Money, Inflation, and Relative Prices: Implications for U.S. Agriculture

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Introduction

In a recent study, Starleaf, Meyers, and Womack (S-M-W, 1985) analyzed the behavior of annual time series data in the United States on various farm and nonfarm price indices over the 1929-1983 period and three subperiods in order to examine the proposition that changes in the general rate of inflation have nonneutral effects on the farm sector. They found that short-run increases (decreases) in the rate of inflation of farm input and nonfarm output prices have typically been accompanied by even larger short-run increases (decreases) in the rate of inflation of farm output prices. While S-M-W did not explicitly account for the effects of unanticipated inflation on these relative prices in their empirical analysis, they concluded that these regularities indicate that an unanticipated increase (decrease) in the general inflation rate tends to enhance (diminish) the well-being of farmers. This conclusion is consistent with macroeconomic theory that unanticipated aggregate demand shocks will affect relative prices in favor of producers of nondurable goods traded in flex-price markets. It is, however, surprising to the believers of the conventional wisdom, who contend that farmers suffer from inflation. Tweeten, for example, has presented evidence in several studies that he says support the view that farmers are harmed by higher rates of general price inflation.

Belongia, (1985) commenting on the S-M-W paper, questioned their interpretation, arguing that their study fails to account for causes of relative price changes other than general price inflation. The need to control for relative price changes due to more fundamental shifts in supply and demand has also been noted by Tweeten (1980). Belongia also argues that the S-M-W study should have explicitly considered the empirical relationship between relative rates of inflation, on one hand, and money supply growth (both anticipated and unanticipated), on the other, to establish any meaningful claims about the effects of unanticipated inflation on relative prices.

The objective of this paper is to examine the effect of unanticipated inflation generated by unanticipated changes in the money supply's growth rate on relative inflation rates that are especially important to the welfare of farmers. Our analysis will proceed within the context of a theoretical and empirical framework that accounts for the most severe of the Belongia criticisms of the S-M-W paper. Results indicate that unanticipated inflation has been an important source of movements in relative prices, and the direction of the non-neutrality is consistent with the findings of the S-M-W study.

Literature Review

The effects of inflation on relative price behavior have been of general as well as particular interest to economists concerned with the farm sector. For example, in the general economic literature, Vining and Elwertowski (1976), Parks (1978), and Bordo (1980) have examined this issue. Tweeten (1980, 1983) concluded that increases in the general inflation rate worsen the farmers' terms of trade by causing prices paid by farmers to rise faster than prices received by farmers. However, Prentice and Schertz (1981), Gardner (1981), and Chambers (1983) were unable to find a significant empirical relationship between general price level changes and farm output-farm input price ratios. One major drawback of these studies is their failure to distinguish between unanticipated and anticipated general price inflation. This distinction is crucial since it is widely accepted among macroeconomists that to the extent that general inflation can in and of itself generate relative price changes, it is only the unanticipated component of inflation that can do so (see Starleaf 1979).

S-M-W considered the following paired relationships between annual price indices: (1) prices received by farmers for all farm products and prices paid by farmers for production items; (2) the National Income and Product Accounts' farm output and farm input price deflators; and (3) farm and nonfarm Net National Product prices deflators. A visual inspection of the time series plots of each pair's behavior over the 1929-1983 period indicates three features. First, each series is dominated by a positive trend. Second, each pair appears to be highly correlated in the sense that for any given pair both elements of the pair appear to share a common trend; and deviations from that trend seem to be quite similar in terms of their timing and direction. Finally, deviations from trend seem to be consistently larger for farm output prices relative to farm input and nonfarm output prices. Suppose that the trend component of a particular price series is interpreted as reflecting the long-run effects of general price inflation while the deviations from trend reflect the temporary effects. If the temporary effects are then associated with unanticipated changes in the general rate of inflation, it would seem to follow that unanticipated increases (decreases) in inflation are associated with increases (decreases) in farm output prices relative to farm input or nonfarm output prices. Regressions of the growth rate of farm output prices on a constant and the growth rate of farm input (or nonfarm output) prices appear to be consistent with this hypothesis. The S-M-W empirical results show that point estimates of the slope coefficients in these regressions are significantly greater than one, indicating that a one percent increase (decrease) in the farm input or nonfarm output price inflation rate is systematically associated with a more than one percent increase (decrease) in the farm output price inflation rate.

