Journal of Agricultural and Resource Economics 35(1):153–165

Dynamic Relationships Between Farm Real Estate Values and Federal Farm Program Payments

Saleem Shaik and Dragan Miljkovic

This study examines the dynamic relationships among farm real estate values, farm returns, farm program payments, and real interest rates in an income capitalization model. Endogeneity is assumed among the variables in a dynamic framework because the direction of causality is unclear from a theoretical standpoint. The analysis encompasses the period beginning with the introduction of the first farm bill in 1933 and ending in 2006. Results indicate farm program payments have positive direct impacts in the short run and positive indirect impacts (via farm returns) in the long run on farm real estate values.

Key words: dynamics, farm program payments, farm real estate values, U.S. data 1933–2006, vector error correction model

Introduction

Agricultural policies and farm program payments in the United States may be driven by a desire to stabilize or increase farm incomes, production, and agricultural prices, but these policies also have important consequences for the structure of U.S. agriculture (e.g., Gardner, 1987, 1990, 1992; Hennessy, 1998; Miljkovic, 2004; Miljkovic, Jin, and Paul, 2008; Shaik and Helmers, 2006; Sumner, 2003). The general structure of U.S. agricultural policies stabilizes farm income when producers experience production shortfalls by providing payments under commodity programs, disaster payments, crop insurance, and other farm programs.[1]

Using farm-level, state, or national data, some studies have concluded that farm program payments are capitalized into farm real estate values. However, previous research suffers from two limitations. First, models of farm program payment effects have not addressed identification issues between farm receipts and farm program payments (Shaik, Atwood, and Helmers, 2005; Goodwin, Mishra, and Ortalo-Magne, 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 traditional variables on farm real estate values.

Accordingly, the objective of this study is to examine the short-run and long-run dynamic relationships among farm real estate values, farm returns, farm program payments, and real interest rates employing vector autoregressive models (VARs) in conjunction with an income

---

Saleem Shaik is assistant professor and Dragan Miljkovic is professor, both in the Department of Agribusiness and Applied Economics, North Dakota State University, Fargo.

Review coordinated by George C. Davis.

[1] The subsidized federal crop insurance program began in 1938, and expanded in the 1980s and 1990s. Unlike farm programs, farmers pay a premium to purchase crop insurance, but the premium is heavily subsidized.

capitalization model using U.S. aggregate data.[2] The analysis covers the period from the introduction of the first farm bill in 1933 through 2006. We address endogeneity issues among farm real estate values, farm program payments, and farm receipts in a dynamic modeling framework.

Certainly, additional variables also affect regional or local farm land values. For example, the impacts of urban development on rural-urban fringes influence the value of 3%–4% of agricultural land. Similarly, alternative farm land uses (e.g., recreation or hunting) can influence farm land values in certain regions. However, the four variables identified in our research are the primary factors that impact most of the 932 million acres of U.S. farm land.

Review of Literature on Farm Real Estate Values

Previous research on farm real estate assets has generally focused on 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 farm land values include income capitalization models (e.g., Alston, 1986; Burt, 1986), hedonic models (Palmquist and Danielson, 1989; Shonkwiler and Reynolds, 1986; Xu, Mittelhammer, and Barkley, 1993), urban-rural expansion using nonfarm factors (e.g., Shi, Phipps, and Colyer, 1997; Plantinga and Miller, 2001), and urban and environmental influences on land values (Freeman, 1974; Gardner and Barrows, 1985; 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 1910–1985 in a vector autoregressive regression framework. Using land values and differences between value of land and rents as endogenous variables, Falk (1991) found that farm land price and rents are highly correlated. In addition, land price movements were found to be inconsistent with the income capitalization model. Falk also argued that farm land values were not cointegrated with agricultural returns because of changes in farm land discount rates over time.

