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Abstract
The possible adverse effects of monetary policy on the agricultural sector have been the focus of several recent papers (e.g., Johnson, 1980; Gardner, 1981; Chambers, 1984; Starleaf et al. 1985; Falk et al. 1985; and Rausser, 1985). Rausser (1985) and Staraoulis et al. (1985) have hypothesized that macroeconomic externalities are imposed upon agriculture because prices are relatively sticky in the nonagricultural sector.

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Differential Effects of Monetary Policy
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By Wallace E. Huffman and Suchada V. Langley

The possible adverse effects of monetary policy on the agricultural
sector have been the focus of several recent papers (e.g., Johnson, 1980;
Gardner, 1981; Chambers, 1984; Starleaf et al. 1985; Falk et al. 1985; and
Rausser, 1985). Rausser (1985) and Stamoulis et al. (1985) have hypothesized
that macroeconomic externalities are imposed upon agriculture because prices
are relatively sticky in the nonagricultural sector.

The differential stickiness is due primarily to differences in characteristics of contracts, which may be optimal, in the two sectors. Most major
agricultural commodities have organized spot and futures markets; but nonagri-
cultural commodities typically have less organized markets, where individual
contracts are infrequently negotiated or new catalogues list prices at
quarterly or annual intervals. One reason for differences in types of
contracts or markets is inherent variability of goods' market prices. Telser
and Higinbotham show that the organization of a futures market is a logical
response to increased price variability of a commodity. One hypothesis is
that the different types of markets in the agricultural and nonagricultural
sectors reflect the greater inherent variability of agricultural commodity
prices.

If prices are relatively more flexible in the agricultural sector, an
expansion of the money supply can be expected to cause relative overshooting
of the agricultural price and to send false signals to producers and consumers
in the short-run. These signals are a potential source of non-neutral short-run differential effects on the agricultural and nonagricultural sectors. The econometric evidence presented by Rausser (1985) and by Stamoulis et al. (1985) is, however, weak. Stronger evidence may be obtainable from an econometric model that has richer implications and from application of stronger statistical tests.

This paper examines the hypothesis of differential effects of U.S. monetary policy on the U.S. agricultural and nonagricultural sectors. The model is from the new classical monetary economics of business cycles (e.g., Lucas, 1972, 1975; Sheehan, 1985). We focus on the differential effects of anticipated and unanticipated money on (real) output and (nominal) output prices of the two sectors. The econometric model contains 5 equations: a monetary rule, output or supply equations for the two sectors, and price or demand equations for the two sectors. The set of equations are fitted to U.S. annual data in percentage rate of change form for the period 1950-1984. We conclude that monetary policy causes short-run differences in the growth rates of agricultural and nonagricultural outputs and causes short-run overshooting of the agricultural price in an absolute sense and relative to the nonagricultural price. Thus, monetary policy has been one source of short-run instability encountered by the U.S. agricultural sector over the sample period. The story unfolds in the following three sections.

The Model

The basic model consists of three types of equations: a Barro-type monetary growth rule, Lucas-type output (supply) growth equations, and price (demand) growth equations. These equations are augmented by two additional equations. They represent differential growth of sector outputs and
differential growth of sector prices.

The model is:

\[ m_t = \delta + \epsilon_t \]

\[ y_{lt} = y_{lt}^n + r_{lt} = \sum_{i=0}^{n} \alpha_{lt} m_{t-i} + \sum_{i=0}^{n} \beta_{lt} (m_{t-i} - m_{t-1}) + x_{lt} y_{lt} + \mu_{lt} \]

where \( m_t \) is the rate of growth of the money stock, \( y_{lt}^n, l = 1,2,3,4 \) is the rate of growth of agricultural output, nonagricultural output, (nominal) agricultural price, and (nominal) nonagricultural price, respectively;

\( y_{5t} = y_{lt} - y_{2t} \) is the differential sectoral output growth rate, and

\( y_{6t} = y_{lt} - y_{4t} \) is the differential sectoral price growth rate; \( z_t \) is a vector of exogenous and (or) predetermined variables; \( x_{lt} \) and \( x_{2t} \) are vectors of variables that determine the natural rate of growth of agricultural and nonagricultural output, respectively; \( x_6 \) determines the natural growth rate differential for agricultural and nonagricultural output; \( x_{3t} \) and \( x_{4t} \) are vectors of variables (other than output) that influence real money balances demanded and that represent nonmonetary (real demand) effects on the sectoral price growth; \( x_6 \) is a vector containing all the variables included in \( x_3 \) and \( x_4 \); \( \delta \) and \( \gamma_{lt}, \ l = 1, \ldots, 6, \) are vectors of unknown coefficients, \( \alpha_{lt} \) and \( \beta_{lt} \) are unknown coefficients; \( \epsilon_t \) and \( \mu_{lt}, \ l = 1, \ldots, 6, \) are zero mean and serially uncorrelated random disturbance terms, and \( \epsilon_t^{lt} \mu_{qt} = \sigma_{lt} \).

