Monetary Policies, Interest Rates, and U.S. Agriculture: An Economic Simulation Analysis

S. Devadoss and William H. Meyers

Working Paper 86-WP 5
June 1986

In the agricultural economics literature, relatively little attention has been given to the effects of interest rates on the U.S. farm sector. According to macroeconomic theory, monetary policy influences the interest rate. Changes in the interest rate will have an effect on a farmer's decision to borrow credit and thus on farm production and inventory decisions. Economists believe that the recent farm financial crisis was caused by higher interest rates, which were the result of a tight monetary policy pursued by the Federal Reserve authorities. This study investigates the effect of changes in U.S. monetary policies on supply, demand, and prices of farm products through the interest rate linkages between the macroeconomy and the farm sector.

Importance of Monetary Policies and the Interest Rates to U.S. Agriculture

Recent studies by Shei (1978), Chambers and Just (1982), Barnett et al. (1981), Starleaf (1982), Chambers (1984), and Devadoss et al. (1985) examined the impact of U.S. monetary policies on the aggregate farm sector variables. The general conclusion of these studies is that an expansionary monetary policy favors the agricultural sector, which in turn leads to an increase in the farm exports, prices, and incomes. On the other hand, a tight monetary policy has a substantial adverse effect on the farm economy. This study specifically examines the effects of changes in monetary policies through the interest rate on the farm sector.

If the government conducts a contractionary monetary policy (i.e., reduces the money supply, which will increase the interest rate), the farm sector can be affected in two ways. First, a higher interest rate will increase the cost of borrowing (for production loans) which in turn raises the cost of production and thereby eventually reduces the farm supply. This declining effect of farm supply because of the increase in the interest rate is termed cost effect. At the same time, the higher interest rate will raise the storage cost of commodity reserves and cause farmers to reduce inventories, thereby decreasing the demand for stock inventories. This decline in stocks because of the higher interest rate is termed stock effect.

There have been no empirical studies which address the effect of interest rates on farm demand and supply. However, the importance of the changes in the domestic interest rate and its implications on the farm sector were emphasized by Schuh et al. (1980), Chambers (1983, 1984), and Freebairn et al. (1982).

The Model Structure

The econometric model that was developed to empirically analyze the effect of changes in monetary policies on the farm sector through the interest rate has a general equilibrium (see Figure 1). The model is divided into a farm block and a macro block. The farm block of the model consists of a crop sector and a livestock sector. The crop sector is described by crop supply, demand, inventory, export, input demand relationships, and an equilibrium condition. Crop price, output, and income are endogenously determined in the endogenously determined in the crop sector part of the model. The livestock sector includes supply of and demand for livestock products, feed demand, and market clearing conditions. Because of restrictive U.S. trade policies against the importation of livestock products (usually through import quotas), livestock imports are assumed to be exogenously determined. Livestock price, output, and income are endogenously determined in the livestock sector. Total farm income is derived from the crop and livestock incomes.

The macro block is divided into the goods market, money market, and foreign exchange market. The goods market contains output supply, consumption demand, export demand, and an equilibrium condition. The money market, from which the interest rate linkage originates, is the catalytic section of the entire model. The monetary sector consists of money demand and supply functions and a money market equilibrium equation. The foreign exchange market includes the balance of payments identity, international capital flows, and an exchange rate equation to determine the exchange rate endogenously.

The interest rate linkage between the macro sector and farm sector can be better understood with the help of Figure 1, in which the important endogenous equations in the model are schematically summarized. Changes in monetary policies influence the interest rate which feeds into the crop supply, stock demand, and livestock supply decisions. Crop price, output, and thus crop income are determined endogenously from the crop sector. Similarly, in the livestock sector, livestock product price, output, and thus livestock income are endogenously determined. The sum of crop and livestock incomes form the total farm income.

Simulation Analysis

This section consists of a discussion of the estimation and simulation techniques, and results. The mathematical structure of the model that corresponds to Figure 1 is nonlinear. In general, fundamental identities, as well as many other basic variables (e.g., relative prices), form ratios that render the model nonlinear. Moreover, a simultaneous system with autocorrelated error terms can lead to a nonlinear system (see Judge et al. 1982). In view of the nonlinear nature of the model, a nonlinear three-stage least square procedure (N3SLS) was used for the final estimation of the model. The computer program used for the estimation is SYSNLIN of SAS/ETS (SAS, 1982).