Previous research relies 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). Recent literature on farm land values has focused on the effect of government payments. 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; Vantreese, Reed, and Skees, 1989). Payments linked to program bases and resulting impacts on agricultural land values were examined by Duffy et al. (1994). The effect of eliminating government payments on agricultural land values was analyzed by Barnard et al. (2001). Their county-level, cross-sectional examination of government payment effects on land values used data from the U.S. Department of Agriculture's 2000 Agricultural Resource Management Survey (ARMS). Based on their analysis of eight

[2] Our emphasis is on the total farm program payments, excluding crop insurance, disaster payments, and nonfarm variables for the United States. Data limitations associated with state-level crop insurance and disaster payments since 1933 prohibit a regional analysis.

U.S. agriculture production regions, eliminating government programs would reduce agricultural land values by 12% to 69%. Weersink et al. (1999) and Gardner (1987) found that government payments increased agricultural land values. Goodwin, Mishra, and Ortalo-Magne (2003) and Lence and Mishra (2003) concluded that government payments positively affected cash rents.

Shaik, Helmers, and Atwood (2005) noted that earlier studies may suffer from identification issues due to countercyclical farm program payments and farm returns. Identification problems occur because of the misuse of farm program payments as exogenous variables in land valuation models. To overcome this problem, the authors analyzed the contribution of farm program payments and crop returns to agricultural land values using a recursive-simultaneous equation model. They concluded that farm program payments and crop receipts represented 30% and 70% of agricultural land values, respectively.[3] Furthermore, they found that the contribution of farm program payments to land values declined from a high of 30%–40% during the 1938–1980 period to about 15%–20% in subsequent farm bill periods. Using regional data from 1938–2005, Shaik, Helmers, and Atwood (2006) found that farm program payments were directly related to farm real estate values. Shaik (2007) reported similar results using four alternative panel estimators.

Specification of Income Capitalization and Vector Autoregressive Model

To address the short-run and long-run dynamics of farm program payments and other variables on farm real estate values, we use a VAR procedure in conjunction with the income capitalization model. A standard approach to determining an asset's value is to use an infinite life capitalization equation:

$$V = A / r, \tag{1}$$

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 rate or, in this case, the real interest rate.[4] The returns to an asset can be decomposed into farm returns (x) generated by the asset and farm program payments (z). The capitalization model can be extended to explicitly incorporate individual components of expected farm returns and farm program payments as:

$$V = A(x, z) / r. \tag{2}$$

This model could be implemented in a static framework. However, such an approach usually assumes farm returns, farm program payments, and real interest rates are exogenous to farm real estate values. While land capitalization models typically ignore farm program payment endogeneity, the microeconomics literature on policy evaluation or economic growth has long considered biases introduced by policy endogeneity (e.g., Rosenzweig and

[3] The parameter coefficients or elasticities of the exogenous variables (when using logs) are the marginal effects, but one can infer this to be a contribution in terms of percentage after taking into account the expectation of the variables in a static framework. Shaik, Helmers, and Atwood (2005), in their appendix, have provided a detailed derivation showing why it is possible to provide the contribution of farm returns and farm program payments to land values in terms of percentages.

[4] The discount factor contains real interest rates and risk premia. For this study, however, we use only real interest rates due to the easy availability of the data for the historical period.

Wolpin, 1986; Rodrik, 2005). Standard solutions to endogeneity problems include instrumental variable estimation and randomized trials. Yet, neither of these strategies is useful when considering country-level impacts of farm program payments (Rodrik). The endogeneity of farm program payments requires an alternative modeling approach to the income capitalization model defined in equation (2). For example, a significant increase in farm real estate values may change the amount and direction of farm program payments. The dynamics of farm real estate values, farm returns, and farm program payments are captured by a static income capitalization model.

Alternatively, we can examine the importance of farm returns, farm program payments, and real interest rates on farm real estate values using vector autoregressive procedures. VAR models are a natural extension of univariate autoregressive models to multivariate time series. VAR models consider all endogenous variables in a system as functions of their lagged values. The income capitalization model provides some direction as to the correlation among variables. Such models, however, reveal little about appropriate lag structures and direction of causality among variables provided by VAR models.