Equation (1) is based upon the hypothesis that the growth rate of the money stock is systematically related to or determined by a set of observed variables \( z_t, \) e.g., percentage change of government expenditures, lagged unemployment rate, lagged money growth. In addition, there is a component of monetary growth \( (\epsilon_{lt}) \) that is random or unpredictable. If economic agents in the agricultural and nonagricultural sectors form expectations about monetary growth rationally in the Muth-sense and on average exploit the systematic
relationship between $m_t$ and $z_t$, then predicted money growth ($m_t^*$) will equal $z_t^\delta$, and unpredicted money growth will equal $\varepsilon_t = m_t - m_t^*$. See Barro (1976), Mishkin (1982), Attfield et al. (1981).

In equation (2), agricultural and nonagricultural output growth rates ($y_{1t}$, $y_{2t}$) are viewed as consisting of two components: a natural rate ($y_{nt}^n$) and a transitory rate ($\mu_{kt}$). In this study, the natural rate is represented by a constant and time trend, which are included in $x_{1t}$ and $x_{2t}$. Other real forces that might explain the natural rate are rate of change of the energy price, change in interest rates, lagged growth in research expenditures, and growth of inputs. The natural rate is, however, believed to be unaffected by monetary policy, i.e., neither anticipated nor unanticipated money has natural growth rate effects (Lucas, 1972). On the other hand, the transitory growth in output is hypothesized to be related to unanticipated and (perhaps) anticipated monetary growth.

Both current and lagged unanticipated money growth may explain part of transitory output growth currently caused by unanticipated money growth and other unpredictable factors can be misinterpreted by economic agents as a change in the relative price of outputs. Thus, a temporary increase in the relative price of their outputs can be expected to increase quantities supplied in the short-run. Because of the differences in the length of the production period and dynamics of production, these short-run sectoral responses of output to currently unanticipated money need not be the same.

Lagged unanticipated money can have its effect on current output in a couple of ways. First, current information and its impact on productive capital can be carried forward into future periods (Lucas, 1975). Second,
money surprises can cause unanticipated increases in aggregate demand (Blinder and Fischer, 1981; Lucas and Sargent, 1981) which are partly met out of increased production and partly from temporarily reduced inventories. The later reestablishment of desired inventories is then a mechanism through which lagged unanticipated money growth can affect real output growth. Furthermore, these short-run effects of lagged money shocks need not be the same in both sectors.

Anticipated money growth is generally viewed as being neutral in aggregate national models. See, for example, Lucas (1972, 1973, 1975) and Barro (1976). Prices are seen as being flexible, agents are rational, and contract lengths are adjustable. On average, agents correctly see that changes in price levels caused by anticipated money are not a change in the relative prices of the goods they produce or consume. A counter view, however, is that anticipated money is not neutral in aggregate national models. See, for example, Dornbusch (1976), Fischer (1977), Blinder (1982), Mishkin (1982), Gordon (1982), Frankel and Hardouvelis (1983), and Sheehan (1985). When national economies are disaggregated into sectors, the empirical evidence against sector neutrality seems to dominate. (See Gauger).

Because the characteristics of economic contracts and the dynamics of production differ between the agricultural and nonagricultural sectors, we can anticipate that monetary policy—at least unanticipated money—will have different effects when the national economy is split into sectors along these lines. Because the agricultural sector has more highly organized commodity markets than the nonagricultural sector, we expect prices to be relatively more flexible in the agricultural sector. When long-term contracts (e.g., longer than 2t) exist in the nonagricultural sector but not in the agricultural sector and anticipated (or unanticipated) money supply increases in t,
the nonagricultural price cannot adjust completely in \( t \). The more flexible agricultural sector price is, however, subject to overshooting. Overshooting is caused primarily by (asset holders) money balance holders bringing real money balances into equilibrium after the increase in nominal money stock. Thus, in the short run, the agricultural price can be expected to rise proportionally more than the nonagricultural price and above its long-run equilibrium level than it would if the nonagricultural price were more flexible.\(^5\) This changes relative prices in the two sectors in the short-run and can be expected to increase quantities supplied of agricultural output. In the long-run, neither anticipated nor unanticipated money supply growth is expected to affect real output growth in either sector. Thus, any short-run effects are expected to dampen out as time passes provided that other things do not change.