In his response to the S-M-W study, Belongia argued that their methods were unable to justify their conclusions. For example, he indicated (p. 398) that to the extent that farm output prices, farm input prices, and nonfarm output prices are simultaneously determined, regressions of one on another cannot be given an economically meaningful interpretation. Further, he suggested it is inappropriate to assume that deviations of farm input prices, farm output prices, and nonfarm output prices from their trend levels entirely reflect the effects of unanticipated inflation. One should instead account for a variety of other factors that could plausibly explain short-run changes in these relative prices. These factors would include changes in demand and supply conditions beyond those due to unanticipated changes in inflation. Assuming such factors can be isolated and unanticipated changes in inflation are due to unanticipated changes in the money supply's growth rate, an appropriate strategy would be to analyze the effects of monetary shocks on relative rates of inflation while controlling for the effects of these other factors.

Specifically, Belongia suggests that the difference between the inflation rates for farm and nonfarm products be regressed on a constant; current and lagged values of anticipated money supply growth; current and lagged values of unanticipated money supply growth; current and lagged values of the difference between farm and nonfarm output growth; and dummy variables to reflect the effects of events such as the Nixon price controls. According to Belongia, one could then test for the neutrality of inflation by testing the restrictions that the coefficients on anticipated money growth are jointly equal to zero and that the sum of the coefficients on unanticipated money growth is equal to zero. Using this approach and quarterly data from 1954:I to 1984:II, he was unable to reject the neutrality hypothesis.

While Belongia's critique of the S-M-W study is well taken, the alternative test he suggests also has serious shortcomings. Indeed, Belongia himself considered his alternative to be merely indicative that testing for the effects of unanticipated inflation on relative inflation rates is more complicated than is suggested by S-M-W. Nonetheless, it will be useful to specify some of our criticisms of his test to motivate the procedures we will eventually follow.

If the actual money supply growth process has an autoregressive component, which seems plausible a priori, then current anticipated money supply growth will be correlated with lagged values of unanticipated money supply growth. In fact, in the simplest case where the money supply growth process can be entirely characterized as an autoregressive process, it will have an equivalent representation in terms of only current and past values of money supply innovations.[1/] Consequently, unless the effects of unanticipated money supply changes are completely dissipated within a single period, regressions of relative price changes on distributed lags of anticipated and unanticipated money supply growth are very difficult to interpret. This is simply a version of the multicollinearity problem in linear regression models. A closely related problem is that money supply shocks may influence the dynamic behavior of the relative growth in output between the farm and nonfarm sectors, inducing substantial correlation between those two sets of regressors. Finally, the use of current relative prices as a dependent variable and relative output as an explanatory variable raises the same concerns about simultaneous equation bias that pertain to the S-M-W regressions.

In the next section, we suggest an alternative framework that enables us to account for Belongia's criticisms of the S-M-W study while avoiding some of the pitfalls inherent in his own testing strategy. The framework we employ combines causality testing and innovation accounting procedures developed previously by Sims (1972, 1980). Similar methods have been used by Bessler (1984) and by Chambers (1984) in related contexts. Bessler was primarily concerned with the relationship between unanticipated inflation and relative price in Brazil.

Chambers focus was on U.S. data; however, he was particularly concerned with very short-term relationships over a very short sample period.