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

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

where t is years; $i = 1, \ldots, n$ is the number of lags; β, γ, δ, and λ are estimated parameters associated with farm real estate values (V), real interest rates (r), farm returns (x), and farm program payments (z), respectively; and ε_1, ε_2, ε_3, and ε_4 are errors for each of the equations. The errors represent innovations that could be contemporaneously correlated, but uncorrelated with their own lagged values and all other right-hand-side variables. Since only lagged (exogenous) values of endogenous variables appear on the right-hand side of each equation, ordinary least squares estimation yields consistent estimates. Although innovations may be contemporaneously correlated, ordinary least squares estimates will be efficient because 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 for cointegrated nonstationary series. A vector error correction (VEC) model is appropriate in this case because the endogenous variables converge to a cointegrating relationship while allowing for short-run adjustment dynamics. The cointegration term is called the error correction term since deviations from long-run equilibrium are gradually corrected 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:

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

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 $(V_{t-1} - \delta x_{t-1} - \lambda z_{t-1} - \gamma r_{t-1})$ also must be stationary. In this model, the only right-hand-side variable is the error correction term which equals zero in long-run equilibrium. 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 equilibrium. Finally, the coefficient α_i measures the speed of adjustment of the *i*th endogenous variable toward equilibrium.

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

Farm returns and farm program payments are converted to a per acre basis using total farm acreage. The variables are then deflated using the gross domestic product implicit price deflator with 2000 as the base year. Annual total farm acreage represents all farm and ranch land including 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 value is measured by the value of all farm land and buildings. Farm receipts are the values of crop and livestock produced during a calendar year exclusive of farm program payments. Farm receipts are used as a proxy for farm returns because the correlation between the two variables is more than 90% (Shaik, Helmers, and Atwood, 2005). Farm program payments include all transfers except disaster payments and crop insurance indemnities.

The real interest rate is calculated by subtracting the rate of inflation (changes in the consumer price index) from the nominal interest rate collected from the Farm Credit System. Data on farm receipts, farm program payments, farm real estate values, and interest rates are available from the U.S. Department of Agriculture (USDA) (online at http://www.ers.usda.gov/Data/farmincome/finfidmu.htm). Table 1 provides summary statistics. The average value of farm real estate for the period 1933–2006 is $743 per acre with a standard deviation of $342. The mean real interest rate for the same period is 3.6%. On average, U.S. agricultural producers received $173 per acre of gross farm receipts for the same period. The average farm program payment was $8.30 per acre with a standard deviation of $6.20.

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

Table 1. Summary Statistics of the Variables, 1933–2006

Description	Farm Real Estate Values ($ / acre)	Real Interest Rates (%)	Farm Receipts ($ / acre)	Farm Program Payments ($ / acre)
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
Standard Deviation	342.1	3.0	48.6	6.2

Source: USDA data, available at http://www.ers.usda.gov/Data/farmincome/finfidmu.htm.

payments.[5] 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. Finally, the lag length for each of the time series was determined based on the Schwarz information criterion (SIC). The optimal lag length is one for real interest rate and farm returns, and zero for farm program payment and farm real estate values.

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), a cointegration analysis was conducted. 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 conclude that the four variables have one cointegrating vector with p-values less than 0.01 (table 2).

Given the presence of unit roots and cointegrating vectors, we proceed with the vector error correction estimation. Model selection criteria for selecting optimal lag structures may not be appropriate for error correction analyses because of long-run adjustments (Hall, 1994). Hall suggested that a reasonable starting point would 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 start with a lag length of 5 in all equations because this spans the duration of most farm bill legislation. However, lags 3–5 were insignificant both separately and jointly. A model using two lags was selected because it had the lowest SIC and Akaike information criterion (AIC) values.

Results of the Vector Autoregressive Income Capitalization Model

Before analyzing short-run parameter estimates 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 (Johansen and Juselius, 1994). With one cointegrating vector, the null hypothesis of weak exogeneity is H_0: $\alpha_{i,1} = 0$ for all i, where i

[5] Nonstationarity of real interest rates has been debated and rationalized by economists for decades. The true issue with the result is that it undermines the basis of the asset theory. Our result is consistent with most findings in the literature (e.g., Rose, 1988; Rapach and Weber, 2004), and we use it in subsequent analysis.