The equations for growth of the (nominal) agricultural and nonagricultural prices \( y_{3t}, y_{4t} \) are derived with a money market equilibrium and with shifts in real forces determining commodity demand in the background. Changes in commodity demand (price) that are due to change in the growth of real income are attributed to growth of anticipated and unanticipated money growth. Thus, \( m_{t-i}^* \) and \( (m_{t-i}^* - m_{t-i}^*) \) appear in the sectoral price change equations, but \( y_{1t} \) and \( y_{2t} \) do not. Additional explanatory variables included in the sectoral price change equations are intercept, change in the interest rate, and the percentage change in the energy price. The interest rate represents one of the costs of holding money, and the change in the domestic energy price represents a change in prices that is affected by world energy price shocks.\(^6\)

In terms of equation (2), the overshooting hypothesis is stated as follows. For a change in anticipated money we expect \( \alpha_{40} < 1 < \alpha_{30} \), i.e., an
increase (decrease) of anticipated money in \( t \) will cause a larger immediate percentage increase (decrease) in the agricultural price than in the nonagricultural price. Furthermore, if money balance holders are in equilibrium during \( t \), then the weighted average change of the two price indexes must be approximately equal to the rate of increase in anticipated money. In the long-run, prices in both sectors are flexible, and an increase (decrease) in anticipated money is expected to cause similar percentage increases (decreases) of the agricultural and nonagricultural prices. This means that changes in the rate of growth of anticipated money cause short-run relative overshooting (undershooting) of the changes in the farm (nonagricultural) price. Thus, monetary policy becomes a cause of fluctuations in agricultural output prices in the short run.

Although an increase (decrease) of unanticipated money is expected to increase (decrease) prices in the long-run, the immediate effects are expected to be small relative to the lagged effects. Immediate output effects are expected, and only later prices change. Sheehan (1985) found that the effects of unanticipated money on the GNP deflator during the first 4 quarters following an increase in money were small relative to effects during the 5th through 16th quarters. With a one-year lag, unanticipated money supply changes also become part of the information available to rational economic agents. An increase of unanticipated money in year \( t \) may have a similar effect on prices in year \( t+i+1 \) as an increase in anticipated money in year \( t \) has in year \( t+i \). Thus, an additional indication of the overshooting phenomena is that an increase in unanticipated money in year \( t \) causes a larger percentage increase in the agricultural price in year \( t+1 \) than in the nonagricultural price, i.e., \( \beta_{41} < 1 < \beta_{31} \). In the long run, we expect long-run effects of unanticipated money to cause similar percentage changes in
the prices of the agricultural and nonagricultural sectors. Thus, both anticipated and unanticipated money may be sources of overshooting of agricultural (relative to nonagricultural) prices and a source of fluctuations in agricultural output prices in the short run.

The interest rate and energy price effects on demand are as follows. The effects of the interest rate on sectoral prices arise from the interest rate effect on real money balances demanded. An increase in the interest rate, other things equal, is expected to reduce the aggregate quantity of real balances demanded and thereby to increase the aggregate price level. If prices are more flexible in the agricultural than nonagricultural sectors, the estimated coefficient of the interest rate should be larger in the agricultural price than in the nonagricultural price equation. After 1973, petroleum based U.S. energy prices have been significantly affected by the noncompetitive activities of the OPEC cartel. These external shocks to U.S. energy prices can be expected to affect the sectoral output prices when energy related goods are inputs in production. We have not included an exchange rate variable because exchange rate changes generally have a domestic and (or) foreign monetary cause (Mussa, 1979). Currently, we are ignoring the domestic influences of foreign money growth.

A number of additional hypotheses about the short-run and long-run sectoral effects of monetary policy can be easily performed on the coefficients of equation (2). If we confine short-run effects of money growth to the time period \( t \) then, the proposition that anticipated (unanticipated) money has no short-run effects on \( y_{st} \) can be represented as a test of the null hypothesis \( \alpha_k = 0 \) [\( \beta_k = 0 \)], \( H_a^k: \) negation, \( k = 1, \ldots, 6 \). Long-run effects of money growth can be represented by the cumulative effects over all time periods. Thus, the proposition that anticipated (unanticipated) money has no
long-run effects on y_{lt} is represented as a test of the null hypotheses
\[ \sum_{i=0}^{n} a_{li} = 0 \quad \text{and} \quad \sum_{i=0}^{n} \beta_{li} = 0, \] (H_{\alpha} \text{ is negation), } l = 1, \ldots, 6. \] With an additional assumption of multivariate normal distribution for the disturbances in the equation system (2), these tests can be performed using the likelihood-ratio test statistic for a set of equations. The sample value of the test statistic under the null hypothesis is \( T\{\ln|\Sigma_R| - \ln|\Sigma_U|\} \) where \( |\Sigma_U| \) and \( |\Sigma_R| \) are the determinant of the estimate of the variance-covariance matrix of the disturbances for the unrestricted set of equations and restricted set of equations under the null hypothesis, respectively; \( T \) is the number of observations in each equation. Under the null hypothesis, the test statistic is distributed in large samples as a chi-square with \( q \) degrees of freedom, where \( q \) is the number of equality restrictions imposed on the coefficients of the model by the null hypothesis.

The Empirical Analysis

After a brief introduction to the data and estimation procedure, the econometric results are presented and discussed.