The N3SLS estimation procedure is a straight forward generalization of the linear, three-stage least squares estimator. Gallant (1977) describes the simultaneous system consisting of M nonlinear equations as

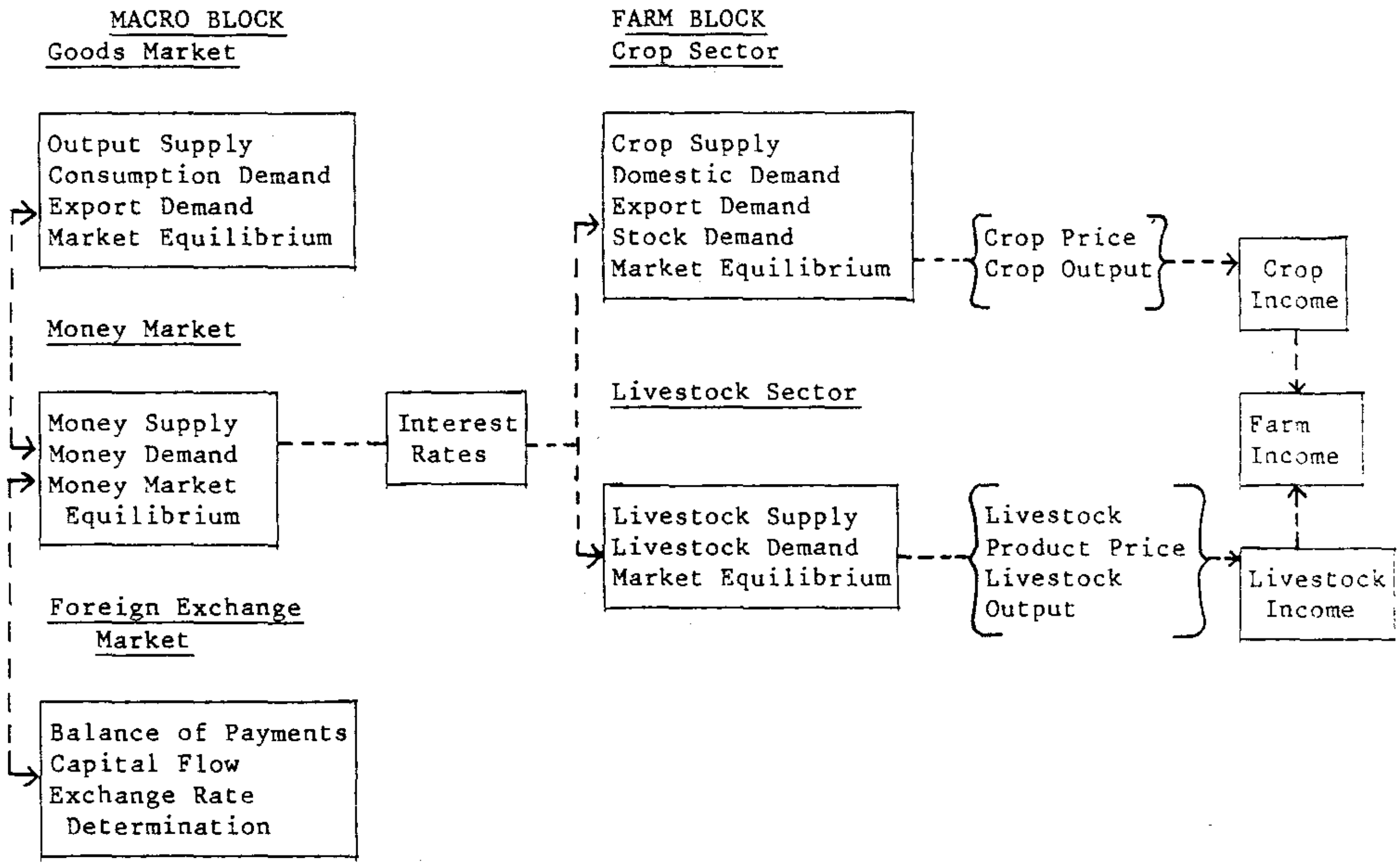

Figure 1. General equilibrium structure of the econometric model

$$(1) \qquad q_\alpha(Y_t, X_t, \theta_\alpha^*) = e_{\alpha t}, \ \alpha = 1,2,\ldots,M; \ t = 1,2,\ldots,n,$$

where Y is an M by 1 vector of endogenous variables, X is a k by 1 vector exogenous variables, in the compact space

$$(2) \qquad e_{\alpha t} = (e_{1t}, e_{2t}, \ldots, e_{Mt})'$$

is the tM by 1 vector of residuals for the M endogenous variables stacked together. The N3SLS procedure estimates the parameters by minimizing the generalized sum of squares of the residuals.