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

Variables	Lag Length [a]	Exogenous Variables	ADF Statistic	Probability [b]
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 Number of Cointegrating Equation(s)	Eigenvalue	Trace/ Max-Eigenvalue Statistic	Critical Value (0.05)	Probability [c]
Unrestricted Cointegration Rank Test (Trace) [d]				
None [e]	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	7.4011	12.5180	0.3045
Unrestricted Cointegration Rank Test (Maximum Eigenvalue) [f]				
None [e]	0.4429	42.1170	32.1183	0.0022
At most 1	0.2274	18.5781	25.8232	0.3345
At most 2	0.1055	8.0239	19.3870	0.8194
At most 3	0.0977	7.4011	12.5180	0.3045

[a] Lag length was automatically selected based on SIC.
[b] MacKinnon (1996) one-sided *p*-values.
[c] MacKinnon, Haug, and Michelis (1999) *p*-values.
[d] Trace test indicates 1 cointegrating equation(s) at the 0.05 level.
[e] Denotes rejection of the hypothesis at the 0.05 level.
[f] Max-eigenvalue test indicates 1 cointegrating equation(s) at the 0.05 level.

represents farm real estate values, farm returns, real interest rates, and farm program payments. The tests are distributed as chi-squared with one 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.

The vector error correction model is used to examine the dynamics of farm real estate values for the period 1933–2006. Estimated coefficients from the vector error correction model are presented in table 4.

Results indicate that lagged farm real estate values positively affect contemporaneous farm real estate values. This outcome is consistent with earlier research (e.g., Featherstone and Baker, 1987; Burt, 1986). Changes in real interest rates do not impact farm real estate values. Parameter estimates on farm returns and farm program payments show a positive and significant effect on farm real estate values. Thus, higher farm returns are expected to increase farm real estate values.

Farm program payments had a positive influence on farm real estate values even though the primary intent of farm program payments is to stabilize farm prices and incomes. This positive influence might be of consequence to new entrants to farming, and small and socially disadvantaged farmers who face higher farm real estate values.

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

Description	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
No. of iterations required to converge	10	9	22	12
LR test for binding restrictions (rank = 1)				
$\chi^2_{[1]}$	5.15688	1.5837	17.19909	9.78289
Probability	0.02315	0.2082	0.00003	0.00176

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)
Cointegration equation (1)	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^2	0.6109	0.2133	0.5535	0.3667
Adjusted R^2	0.5535	0.0972	0.4876	0.2732
Sum of squared residuals	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 information criterion	10.1442	7.9725	2.6248	5.1925
Schwarz information criterion	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: Single, double, and triple asterisks (*,**,***) denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Results from the farm returns equation indicate that lagged farm returns lead to higher current farm returns. The low explanatory power of this equation probably reflects the exclusion of farm inputs in the models.

The farm program payment equation indicates that lagged farm program payments positively affect current payments. In addition, declining farm real estate values and lower farm returns lead to higher contemporaneous farm program payments. The countercyclical nature of farm program payments and farm returns has been suggested within static frameworks by Shaik, Atwood, and Helmers (2005) and is consistent with policies that stabilize farm prices and income. However, the positive coefficient estimate on the second lagged farm returns variable suggests higher farm returns would lead to higher current farm program payments. This positive coefficient of farm program payments may be self-perpetuating since legislation often covers multiple years.

Impulse Response Functions

We examine 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 variable interactions. As a practical matter, the two innovations $\varepsilon_{y,t}$ and $\varepsilon_{z,t}$ 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, Cholesky decomposition is used to orthogonalize the innovations.

Impulse responses are sensitive to the ordering of variables. Economic theory can sometimes assist in this ordering.[6] In this case, the farm income capitalization model suggests that variables be ordered as (*a*) farm real estate values, (*b*) farm returns, (*c*) farm program payments, and (*d*) real interest rates. This ordering reflects our desire to evaluate effects of shocks to farm returns and farm program payments on farm real estate values. Figure 1 traces the effects of one-unit shocks to all ε's on the time paths of farm real estate values, farm returns, farm program payments, and real interest rates. We are interested in the effects of one-unit shocks in $\varepsilon_{z,t}$, $\varepsilon_{x,t}$, and $\varepsilon_{r,t}$ on farm real estate values and of one unit-shocks in $\varepsilon_{V,t}$ and $\varepsilon_{x,t}$ on farm program payments.[7]