Chambers uses monthly data over the 1976:5-1982:5 time period and analyzes the within year responses of the ratio of the food consumer price index to the nonfood consumer price index to money supply shocks within the context of a VAR that also includes agricultural exports and farm income among its variables. Since we are primarily concerned with re-evaluating the Starleaf, Meyers, and Womack data, we use annual data (1929-83). Chambers considered a lag length of up to six months for the unconstrained VAR before settling upon a lag length of four months. We find, however, that with annual data a lag length of one year is too short, and we adopt a two-year lag length. While we do not include farm income among our variables, unlike Chambers, we do, include a measure of supply side movements by using the difference between farm and nonfarm sector output growth rates.

One feature of Chambers's specification we find a bit strange is his inclusion of a trend variable on the right hand side of each equation of the VAR. If we look at the ratio of the farm sector NNP deflator to the nonfarm sector NNP deflator, which is our closest measure to the ratio of food to nonfood price indices, it is apparent that the 1976-82 period was generally characterized by cyclical growth in the farm sector NNP deflator relative to the nonfarm sector's NNP deflator. Removing the trend in this ratio over that period could easily obscure the bulk of the short-term effects of monetary shocks on relative prices. This could account for the fact that while we find, like Chambers, that positive money supply shocks generate increases in the price of farm sector output relative to the price of nonfarm sector output, we also find, unlike Chambers, that monetary shocks have been as important source of variability in these relative prices.

The Theoretical Model

Assume that the difference between the rate of inflation in farm output and farm input or nonfarm outprice prices (RELINF) is subject to outside disturbances in the form of supply (SUP) shocks, foreign demand (XDEM) shocks, and domestic demand shocks, which we represent by money supply (M1) shocks. To avoid the imposition of prior exogeneity-endogeneity restrictions among these variables it will be convenient to assume that their relationship can be characterized by the n-th order vector autoregression (VAR):[2/]

$$[I-A(L)] \begin{bmatrix} RELINF(t) \\ SUP(t) \\ XDEM\ (t) \\ M1(t) \end{bmatrix} = U(t). \qquad (1)$$

In (1), I is the 4 x 4 identity matrix; $A(L) = A(1)L + \ldots + A(n)L^n$ where A(s), s=1,...,n, is a 4 x 4 matrix of constants and L is the lag operator; and, U(t) is the 4 x 1 innovation vector whose elements can be contemporaneously correlated according to the constant and finite, 4 x 4 variance-covariance matrix Σ. We assume that the roots of the characteristic equation, $\det[I - A(z)] = 0$, all exceed one in modulus to assure stationarity (in the wide-sense) of the [RELINF(t) ... M1(t)] process.[3/]

In our empirical work the time index t denotes a particular year and we used the following measures of the variables in (1):

RELINF = RELINF1 or RELINF2 or RELINF3

where

RELINF1 = prices received by farmers for all farm products minus prices paid by farmers for production items;

RELINF2 = farm output price deflator minus farm input price deflator;

RELINF3 = farm net output NNP deflator minus nonfarm NNP deflator.

SUP = real farm sector NNP minus real nonfarm sector NNP.

XDEM = real farm sector exports.

M1 = nominal money stock, M1.

All variables were measured as growth rates, which we calculated according to $\log_e X(t) - \log_e X(t - 1)$. A constant term was included in each regression. The sample period is 1929 to 1983. Data sources are given in the appendix.

Suppose, for the moment, that the true values of the sequence A(1),...,A(n) were known a priori. Consider the problem of deducing the effects of an unanticipated money supply growth change on the relative inflation rate between farm outputs and farm inputs (or nonfarm outputs). In terms of system (1), the unanticipated change in the money supply's growth rate in period t, given information available prior to t, is equal to $u_4(t)$. Notice that even if the coefficients on lagged money supply growth in the first equation of (1) are identically equal to zero, monetary shocks could still have a persistent effect on the relative inflation rate. For example, if lagged values of the money supply's growth rate enter the second equation of (1) with nonzero coefficients, and if lagged values of SUP(t) enter the first equation with nonzero coefficients, then monetary shocks would have persistent effects on RELINF even if the coefficients of lagged M1 in the first equation of (1) were all equal to zero. Alternatively, suppose that RELINF can be characterized as a purely autoregressive process so that the coefficients on lagged values of SUP, XDEM, and M1 are all equal to zero in (1), but that $E[u_1(t)u_4(t)] \neq 0$. In this case, where the innovations in RELINF and M1 are contemporaneously correlated, unanticipated changes in money supply growth would also have a persistent effect on RELINF.