The sample period of the study is from 1951 to 1982. The model contains 33 equations and 26 endogenous variables. The estimated equations are not reported because of space limitation. The estimated coefficients have good statistical properties. In particular, all the coefficients related to the interest rate linkages are consistent with a priori expectations, and most of them are significant.

The model has been validated to test the overall ability of the model to replicate the observed values of the endogenous variables, and also to test the stability of the model. In the validation run, the structural form of the model is dynamically simulated over the entire study period. The simulation procedure is dynamic in the sense that solved values are used for lagged values of endogenous variables rather than the actual values for those variables. A dynamic simulation seems preferable to static simulation since it allows the researcher to study the evolutionary character of the model overtime.

As the model is nonlinear, a nonlinear simulation procedure, SIMNLIN from SAS/ETS (SAS 1982), is used to solve the model. The Gauss-Seidel solution method is used for the validation run and also for the simulations. Some of the standard criteria that are often used in evaluating a simulation model are (see Pindyck and Rubenfeld, 1981, for further details on evaluating the simulation model) root mean square error (RMSE), root mean square percent error (RMSPE), Theil's inequality coefficients (U) and turning point method. The Theil inequality coefficient can be decomposed into three different components: bias (U^m), regression (U^s), and disturbance (U^c) proportions. The perfect correlation of simulated values with actual values would imply the ideal distribution of inequality over the three sources as $U^m = U^s = 0$, and $U^c = 1$. RMSE, RMSPE, and the number of turning points missed should be small for better prediction of actual values. Table 1 presents RMSPE and Theil's forecast statistics for important endogenous variables in the model. The values of RMSPE and Theil's forecast statistics suggest that the model does an excellent job of depicting the behavior of the endogenous variables. The model appears to provide a good foundation upon which to base further empirical research.

To examine the effect of U.S. monetary policy on the farm economy through the interest rate, it is assumed that the monetary authority decreases the money supply growth rate by an additional 3 percent in every year from 1972 to 1982. This sustained decrease in the money supply growth rate will have compounding effects, i.e., the consequent changes in the endogenous variables in any period will include the dynamic effects of the decrease in the money supply of all previous periods. Table 2 reports in percentage terms the dynamic multipliers associated with the decrease in the U.S. money supply.

The simulation results support the hypothesis that contractionary monetary policy will increase the domestic interest rate and decrease the general price level and disposable income. Crop and livestock product supply then declines because of the higher interest rate. The higher interest rate also reduces crop inventories. Furthermore, the tight monetary policy has a depressing effect on crop and livestock product price indexes.

Conclusions

In light of the recent farm crisis, the interest rate linkage between the general economy and farm sector is very important. Higher interest rates would increase farm cash flow problems. The cash costs of production for those farmers who borrow heavily would be increased. A large econometric model has been developed to analyze this interest rate linkage. N3SLS is used to estimate the model. Empirical results are derived from the simulation analysis. Results indicate that a 3 percent decrease in money supply growth has a significant impact on the farm sector through higher interest rates.

Abstract of Paper

A large econometric model is developed to capture the economic relationship among the crop, livestock, and macro sectors through the interest rate linkage. The interest rate is endogenized with the money supply as an important explanatory variable. A nonlinear, three-stage least square technique is used to estimate the parameters, and the Gauss-Seidel solution method is used for the dynamic simulation analysis. Results indicate that a three percent decrease in the money supply growth has a significant impact on the farm sector through the interest rate.

Table 1. Root mean square percent error and Theil's forecast error measures from the dynamic simulation analysis

Variable	RMSPE	Bias U^m	Regression U^s	Disturbance U^c	Accuracy (inequality coefficient) U
Real crop supply (S_t^c)	0.117	0.01	0.78	0.22	0.0006
Domestic demand for real crop output (D_t^c)	0.127	0.00	0.43	0.57	0.0008
Real crop inventories (I_t^c)	0.108	0.05	0.21	0.74	0.0010
Real crop net exports (X_t^c)	0.743	0.03	0.11	0.86	0.0198
Crop price (X_t^c)	0.148	0.00	0.61	0.39	0.0010
Real livestock product supply (S_t^L)	0.050	0.00	0.77	0.22	0.0002
Domestic demand for livestock products (D_t^L)	0.050	0.00	0.78	0.22	0.0002
Livestock product price (P_t^L)	0.105	0.00	0.41	0.59	0.0007
Real agricultural investment (i_t^a)	0.134	0.00	0.55	0.45	0.0021
Interest rate in the farm sector (r_t^a)	0.156	0.01	0.69	0.30	0.0194
Real farm income (S_t^a)	0.085	0.00	0.88	0.12	0.0002
Real output in the industrial sector (s_t^m)	0.031	0.51	0.09	0.40	0.0000
Manufactured goods price (P_t^m)	0.082	0.18	0.61	0.22	0.0006
Real investment in the industrial sector (i_t^m)	0.086	0.05	0.03	0.93	0.0001
Interest rate in the economy (r_t)	0.210	0.10	0.77	0.13	0.0318
Consumer price index (CPI_t)	0.034	0.16	0.48	0.35	0.0003
Exchange rate (e_t)	0.065	0.00	0.89	0.11	0.0006
Real gross national products (S_t)	0.015	0.04	0.00	0.96	0.0000