The Data and Econometric Procedures

Rates of change of annual data for the period 1948-1984 are employed in the econometric analysis. Our concern is with monetary effects on production rather than on inventory decisions. Although production tends to be a continuous process in the nonagricultural sector, much of agriculture has an annual cycle. Thus, we chose annual rather than quarterly or monthly data. This means that in this study, short-run adjustments occur within a year and long-run adjustments occur over several years. All of the variables, which are defined in Table 1, are represented as proportional rates of change or \( \log_e \) first differences (except for the interest rate and unemployment rate) to remove trend dominated effects that can cause spurious relationships among
(log_e) levels of variables and to reduce the problem with serial correlation of disturbance terms in the equations of the model. The attempt to explain percentage rates of change of sectoral outputs and prices is a major challenge for any model, and the share of the variation that is explained may be relatively low.

We focus on the post-World War II period because it provides a variety of relatively recent monetary experiences without the disruptions of a major war. This period is, however, long enough that several significant changes in Federal Reserve policies have occurred. Before October 1979, the Federal Reserve placed relatively heavy weight on short-term interest rates in setting its policies. After October 1979, the Federal Reserve placed primary emphasis on the rate of growth of M1. In the summer of 1982, the Federal Reserve made another change, placing less emphasis on M1 and greater emphasis on growth of M2 and M3 because of political considerations and a perceived shift in the demand for money function or drop in M1 velocity (U.S. President, 1983, pp. 140-142). We have, however, chosen a relatively simple representation of the monetary rule for the whole period. Current monetary growth is explained by the one-year lagged monetary growth, the current growth in total government expenditures, the lagged ratio of the unemployment to the employment rate, and trend. Our rule is similar to ones employed by Barro (1976), Attfield et al. (1981), and Sheehan (1985), and we chose it after trying several different specifications. Other U.S. governmental policies, including price supports and land retirement programs for food and feedgrains, have also changed over time. These changes have been irregular, they cannot be easily summarized in an empirical measure, and we ignore them.

The basic econometric model is a 5-equation simultaneous system. They are the money rule, output or supply equations in the agricultural and
nonagricultural sectors, and price or demand equations in the agricultural and nonagricultural sectors. The full-information maximum-likelihood estimator for the 5-equation system failed to converge, so we applied a two-stage estimation procedure. First, the equation for the monetary rule was estimated by ordinary least squares. The predicted values of money from this equation were employed to construct estimates of anticipated money ($\hat{m}_{t-1}$) and unanticipated money ($m_{t-1} - \hat{m}_{t-1}$) in equation (2). The four equation system, containing agricultural and nonagricultural outputs and agricultural and non-agricultural prices or $y^*_t$, $t = 1, \ldots, 4$, is a seemingly unrelated set of equations. Because the variances of the disturbances of the four equations seemed likely to be different and contemporaneous cross-equation correlation of disturbances to occur, the four equations (2) were jointly estimated. Pagan (1984) has shown that this estimation procedure leads to consistent estimates of the coefficients of the model, but the estimates of some standard errors are inconsistent. This can affect the conclusion of hypothesis tests.

The dependent variables (with mean removed) of the four-equation system are plotted against time in Figures 1 and 2. These plots show that the annual changes in agricultural output price (about trend) have been on average larger over the sample period than for the nonagricultural output price. This suspicion is confirmed by the fact that the root-mean-square error of the agricultural price is 11.3 percent, but for the nonagricultural price, it is only 2.7 percent. Although differences are not as large for outputs, annual changes of (real) agricultural output have also been larger on average than for nonagricultural output. The root-mean-square error of agricultural and nonagricultural output growth rates are 5.4 percent and 3.2 percent, respectively. The issue to be examined in this study is the contribution of monetary policy to these differences.
The Econometric Results

The basic 5-equation model for examining the differential effects of U.S. monetary policy on the agricultural and nonagricultural sectors is fitted to data for 1950-1984. The choice of lag length for the monetary variables was based upon evidence from other studies and statistical tests. Studies by Sheehan (1985) and Mishkin (1982) have suggested that most of the effects of money are confined to a three-year period starting with the date of the increase. In our statistical tests, we found that the coefficients of the three-year lagged values of anticipated and unanticipated money growth were not significantly different from zero at the 5 percent level. The coefficients of the two-year lagged values of the monetary variables were, however, significantly different from zero. Thus, we include the current and one- and two-year lagged values of anticipated and unanticipated money in the sectoral output and price equations. In constructing these variables, three observations were lost from the 1947-1950 period, and observations on output and prices start in 1950.

The econometric results are presented in Tables 2-4. Table 2 contains estimates of the coefficients and asymptotic t-ratios for the agricultural and nonagricultural supply (output) and demand (price) equations and the monetary rule for anticipated money. Table 3 reports results from joint tests that anticipated or unanticipated money has no short-run or annual effects on sectoral outputs and prices, and Table 4 reports similar tests of no long-run or multi-year effects of anticipated or unanticipated money.