All innovations are considered over a 20-year time frame. The most significant finding is that an innovation or shock to farm program payments has little impact on the long-run equilibrium path of farm real estate values. Specifically, changes in farm program payments do not affect the long-run equilibrium of farm real estate values. On the other hand, an increase in farm returns has a lasting, positive impact on farm real estate values. For example, if farm returns increase because of new technology (e.g., increased use of chemicals and capital in the 1940s and 1950s, or use of genetically modified seeds in the 1990s and 2000s), long-run farm real estate values increase over time relative to the equilibrium path based on the no-impact scenario. This finding is consistent with the capitalization model assumption that returns from farming activities are capitalized into farm real estate values.

Finally, a shock in real interest rates due to changes in macroeconomic or monetary policy leads to permanent changes in long-run farm real estate values. Again, after an adjustment period, farm real estate values stabilize at levels significantly above the original equilibrium path. Farm real estate values react to (independent) macroeconomic factors, while farm program payments may reflect policy makers' reaction to low farm returns. A positive shock or change in farm returns leads to (permanently) lower government transfers to agriculture after a one- to two-year lag. On the other hand, a positive shock in farm real estate values leads to a swift response by government as evidenced by decreased farm program payments. However, government transfers exhibit a level of "stickiness" and increase over time, returning to the initial equilibrium path level.

---

[6] 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.

[7] While the impact of shocks in model variables on farm returns is interesting, it may not be very informative considering that farm returns are very dependent on productivity. This, in turn, is 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 here. However, the impulse response graphs for both farm returns and real interest rates are available from the authors upon request.