The preceding discussion illustrates two problems that occur generally in vector autoregressions and make their direct economic interpretation difficult: (1) the complicated interrelationships across coefficients in different equations and (2) the contemporaneous correlation across the elements of the innovation vector. Consider the second of these problems first. In terms of system (1) we are primarily concerned with the effects of money supply growth shocks on the evolution of the system, particularly RELINF. If, however, the unanticipated change in M1(t), $u_4(t)$ is correlated with other elements of U(t), then it is not clear what distinguishes a monetary shock from other shocks to the system.

Assuming that none of the four elements of U(t) is perfectly correlated with any of the other elements, each element of U(t) will have a component that is orthogonal to the other three elements. Let $v_i(t)$ denote the component of $u_i(t)$ that is orthogonal to the other elements of U(t) and let V(t) denote $[v_1(t),...,v_4(t)]'$. Presumably when we talk about the effects of a pure unanticipated money supply shock on the system's behavior, we mean the effects of $v_4(t)$, the orthogonal component of the money supply's innovation. The problem remains, however, as to how to disentangle U(t) to obtain V(t). One such strategy was suggested by Sims (1980). Consider the second moment matrix of U(t), Σ, which we will assume for now is known a priori. Since Σ is symmetric and positive definite, it can be decomposed into the product PP' where P is a 4 x 4 nonsingular, lower triangular matrix.[4/] Next, consider the vector $P^{-1}U(t)$ and notice that its variance-covariance matrix is simply the 4 x 4 identity matrix. In other words, premultiplying the innovation vector U(t) by P^{-1} generates a vector of orthonormal random variables, which we will denote as V(t). With this in mind we can rewrite system (1) as:

$$P^{-1}\ [I - A(L)] \begin{bmatrix} \text{RELINF}(t) \\ \text{SUP}(t) \\ \text{XDEM}(t) \\ \text{M1}(t) \end{bmatrix} = V(t). \qquad (2)$$

Since P^{-1} is lower triangular, it is apparent from (2) that the effect of the transformation is to recast the VAR into a system that is Wold-recursive. Consequently it is natural to interpret $v_i(t)$ as being an orthogonal innovation emanating out of the distinct sector of the economy correspoding to the i-th dependent variable. Notice also, however, that the VAR does not have a unique Wold causal representation (i.e., the matrix P is not unique but instead will depend upon how the variables in the system are ordered). We will return to this problem in the next section.

Having rewritten the system in terms of orthogonal innovations, we return to the first problem of how to characterize the response of the system's dependent variables to shocks emanating from different sectors of the system. Since I - A(L) is invertible we can rewrite (1) in terms of its moving average representation:

$$\begin{bmatrix} \text{RELINF}(t) \\ \text{SUP}(t) \\ \text{XDEM}(t) \\ \text{M1}(t) \end{bmatrix} = \{[I - A(L)]^{-1}P\}V(t). \qquad (3)$$

Let $\{[I-A(L)]^{-1}\ P\} = B(L)$ where $B(L) = B(0) + B(1)L + B(2)L^2 + \ldots.$ Next, let $b_{ij}(s)$ denote the i, j-th element of B(s) where $i,j = 1,\ldots,4$ and $s = 0,1,2,\ldots$ Then,

$$\text{RELINF}(t) = \sum_{s=0}^{\infty} [b_{11}(s)v_1(t - s) + b_{12}(s)v_2(t - s) + b_{13}(s)v_3(t - s) + b_{14}(s)v_4(t - s)] \qquad (4)$$

so that the response of RELINF(t) to current and past money supply growth shocks can be characterized by the infinite sequence $b_{14}(s)$, s = 0,1,2,... Given knowledge of A(L) and Σ (and, hence, P), Sims has shown that the $b_{14}(s)$ sequence can be deduced:

Set: RELINF(t - s) = SUP(t - s) = XDEM(t - s) = M1(t - s) = 0, s > 0; $v_1(t + s) = v_2(t + s) = v_3(t + s) = v_4(t + s) = 0$, s > 0; $v_1(t) = v_2(t) = v_3(t) = 0$; and, $v_4(t) = 1$. Next, premultiply V(t) by P to obtain U(t) (i.e., set U(t) equal to the fourth column of P).[5/] Then use (1) to deduce RELINF(t), RELINF(t + 1),..., RELINF(t + k) for any nonnegative integer k. Following this procedure, RELINF(t + s) = $b_{14}(s)$. In the process, simulated values for SUP(t + s), XDEM(t + s), and M1(t + s) will have been generated and these values are equal to $b_{24}(s)$, $b_{34}(s)$, and $b_{44}(s)$ respectively. By duplicating this procedure with $v_1(t) = 1$ and $v_2(t) = v_3(t) = v_4(t) = 0$, one can obtain $b_{11}(s)$, $b_{21}(s)$, $b_{31}(s)$ and $b_{41}(s)$. The remaining elements of B(L) are obtained similiarly.

It is clear from the derivation of the lag distribution B(0), B(1),..., that $b_{ij}(k)$ can be interpreted as the k step-ahead impulse response of variable i to an orthogonal unit shock in variable j, all else equal. Thus the shape of the discrete function $b_{14}(s)$ can tell us something about the direction and timing of changes in RELINF in response to M1 shocks. One way to measure the importance of such shocks in explaining the actual behavior of RELINF over the sample would be to consider the sequence $d_{14}(k)$, where:

$$d_{14}(k) = \sum_{s=0}^{k} b_{14}^2(s) / \left[\sum_{j=1}^{4} \sum_{s=0}^{k} b_{1j}^2(s) \right] \quad (5)$$

Thus $d_{14}(k)$ is a measure of the proportion of the total k step-ahead variance in RELINF [given by the denominator in (5)] attributable to orthogonal money supply shocks. The closer $d_{14}(k)$ is to unity, the more important are money shocks relative to other shocks in explaining RELINF.

Empirical Analysis

Since A(L) and Σ are not known a priori, the strategy described in the preceding section cannot be applied directly. Instead we will replace these matrices with estimated values. If the order of A(L), were known exactly, A(L) could be efficiently estimated by applying OLS to each of the equations in (1).[6/] Then Σ could be approximated by the sample second moment matrix of the residual vector $[u_1(t),\ldots,u_4(t)]$. In the absence of prior knowledge of n there is no widely accepted procedure as to how to estimate its value. Here we will use a test previously suggested by Sims. According to Sims, the test statistic $(T - k)(\ln \det \Sigma_{n_1} - \ln \det \Sigma_{n_2})$ will be asymptotically distributed as $X^2(q)$ under the null hypothesis that $A(n_1 + 1),\ldots,A(n_2) = 0$ where: Σ_{n_i} is the sample contemporaneous variance-covariance matrix of the residuals in (1) obtained from OLS regressions for a lag length of n_i, T is the sample size, k is the number of coefficients per equation in the unrestricted system ($k = 4n_2 + 1$, $n_2 > n_1$), and q is the total number of restrictions tested [$q = (n_2 - n_1) \times 16$]. Since we are considering annual data, we assumed that n would be fairly small and did not consider values of n larger than three. The test results, which are summarized in Table 1, led us to fix n at a value of two. We then estimated A(1), A(2), and Σ as described above.