Although the evidence is not overwhelming, money policy seems to cause different short-run effects in the agricultural and nonagricultural sectors. In Table 2, column 5 reports the estimates of the coefficients of the equation
for the monetary rule. Although t-ratios for coefficients of some of the variables, e.g., $m_{t-1}$ are lower than might be expected, the $R^2$ or share of the variation in actual money growth that is explained by the equation, which is the key performance indicator for the empirical measure of anticipated money, is a respectable 66 percent. This equation is employed to derive empirical measures of anticipated and unanticipated money growth for the regressors in the sectoral output and price equations.

Monetary policy has significant differential short-run (annual) effects on agricultural and nonagricultural output growth, but it has no long-term (multi-year) effects on sectoral or differential output growth rates. Different short-run effects of anticipated and unanticipated money on sectoral output growth rates are shown in columns (1) and (2), Table 2. In the non-agricultural output equation, the coefficients on one- and two-year lagged anticipated money are (individually) significantly different from zero at the 5 percent level, and the hypothesis that current and lagged anticipated money have no short-run effects on nonagricultural output growth can be rejected at the 10 percent significance level. (The sample $\chi^2 = 7.51$, $\chi^2_{3,.05} = 7.8$).

Current and lagged unanticipated money do not individually or jointly explain changes in the growth of agricultural output. Combining information from equations (1) and (2), Table 2, anticipated money growth is a source of statistically significant short-run differences in the growth rates of agricultural and nonagricultural outputs. See Table 3, column 1. Furthermore, these are the results that we expect when the average contract length is longer in the nonagricultural sector. Although the coefficients on current and lagged anticipated money sum to 1.112 in the agricultural output equation and to 0.096 in the nonagricultural output equation, these totals are not
significantly different from zero. Anticipated money growth is not a source
of significant (differences in) long-run output growth. See Table 4,
column 1. Since we expect economic agents to be rational and contracts are
renegotiated in the long-run, no long-run effects of anticipated money growth
on sector output growth rates or growth rate differences was expected.

Unanticipated money growth is expected to affect output growth rates in
both sectors. Although the sign of the coefficient on current unanticipated
money growth is opposite expectations in the nonagricultural output equation,
lagged unanticipated money has statistically significant (individual) effects
on growth of nonagricultural output. Furthermore, the hypothesis that current
and one- and two-year lagged unanticipated money growth have no joint effect
on short-run nonagricultural output growth is rejected at the 5 percent
significance level. See Table 3, column 2. In the agricultural output
equation, the coefficients of unanticipated money growth are not individually
or jointly significantly different from zero. Thus, unanticipated money
growth has no significant effect on annual agricultural output growth.
Unanticipated money is, however, a statistically significant source of
short-run differences in the growth rate of agricultural and nonagricultural
outputs. See Table 3, column 2. This result arises primarily from the
effects of unanticipated money growth on annual nonagricultural output growth.
Although these short-run results are not completely consistent with our prior
expectations, we do not view them as being contradictory. Annual rates of
change of agricultural output contain a relatively large share of noise due to
annual weather variability. This makes it harder to identify other effects.

For the long-run, the point estimate is that a 10 percent increase in
unanticipated money causes agricultural output to increase by 5.2 percent and
nonagricultural output to decrease by 0.6 percent. These changes are,
however, not significantly different from zero. See Table 4, column 2. In the long-run, unanticipated money growth has no significant long-run or natural output growth rate effects. These results were expected.

The overall performance of the output equations confirms that a much larger share of the variation in transitory annual output growth is explained by monetary policy for the nonagricultural than for agricultural sector. Fifty-five percent of the variation in nonagricultural annual output growth is explained by monetary policy (and trend) and the root-mean-square error of the estimate is 2.4 percent. Only 22 percent of the variation in annual agricultural output growth is explained by these same variables and the mean square error of the estimate is 5.4 percent. This is, however, not too surprising, given that random variation in weather conditions seem likely to create more noise in annual agricultural than in nonagricultural output growth rates.

Increases in the money supply are expected to increase prices. Three-fourths of the coefficients on the monetary variables in the agricultural and nonagricultural price equations have positive signs. See Table 2, columns (3) and (4). The negative monetary coefficient in both price equations show that sectoral undershooting-overshooting of prices is occurring on an annual basis in both sectors. Across the two sectors, there is evidence of short-run relative overshooting of the agricultural prices.

First, consider the short-run or annual effects. The coefficient of current anticipated money is 3.28 in the agricultural price equation, and it is 8 times larger than in the nonagricultural price equation. An increase (decrease) in anticipated money supply for year t causes the agricultural output price to rise (fall) during that year by much more than the increase (decrease) in anticipated money or nonagricultural output price. This
difference is consistent with our hypothesis about differences in contract length. In the long-run, the differences between sectors are moderated. The results show that a 10 percent increase in anticipated money will cause an increase in the long run (over three years) of raising the agricultural output price by 8.9 percent and the nonagricultural output price by 5.6 percent. These long-run effects of anticipated money on prices are not significantly different at any reasonable significance level. The \( x^2 \) is 0.10. See Table 4, column 1.