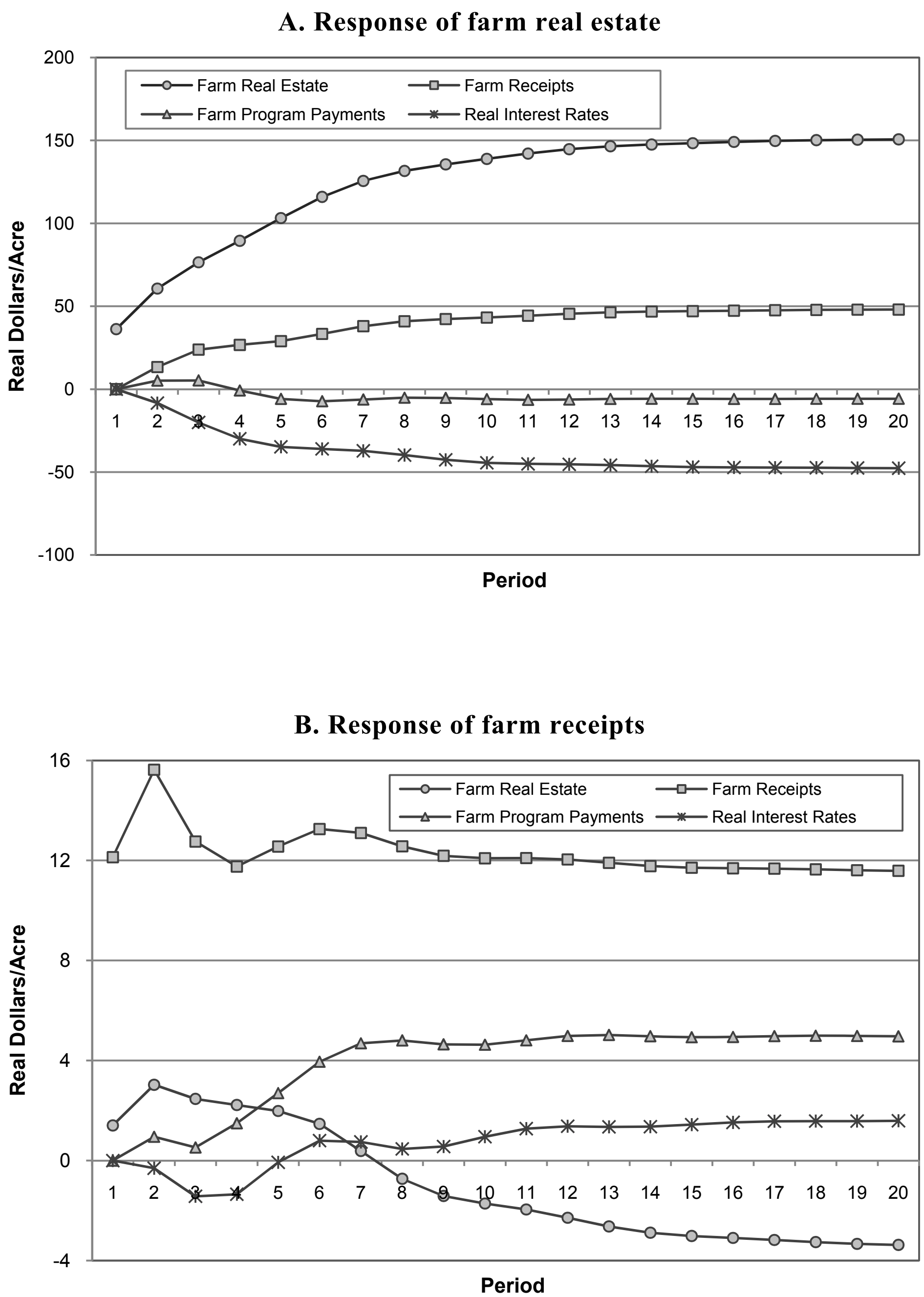

Figure 1. Impulse response functions to Cholesky one standard deviation innovations

These results reveal three findings: (*a*) policy makers reduce government transfers when production agriculture is financially healthy, (*b*) farm real estate values may not be used by policy makers as a measure of the sector's financial health, and (*c*) farm program payments adjust to pre-shock equilibrium levels.

Conclusions

We investigate the role of farm program payments and farm returns on farm real estate values. This research uses historical U.S. data from 1933–2006 to examine the dynamics of farm program payments, farm returns, real interest rates, and farm real estate values while accounting for endogeneity.

Our results reveal that policy makers are reactive, rather than proactive, in deciding to transfer income to farmers. Granger causality tests suggest that farm returns and farm real estate values Granger-cause farm program payments, while the opposite is not true. Exogeneity tests indicate that farm returns determine the long-run behavior of the other variables in the model.

Results from our VEC analysis show that farm returns have a negative effect on farm real estate values. Thus, one would expect government transfers to decline as farm returns and farm real estate values increase. Moreover, once farm program payments are implemented, they have positive impacts only in the short run (one year). Based on impulse response functions, program payments do not have a lasting impact on farm real estate values. Perhaps this finding is reasonable if policy makers intend to maintain incomes and lifestyles of rural Americans. However, farm real estate values are ultimately a function of farm returns. This result is consistent with the Lucas critique, which argues that traditional methods of policy evaluation do not adequately account for the impact of policy on expectations (Lucas, 1976). In this context, our results are in keeping with rational expectations that a government transfer in one year will likely be followed by similar payments in subsequent periods. Therefore, a payment in one year will have only a short-term impact on farm land value.

In contrast, a significant increase in farm program payments has a positive and lasting impact on farm returns. This finding also appears reasonable since an infusion of additional revenue may serve not only to bridge current liquidity problems, but also to modernize and adopt new technologies. This would lead to increased revenues in the long run. Finally, farm program payments have a positive indirect impact (via farm returns) on farm real estate values.

[*Received September 2009; final revision received February 2010.*]

References

Alston, J. M. "An Analysis of Growth of U.S. Farmland Prices, 1963–82." *Amer. J. Agr. Econ.* 68,1(1986): 1–9.

Barnard, C., R. Nehring, J. Ryan, and R. Collender. "Higher Cropland Value from Farm Program Payments: Who Gains?" *Agr. Outlook* (USDA) (November 2001):26–30.

Burt, O. R. "Econometric Modeling of the Capitalization Formula for Farmland Prices." *Amer. J. Agr. Econ.* 68,1(1986):10–26.