In any ordering chosen, orthogonal shocks assumed to emanate from the sector represented by the first variable can be immediately reflected in all of the variables in the VAR. The first variable, however, cannot be immediately affected by orthogonal shocks emanating elsewhere in the system. The last variable in the ordering can be immediately affected by shocks emanating from any sector in the system. Consequently one should order the variables so that the "more exogenous" factors appear prior to "less exogenous" factors. Since the ordering implied by this criteria will be largely subjective, it is generally worthwhile to consider more than one ordering. We initially considered two alternative orderings: M1 - XDEM - SUP - RELINF and RELINF - SUP - XDEM - M1. The first of these orderings seemed to be the most natural one based upon a priori economic reasoning while the second simply reverses the first.

Impulse Responses

The simulated responses of the various measures of the relative inflation rate to the orthogonal component of a money supply growth shock are summarized in Table 2. We have only listed the first six moving average coefficients because a twelve year period simulation indicated that the responses are essentially completed within the first several years following the shock. In all cases, (i.e., regardless of the ordering or the measure of relative inflation) the predominant response to a positive money supply shock is an increase in the growth rate of farm output prices relative to the growth rate of farm input and nonfarm output prices. The paths of the responses are very similar, too. The main difference is that in ordering II the responses to a money shock occur with a lag of one period whereas in ordering I they are instantaneous. This is a consequence of the ordering itself (i.e., with RELINF placed before M1 in the ordering it is not possible for an M1 shock to instantaneously affect RELINF). Thus, we are led to conclude that to the extent that money supply shocks influence the difference between the inflation rate for farm output prices and farm input or nonfarm output prices, they do so in a positive direction.[7]

Variance Decomposition

The question that remains unanswered is how significant money supply shocks have been relative to other kinds of shocks in generating movements between farm output and farm input (or nonfarm output) inflation rates? One way to attack this question was suggested at the end of Section 3. That is, we can compute the impulse responses of RELINF sequentially to each of the four types of orthogonal shocks and calculate the sequence $d_{1j}(k)$, $j = 1,\ldots,4$ defined by (5). In Table 3 we summarize our findings for each of the three measures of RELINF and for $k = 0,1,2$. We did not go beyond $k = 2$ in the table because we found, virtually uniformly that $d_{1j}(2 + s) \approx d_{ij}(2)$ for $s > 0$. According to the results in the top half of the table, which pertains to ordering I, money supply innovations do make a substantial contribution to RELINF at all- time horizons while accounting for approximately 20 to 40 percent of the total variance in RELINF depending upon which measure of RELINF is used.[8/] Moreover, money supply shocks have consistently larger impacts than the impacts originating from export or relative supply shocks.

In the lower half of Table 3 we present the variance decomposition implied by the extreme alternative ordering (RELINF-SUP-XDEM-M1). Again we do not report our results for $k > 2$ since they appear to be virtually identical to those obtained for $k = 2$. In this case, however, we obtain quite different results. Its own innovations account for at least 70 percent of the forecast error variance in RELINF at all time horizons. Monetary innovations explain less than 10 percent of the forecast error variance in RELINF at all horizons. This result would, in and of itself, indicate that monetary innovations play such a small role in explaining the behavior of RELINF that any economic significance attached to the impulse responses themselves would be extremely tenuous. In fact, these results indicate a good possibility that RELINF is exogenously determined with respect to the remaining variables in this system.[9/]

In an effort to reconcile the different implications that would be drawn from the two orderings, we experimented with a number of other orderings and found that as long as M1 appeared prior to RELINF in the causal ordering the results appeared to be consistent with those presented in the top half of Table III. However, whenever RELINF appeared prior to M1, the results more closely approximated those in the lower half of the table. Thus the significance that one attaches to monetary shocks in terms of explaining the difference between the rates of inflation for farm output and farm input (or nonfarm output) will depend upon whether one perceives money growth to be causally prior to relative inflation rates or the reverse. The former is the generally accepted ordering.

Causality Tests

To pursue this issue one step further, consider the following two alternative hypotheses.

> **Hypothesis I:** RELINF(t) is exogenous with respect to the [SUP(t), XDEM(t), M1(t)]' process and M1(t) is not exogenous with respect to the [RELINF(t), SUP(t), XDEM(t)]' process.