Second, one-year lagged effects of unanticipated money supply growth are also a source of short-run absolute and relative overshooting of agricultural prices. Although the coefficient of unanticipated money are small (between 0.1 and 0.2) in both price equations and not significantly different from zero, the coefficient of one-year lagged unanticipated money is 3.10 in the agricultural price equation and 0.08 in the nonagricultural price equation. These coefficients differ by an order of magnitude of 40, and they are significantly different at the 5 percent level. (Sample \( x^2 \) of 5.2.) This result, combined with the effects of current anticipated money on prices, suggests that unanticipated money becomes part of the perceived information that economic agents act upon, but this information becomes available with a one-year lag. Unanticipated money causes short-run absolute and relative overshooting of the agricultural price.

For the long-run (over 3 years), these results imply that an increase of unanticipated money by 10 percent causes agricultural prices to rise by 37.8 percent and nonagricultural prices to rise by 1.4 percent. Although the long-run effects of unanticipated money are not significantly different from zero in either price equation and not significantly different across price equations (see Table 4), they show that a tendency exists for unanticipated
money supply changes to cause overshooting of agricultural prices.

The estimated coefficients in our price equations imply that the long-run effects of a change in the money supply on aggregate prices (weighted average of the agricultural and nonagricultural prices) are consistent with a classical quantity theory of money model (Friedman and Schwartz, 1982, Ch. 2). The percentage change in anticipated plus unanticipated money equals the percentage change in the total money supply.

Our results imply that a 10 percent increase in the money supply will cause in the long run (over 3 years) a 46.7 percent increase in agricultural prices and a 7.0 percent increase in nonagricultural prices. With agricultural output on average comprising 2.6 percent of gross domestic product and nonagricultural output comprising 97.4 percent, the implication is that the 10 percent increase in the money supply causes the aggregate price index for gross domestic product to rise by 8 percent (.026 x 46.7 + .974 x 7.0). When real gross domestic product is growing at 2-3 percent and the income elasticity of demand for money is approximately 1, this result is consistent with a classical quantity theory of money prediction.

The nonmonetary variables seem to be contributing relatively little to the explanation of sectoral price variation. The coefficient of the change in the long-term interest rate is positive as expected in both price equations. The interest rate coefficient in the agricultural price equation is 5 times larger than in the nonagricultural price equation, which supports the short-run overshooting hypothesis. The coefficients, however, are individually not significantly different from zero. The energy price is playing a larger role in explaining prices. An increase of the energy price has an immediate positive and statistically significant effect on the nonagricultural price, but the agricultural price is not affected by current energy price changes.
A comparison of the overall performance of the two price equations shows that monetary variables tell a much larger share of the story about changes in the nonagricultural price than the agricultural price. For the agricultural price equation, the $R^2$ is 0.35 and the root-mean-square error of the estimate is 10 percent. For the nonagricultural price equation, the $R^2$ is 0.78 and the root-mean-square error of the estimate is only 1.4 percent. These results are consistent with random climatic conditions playing a relatively greater role in annual fluctuations of agricultural than nonagricultural output.

**Conclusions**

Inherent differences in agricultural and nonagricultural markets provide one major reason for different characteristics of contracts. In particular, shorter average contract lengths exist on average for agricultural than for nonagricultural commodities. This is a source of differential stickyness of prices in the two sectors.

We found econometric evidence of differential effects of U.S. monetary policy during the period 1950-1984 that is consistent with the contract length hypothesis. An increase in anticipated money causes a contemporaneous overshooting of agricultural prices absolutely and relative to nonagricultural prices, and an increase of unanticipated money causes a similar behavior of sectoral prices, except that the overshooting phenomena occurs with a one-year lag. No differential long-term effects of monetary policy was uncovered. Although monetary variables explain a larger share of the variance of nonagricultural than agricultural prices, U.S. monetary policy has contributed to the variability of U.S. agricultural output prices.
Our results suggest that there is nothing unusual or perverse about the differences in output price behavior in the two sectors over the period of analysis. It does, however, suggest that further institutional innovations should be incorporated into the markets so that agents can more easily bear risk associated with price variability according to their preferences and resource constraints. Wider use of options markets would be one method of achieving this.
Footnotes

*The authors are Professor of Economics, Iowa State University and Economist, ERS/USDA, respectively. They acknowledge the helpful comments of James Lothian, Robert Chambers, Barry Falk, G. Edward Schuh, Andy Schmitz, and Robert Evenson.

1Stigler and Kindah (1970) show that industrial prices do have considerable variability over business cycles.

2Enders and Falk (1984) report a micro test of monetary neutrality for the agricultural sector. They find significant and positive effects of unanticipated money growth on the pounds of pork slaughtered and of pork bellies in frozen storage. There is no statistically significant effect of anticipated money growth on these variables.

3Economic agents in both sectors are considered to be equally efficient at using information and in making decisions. Thus, the rationale for relatively sticky prices in the nonagricultural sector is not generally faulty expectations.