Dickey, D. A., and W. A. Fuller. "Distribution of the Estimators for Autoregressive Time Series with a Unit Root." *J. Amer. Statis. Assoc.* 74(1979):427–431.

Duffy, P. A., C. R. Taylor, D. L. Casin, and G. J. Young. "The Economic Value of Farm Program Base." *Land Econ.* 70,2(1994):318–329.

Enders, W. *Applied Econometric Time Series*. New York: John Wiley and Sons, Inc., 1995.

Falk, B. "Formally Testing the Present Value Model of Farmland Prices." *Amer. J. Agr. Econ.* 73(1991): 1–10.

Featherstone, A. M., and T. G. Baker. "An Examination of Farm Sector Real Asset Dynamics, 1910–1985." *Amer. J. Agr. Econ.* 69,3(1987):532–546.

Freeman, A. M. "On Estimating Air Pollution Control Benefits from Land Value Studies." *J. Environ. Econ. and Mgmt.* 1,1(1974):74–83.

Gardner, B. L. "Causes of Farm Commodity Programs." *J. Polit. Econ.* 95,2(1987):290–310.

———. *The Economics of Agricultural Policies*. New York: McGraw-Hill Publishing Co., 1990.

———. "Changing Economic Perspectives on the Farm Problem." *J. Econ. Lit.* 30,1(1992):62–101.

Gardner, K., and R. Barrows. "The Impact of Soil Investments on Land Prices." *Amer. J. Agr. Econ.* 67,5(1985):943–947.

Goodwin, B. K., A. K. Mishra, and F. N. Ortalo-Magne. "What's Wrong with Our Models of Agricultural Land Values?" *Amer. J. Agr. Econ.* 85,3(2003):744–752.

Goodwin, B. K., and F. N. Ortalo-Magne. "The Capitalization of Wheat Subsidies into Agricultural Land Values." *Can. J. Agr. Econ.* 40,1(1992):37–54.

Hall, A. R. "Testing for a Unit Root with Pretest Data-Based Model Selection." *J. Bus. and Econ. Statis.* 12,3(1994):461–470.

Hennessy, D. A. "The Production Effects of Agricultural Income Support Policies Under Uncertainty." *Amer. J. Agr. Econ.* 80,1(1998):46–57.

Johansen, S. "Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models." *Econometrica* 59,6(1991):1551–1580.

———. *Likelihood-Based Inference in Cointegrated Vector Autoregressive Models*. London: Oxford University Press, 1995.

Johansen, S., and K. Juselius. "Identification of the Long-Run and the Short-Run Structure: An Application to the IS-LM Model." *J. Econometrics* 63,1(1994):7–36.

Jorgenson, D. W., and K. J. Stiroh. "Raising the Speed Limit: U.S. Economic Growth in the Information Age." *Brookings Papers on Economic Activity* 1(2000):125–235.

Just, R. E., and J. A. Miranowski. "Understanding Farmland Price Changes." *Amer. J. Agr. Econ.* 75,1(1993): 156–168.

Lence, S. H., and A. K. Mishra. "The Impacts of Different Farm Programs on Cash Rents." *Amer. J. Agr. Econ.* 85,3(2003):753–761.

Lucas, R. E., Jr. "Econometric Policy Evaluation: A Critique." In proceedings, *Carnegie Rochester Conference on Public Policy 1* (pp. 19–46). Amsterdam: North-Holland Publishing Co., 1976.

Lutkepohl, H., and H. E. Reimers. "Impulse Response Analysis of Cointegrated Systems." *J. Econ. Dynamics and Control* 16,1(1992):53–78.

MacKinnon, J. G. "Numerical Distribution Functions for Unit Root and Cointegration Tests." *J. Appl. Econometrics* 11,6(1996):601–618.

MacKinnon, J. G., A. A. Haug, and L. Michelis. "Numerical Distribution Functions of Likelihood Ratio Tests for Cointegration." *J. Appl. Econometrics* 14,5(1999):563–577.

Miljkovic, D. "Agricultural Trade, Commodity Programs, and Income Protection in the United States." *J. Policy Modeling* 26,1(2004):41–46.