> **Hypothesis II:** M1(t) is exogenous with respect to the [RELINF(t), SUP(t), XDEM(t)]' process and RELINF(t) is not exogenous with respect to the [SUP(t), XDEM(t), M1(t)]' process.

While it is possible that neither hypothesis is correct, it is not possible for both to be correct. If I is correct but II is not, it would suggest that M1(t) is not causally prior to RELINF(t) and thus lend further support to the argument that monetary shocks do not form an important explanatory factor with respect to RELINF(t). If, however, hypothesis II is not rejected while I is, then it would lend support to the argument that monetary shocks are important in the determination of RELINF(t).

Sims (1972) has shown in a more general context that a necessary and sufficient condition for hypothesis I to be correct, given system (1), is that in (1), $a_{i,1,k} = 0$ for i = 1,...,n and k = 2,3,4 while $a_{i,4,k} \neq 0$ for some (i,k) such that i = 1,...,n and k = 1,2,3 where $a_{i,j,k}$ denotes the jk-th element of A(i). Similarly, a necessary and sufficient condition for hypothesis II to be correct is that $a_{i,4,k} = 0$ for i = 1,...,n and k = 1,2,3 while $a_{i,1,k} \neq 0$ for some (i,k) such that i = 1,...,n and k = 2,3,4.

Consider first the restriction that $a_{i,1,k} = 0$, i = 1,...,n and k = 2,3,4. This restriction requires that the coefficients on lagged values of SUP(t), XDEM(t), and M1(t) are identically equal to zero in a regression whose dependent variable is RELINF(t) when lagged values of RELINF(t) are included among the regressors. We can test this restriction using an F-test. For n = 2, we found the F-statistic to equal 2.19, 2.96, and 2.53 when the dependent variable was RELINF1(t), RELINF2(t), and RELINF3(t), respectively. Under the null hypothesis, this statistic is distributed as F(6,41). Therefore we would reject H_o at the five percent significance level for RELINF2 and RELINF3 and at the 10 percent level for all three variables. Therefore, these results indicate that hypothesis II is more likely to be true than is hypothesis I.

Next consider the restriction that $a_{i,4,k} = 0$, i = 1,...,n and k = 2,3,4. This restriction requires that the coefficients on lagged values of RELINF(t), SUP(t), and XDEM(t) are identically equal to zero in a regression whose dependent variable is M1(t) when lagged values of M1(t) are included among regressors. For n = 2, we computed F-statistics of 1.33, 1.17, 1.12 as we used RELIF1(t), RELINF2(t), and RELINF3(t). These F values, which are distributed as F(6,41) under the null, would typically be interpreted as being consistent with the null hypothesis, given that the null cannot be rejected at conventional significance levels.

Therefore we are led to conclude on the basis of these tests that hypothesis II seems much more plausible than hypothesis I. Consequently it seems more reasonable to place M1 prior to RELINF in the causal ordering than the reverse regardless of which measure of RELINF we choose. We have argued previously that under such a causal ordering it appears monetary shocks play a substantial role in explaining differences between the rates of inflation for farm output prices and farm input (or nonfarm output) prices.

Conclusion

This study examines the effects of unanticipated inflation on the terms of trade for farmers. Using annual data for the 1929-83 period and innovation accounting methods developed by Sims, we find results consistent with the conclusions of an earlier study by Starleaf, Meyers, and Womack. Specifically, we find unanticipated inflation to be an important determinant of terms of trade for agriculture, such that unanticipated increases (decreases) in the general inflation rate tend to improve (worsen) the terms of trade from the farmer's point of view. The results are somewhat consistent with earlier findings by Chambers (1984), who used similar empirical methods but with monthly data and a much shorter sample period. Our main differences are that we find monetary shocks to be much more important and their effects to be more persistent.