4In preliminary tests of our model, the change in the long-term interest rate and percentage change in the energy price did not have significant effects on real output growth in either sector.

5The length of contracts in the nonagricultural sector is considered to be endogenous to economic conditions. If the behavior of prices becomes more irregular, we expect the average length of the contract period to be shortened. We, however, expect market prices in the agricultural sector to remain relatively more flexible.

6See Gandolfi and Lothian (1983) for a similar model of the aggregate price behavior.
Friedman (1977) argues that no single interest rate (i.e., long term, short term) is necessarily any better than another for representing the cost of holding money. It is really the whole term structure of interest rates that matters.

In a multiple-equation system, it is important that the test statistic takes account of the effects of restrictions imposed by the null hypothesis on the whole set of equations.

We are indebted to James Lothian for pointing out these significant changes in the Federal policy.

In preliminary test of the model, a dummy variable distinguishing fixed and flexible exchange rate years was not significant.

This is the standard deviation of the variable after its mean has been removed.

The sample $X^2$ statistic for a joint test that the eight coefficients for the three-year lagged values of anticipated and unanticipated money are jointly equal to zero versus the alternative that they are nonzero is 2.25. The sample $X^2$ statistic for the joint test that the eight coefficients for the two-year lagged values of money are zero is 32.86. The critical value of the $X^2$ with 8 degrees of freedom at the 5 percent significance level is 15.5.

A single-equation test of the null hypothesis that the nonintercept variables in the agricultural output equation jointly have no explanatory power cannot be rejected at the 5 percent significance level. The sample value of the F statistic is 1.13 and the critical value with 6 and 27 degrees of freedom at the 5 percent significance level is 2.45.

For the sectoral price equations, the coefficients of current anticipated money are significantly different from zero at the 15 percent level. The sample $X^2$ is 2.3 and $X^2_{1,1} = 2.7$. 
A puzzling result is that the null hypothesis that anticipated money has no long-run effect on agricultural output prices cannot be rejected. See Table 4, column 1.

We use a long-term bond rate as the interest-rate variable to reduce problems of simultaneity. The results were not changed when the interest rate variable was assumed to be a random variable and its movement described by an autoregressive process.

We did not explore possible effects of lagged energy prices on sectoral prices.
References


Table 1. Definitions of Variables

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>( m_t )</td>
<td>annual proportional change in nominal money stock (M1)</td>
</tr>
<tr>
<td>( y_{1t} )</td>
<td>annual proportional change in gross domestic product (GDP) from the U.S. farm business sector (1972 prices)</td>
</tr>
<tr>
<td>( y_{2t} )</td>
<td>annual proportional change in GDP from the U.S. nonfarm business sector (1972 prices)</td>
</tr>
<tr>
<td>( y_{3t} )</td>
<td>annual proportional change in implicit price deflator for U.S. GDP in farm sector</td>
</tr>
<tr>
<td>( y_{4t} )</td>
<td>annual proportional change in implicit price deflator for U.S. GDP in the nonfarm sector</td>
</tr>
<tr>
<td>( \Delta r_t )</td>
<td>annual change in Moody's triple-A bond yield</td>
</tr>
<tr>
<td>( p_{en}^t )</td>
<td>annual proportional change in price of energy</td>
</tr>
<tr>
<td>( g_t )</td>
<td>annual proportional change in total real U.S. government expenditures</td>
</tr>
<tr>
<td>( u_{nt} )</td>
<td>( \log_e (U.S. \text{ unemployment rate}) / (1 - U.S. \text{ unemployment rate}) )</td>
</tr>
<tr>
<td>( D_{59} )</td>
<td>1 in 1959 and 0 otherwise</td>
</tr>
<tr>
<td>( t )</td>
<td>time trend, 0, 1, ..., 34</td>
</tr>
</tbody>
</table>
Table 2. Estimate (Seemingly-Unrelated) of a Two Sector Monetary Model: Growth of (Real) Output and of (Nominal) Price for Agricultural and Nonagricultural Sectors, 1950-1984 (Annual)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Output</th>
<th></th>
<th></th>
<th>Price</th>
<th></th>
<th></th>
<th>Money</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \hat{m}_t )</td>
<td>-0.112</td>
<td>0.057</td>
<td>3.283</td>
<td>0.403</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>( \hat{m}_{t-1} )</td>
<td>-0.256</td>
<td>1.094</td>
<td>-0.569</td>
<td>-0.288</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>( \hat{m}_{t-2} )</td>
<td>1.480</td>
<td>-1.055</td>
<td>-1.826</td>
<td>0.444</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>( m_t - \hat{m}_t )</td>
<td>0.601</td>
<td>-0.316</td>
<td>0.194</td>
<td>0.116</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>( m_{t-1} - \hat{m}_{t-1} )</td>
<td>-0.961</td>
<td>1.141</td>
<td>3.099</td>
<td>0.079</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>( m_{t-2} - \hat{m}_{t-2} )</td>
<td>0.884</td>
<td>-0.885</td>
<td>0.489</td>
<td>-0.051</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>( \Delta r_t )</td>
<td>-</td>
<td>-</td>
<td>0.022</td>
<td>0.004</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>( p_{en} )</td>
<td>-</td>
<td>-</td>
<td>-0.144</td>
<td>0.162</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>( m_{t-1} )</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.193</td>
</tr>
<tr>
<td>( g_t )</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.164</td>
</tr>
<tr>
<td>( u_{nt-1} )</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.004</td>
</tr>
<tr>
<td>( D_{59} )</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-0.030</td>
</tr>
<tr>
<td>( t )</td>
<td>-0.0012</td>
<td>-0.0004</td>
<td>-</td>
<td>-</td>
<td>0.002</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>-0.006</td>
<td>0.0359</td>
<td>-0.026</td>
<td>0.007</td>
<td>0.010</td>
<td>0.010</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.26)</td>
<td>(3.34)</td>
<td>(-0.05)</td>
<td>(1.11)</td>
<td>(2.23)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( R^2 )</td>
<td>0.224</td>
<td>0.541</td>
<td>0.354</td>
<td>0.784</td>
<td>0.660</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*aAbsolute value asymptotic t-ratios are in parentheses.*
Table 3. Results from Hypothesis Tests: Monetary Policy (Anticipated and Unanticipated Money Growth) has No Short-Run Real Output or Price Effects in the Agricultural and Nonagricultural Sectors, 1950-1984 (Annual)