Table 2. Dynamic effect of sustained decrease in money supply growth rate by 3 percent

Variables	Average impact[a] of money supply decrease for the period 1978-1982	Long-run[b] elasticity
Exchange rate (SDR/U.S.$)	9.60	3.25
Domestic interest rate	3.17	1.12
Consumer price index (1967=100)	-1.32	-0.48
Real crop supply (mil. dol. in 1967 prices)	-0.63	-0.23
Real domestic demand for crop output (mil. dol. in 1967 prices)	5.23	1.87
Real crop inventories (mil. dol. in 1967 prices)	-1.43	-0.90
Real crop net exports (mil. dol. in 1967 prices)	-22.85	-6.69
Crop price index (1967=100)	-3.72	-1.28
Real livestock product supply (mil. dol. in 1967 prices)	-0.20	-0.07
Real domestic demand for livestock products (mil. dol. in 1967 prices)	-0.20	-0.07
Livestock product price (1967=100)	-1.59	-0.59
Real farm income (mil. dol. in 1967 prices)	-3.05	-1.08

[a] Calculated as average percentage changes of simulated values compared with the base values. The period 1978-1982 is considered for the purpose of long-run analysis.

[b] Calculated as average changes of each variable divided by average changes of the money supply, and evaluated at the means over the period 1978-1982.

References

Barnett, R.C., D. A. Bessler, and R. L. Thompson. 1981. "Agricultural Prices in 1970's and the Quantity Theory of Money." Paper presented at AAEA annual meeting. Clemson University. Clemson, South Carolina.

Chambers, Robert G. 1983. "Discussion: Impact of Federal Fiscal-Monetary Policy on Farm Structure." Southern Journal of Agricultural Economics 15(1):69-71.

Chambers, Robert G. 1984. "Agricultural and Financial Market Interdependence in the Short Run." American Journal of Agricultural Economics 66:12-24.

Chambers, Robert G. and Richard E. Just. 1982. "An Investigation of the Effect of Monetary Factors on U.S. Agriculture." Journal of Monetary Economics 9:235-47.

Devadoss, S., William H. Meyers, and Dennis R. Starleaf. 1985. "The Impacts of U.S. Monetary Policies on the Farm Sector." Paper presented at AAEA annual meeting. Iowa State University. Ames, Iowa.

Freebairn, John W., Gordon C. Rausser, and Harry de Gorter. 1982. "Food and Agriculture Sector Linkages to the International and Domestic Macroeconomies." In G.C. Rausser, ed. New Directions in Econometric Modeling and Forecasting in U.S. Agriculture. Amsterdam: North-Holland Publishing Co.

Gallant, A. Ronald. 1977. "Three-Stage Least-Squares Estimation for a System of Simultaneous Nonlinear, Implicit Equations." Journal of Econometrics 5:71-88.

Judge, G. George, R.C. Hill, W. Griffiths, H. Lutkepohl, and T.C. Lee. 1982. "Introduction to the Theory and Practice of Econometrics." John Wiley & Sons, Inc.

Pindyck, R.S. and D.L. Rubenfeld. 1981. "Econometric Models and Economic Forecasts." New York, NY: McGraw-Hill.

SAS. 1982. SAS/ETS User's Guide. Cary, North Carolina: SAS Institute, Inc.

Schuh, G.E., Chris Hodges, and Dave Orden. 1980. "Monetary Aspects of International Agricultural Trade." Presented at meeting of Research Consortium of Agricultural Trade. Tucson, Arizona.

Shei, Shuh-Yi. 1978. "The Exchange Rate and United States Agricultural Product Markets: A General Equilibrium Approach." Ph.D. dissertation. Purdue University. West Lafayette, Indiana.

Starleaf, Dennis R. 1982. "Macroeconomic Policies and Their Impact Upon the Farm Sector." American Journal of Agricultural Economics 64:854-60.