchase crop insurance and receive indemnity if there is shortfall in production

³ Discount factor contains real interest rates and risk premia. However for this study we use only real interest rates due to the easy availability of the data for the historical period.

⁴ The very idea of imposing a structure on a vector autoregressive system seems contrary to the spirit of Sims' (1980, 1988) argument against "incredible identifying restriction." Unfortunately, there is no simple way to circumvent the problem; identification necessitates imposing some structure on the system. The Cholesky decomposition provides a minimal set of assumptions that can be used to identify the primitive model.

⁵ The impact of shocks in model variables on farm returns is interesting but it may not be very informative considering that farm returns are very dependent on productivity which is in turn influenced by changes in technology in the long run and farmers' production decisions in the short run (Jorgenson and Stiroh, 2000; Stiroh, 2002; Miljkovic, Jin, and Paul, 2008). Again, these variables are not of interest in our policy/political economy framework and as such are not included in it. However, the impulse response graphs for both farm returns and real interest rates are available from the authors per request.