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Output</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Anticipated money</td>
<td>Unanticipated money</td>
</tr>
<tr>
<td></td>
<td>(H_0: \alpha_{0} = \alpha_{1} = \alpha_{2} = 0)</td>
<td>(H_0: \beta_{0} = \beta_{1} = \beta_{2} = 0)</td>
</tr>
<tr>
<td></td>
<td>Sample Chi-square</td>
<td>Sample Chi-square</td>
</tr>
<tr>
<td>Agri. ((y_1))</td>
<td>1.90</td>
<td>5.24</td>
</tr>
<tr>
<td>Nonagri. ((y_2))</td>
<td>7.51(^b)</td>
<td>24.09(^a)</td>
</tr>
<tr>
<td>Relative ((y_5 = y_1 - y_2))</td>
<td>23.09(^a)</td>
<td>32.5(^a)</td>
</tr>
<tr>
<td>Agri. ((y_3))</td>
<td>4.42</td>
<td>5.77</td>
</tr>
<tr>
<td>Nonagri. ((y_4))</td>
<td>17.48(^a)</td>
<td>0.81</td>
</tr>
<tr>
<td>Relative ((y_6 = y_3 - y_4))</td>
<td>10.41(^a)</td>
<td>6.87(^b)</td>
</tr>
</tbody>
</table>

\(^a\)Significant at 5 percent level, \(\chi^2_{0.05} = 7.81; \chi^2_{0.05} = 12.59\)

\(^b\)Significant at 10 percent level, \(\chi^2_{0.10} = 6.25; \chi^2_{0.10} = 10.64\)
Table 4. Results from Hypotheses Tests: Monetary Policy (Anticipated and Unanticipated Money Growth) has No Long-Run Real Output or Price Effects in the Agricultural and Nonagricultural Sectors, 1950-1984 (Annual)

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Sample Chi-Square</th>
<th>Anticipated money</th>
<th>Unanticipated money</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$H_0: \sum_{i=0}^{n} \alpha_i = 0$</td>
<td>$H_0: \sum_{i=0}^{n} \beta_i = 0$</td>
<td></td>
</tr>
<tr>
<td>Output</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agri. ($y_1$)</td>
<td>0.46</td>
<td>0.21</td>
<td></td>
</tr>
<tr>
<td>Nonagri. ($y_2$)</td>
<td>0.02</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>Joint ($y_1 &amp; y_2$)</td>
<td>0.43</td>
<td>0.19</td>
<td></td>
</tr>
<tr>
<td>Relative ($y_1-y_2$)</td>
<td>0.37</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>Price</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agri. ($y_3$)</td>
<td>0.47</td>
<td>1.98</td>
<td></td>
</tr>
<tr>
<td>Nonagri. ($y_4$)</td>
<td>15.63$^a$</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>Joint ($y_3 &amp; y_4$)</td>
<td>1.98</td>
<td>2.16</td>
<td></td>
</tr>
<tr>
<td>Relative ($y_3-y_4$)</td>
<td>0.10</td>
<td>1.75</td>
<td></td>
</tr>
</tbody>
</table>

$^a$Significant at the 5 percent level, $X^2_{1,0.05} = 3.84; X^2_{2,0.05} = 5.99$

$^b$Significant at the 10 percent level, $X^2_{1,0.1} = 2.71; X^2_{2,0.1} = 4.61$