Miljkovic, D., H. Jin, and R. Paul. "The Role of Productivity Growth and Farmers' Income Protection Policies in the Decline of Relative Farm Prices in the United States." *J. Policy Modeling* 30,5(2008): 873–885.

Miranowski, J. A., and B. D. Hammes. "Implicit Prices of Soil Characteristics for Farmland in Iowa." *Amer. J. Agr. Econ.* 66,5(1984):745–749.

Palmquist, R. B., and L. E. Danielson. "A Hedonic Study of the Effects of Erosion Control and Drainage on Farmland Values." *Amer. J. Agr. Econ.* 71,5(1989):943–946.

Plantinga, A. J., and D. J. Miller. "Agricultural Land Values and the Value of Rights to Future Land Development." *Land Econ.* 77,1(2001):56–67.

Rapach, D. E., and C. E. Weber. "Are Real Interest Rates Really Nonstationary? New Evidence from Tests with Good Size and Power." *J. Macroeconomics* 26,3(2004):409–430.

Rodrik, D. "Why We Learn Nothing from Regressing Economic Growth on Policies." Work. paper, Harvard University, 2005. Online. Available at http://www.hks.harvard.edu/fs/drodrik/Research%20papers/policy%20regressions.pdf [Accessed January 2008.]

Rose, A. K. "Is the Real Interest Rate Stable?" *J. Finance* 43,5(1988):1095–1112.

Rosenzweig, M. R., and K. I. Wolpin. "Evaluating the Effects of Optimally Distributed Public Programs: Child Health and Family Planning Interventions." *Amer. Econ. Rev.* 76,3(1986):470–482.

Shaik, S. "Farm Programs and Land Values in Mountain States: Alternative Panel Estimators." Selected paper presented at WAEA annual meetings, Portland, OR, 29 July–1 August 2007.

Shaik, S., J. A. Atwood, and G. A. Helmers. "The Evolution of Farm Programs and Their Contribution to Agricultural Land Values." *Amer. J. Agr. Econ.* 87,5(2005):1190–1197.

Shaik, S., and G. A. Helmers. "An examination of Farm Program Payments on Farm Economic Structure." Selected paper presented at SAEA annual meetings, Long Beach, CA, 23–26 July 2006.

Shaik, S., G. A. Helmers, and J. A. Atwood. "Government Payments and Agricultural Land Values." Staff Rep. No. 2005-02, Dept. of Agr. Econ., Mississippi State University, February 2005.

———. "Farm Program and Agriculture Land Values: The Case of Southern Agriculture." Selected paper presented at SAEA annual meetings, Orlando, FL, 5–8 February 2006.

Shi, Y. J., T. T. Phipps, and D. Colyer. "Agricultural Land Values Under Urbanizing Influences." *Land Econ.* 73,1(1997):90–100.

Shonkwiler, J. S., and J. E. Reynolds. "A Note on the Use of Hedonic Price Models in the Analysis of Land Prices at the Urban Fringe." *Land Econ.* 62,1(1986):58–63.

Sims, C. "Macroeconomics and Reality." *Econometrica* 48,1(1980):1–49.

———. "Bayesian Skepticism on Unit Root Econometrics." *J. Econ. Dynamics and Control* 12,2(1988): 463–474.

Stiroh, K. J. "Information Technology and the U.S. Productivity Revival: What Do the Industry Data Say?" *Amer. Econ. Rev.* 92,5(2002):1559–1576.

Sumner, D. A. "Implications of the U.S. Farm Bill of 2002 for Agricultural Trade and Trade Negotiations." *Austral. J. Agr. and Resour. Econ.* 47,1(2003):99–122.

Vantreese, V. L., M. R. Reed, and J. R. Skees. "Production Controls and Asset Values." *Amer. J. Agr. Econ.* 71,2(1989):319–325.

Weersink, A., S. Clark, C. G. Turvey, and R. Sarker. "The Effect of Agricultural Policy on Farmland Values." *Land Econ.* 75,3(1999):425–439.

Xu, F., R. C. Mittelhammer, and P. W. Barkley. "Measuring the Contributions of Site Characteristics to the Value of Agricultural Land." *Land Econ.* 69,3(1993):356–369.