Table 1. Lag length tests

$$Y(t) = \sum_{s=1}^{n} A(s)Y(t - s)+U(t), \; H_o:A(n) = 0$$

$$Y(t) = [RELINF\ SUP\ XDEM\ M1]'$$

	S^b =
RELINF1[a]	
n=2	26.57
n=3	11.96
RELINF2	
n=2	27.13
n=3	12.80
RELINF3	
n=2	24.79
n=3	9.90

[a]RELINF1 = prices received by farmers minus prices paid by farmers for production items

RELINF2 = farm output price deflator minus farm input price deflator

RELINF3 = farm net output NNP deflator minus nonfarm NNP deflator

[b]Under H_o, $S = (T - k)(\ln \det \Sigma_R - \ln \det \Sigma_u) \sim X^2\ (q)$ where T = numbers of observations, k = number of coefficients per equation in the unrestricted system, Σ_R = sample contemporaneous variance-covariance matrix of U(t) in the restricted system, Σ_u = sample contemporaneous variance-covariance matrix of U(k) in the unrestricted system, q = number of restrictions tested.

Table 2. Responses of relative inflation fates K years after orthogonal innovations in money supply growth

Relative Inflation Measure	K	Ordering I[a]	Ordering II[b]
		------Impulses	Responses------
<u>RELINF1</u>			
	0	.026	.000
Growth in prices received by farmers	1	.024	.012
minus growth in prices paid by farmers	2	.008	.014
	3	-.006	.016
	4	-.009	-.007
	5	-.003	-.006
<u>RELINF2</u>			
	0	.031	.000
Growth in farm output price deflator	1	.025	.014
minus growth in farm input price	2	.008	.019
deflator	3	-.009	.000
	4	-.009	-.010
	5	.000	-.004
<u>RELINF3</u>			
	0	.053	.000
Growth in farm net output NNP deflator	1	.041	.021
minus growth in nonfarm NNP deflator	2	.013	.031
	3	-.013	.003
	4	-.010	-.013
	5	.000	-.007

[a]Ordering I: Money Growth-Export Growth-Relative Output Growth-Relative Inflation.

[b]Order II: Relative Inflation-Relative Output Growth-Export Growth-Money Growth.

Table 3. Percentage of K year ahead forecast error variance in relative inflation attributable to orthogonalized shocks

Ordering I

Relative Inflation Measure	K	Shock in:	Money Growth	Export Growth	Relative Output Growth	Relative Inflation
	0		29.6	14.4	0.1	55.3
RELINF1	1		40.4	12.4	0.7	46.5
	2		35.4	20.2	5.8	38.6
	0		18.2	16.6	0.2	65.1
RELINF2	1		23.7	16.2	7.0	53.0
	2		22.0	19.3	11.2	47.5
	0		20.2	14.5	0.0	64.8
RELINF3	1		26.7	12.0	7.8	53.5
	2		24.8	14.7	12.4	48.1

Ordering II

Relative Inflation Measure	K	Shock in:	Relative Inflation	Relative Output Growth	Export Growth	Money Growth
	0		100.0	0.0	0.0	0.0
RELINF1	1		87.2	1.1	7.4	4.3
	2		73.0	3.0	15.2	8.8
	0		100.0	0.0	0.0	0.0
RELINF2	1		79.5	16.1	1.4	3.0
	2		71.9	15.9	4.9	7.4
	0		100.0	0.0	0.0	0.0
RELINF3	1		82.4	14.8	0.1	2.7
	2		74.5	15.1	2.7	7.6

Appendix

The data for the farm output price deflator, farm input price deflator, farm net output NNP deflator, nonfarm NNP deflator, farm sector real NNP, and nonfarm sector real NNP were obtained from the National Income and Product Accounts of the United States and July issues of the Survey of Current Business. The data for the prices received and paid by farmers were collected from USDA agricultural statistics books. Farm Exports and M1 money supply were obtained from U.S. Foreign Agricultural Trade Statistical Reports and Business Statistics, respectively.

Footnotes

1. That is, if the money supply's growth rate can be represented as an AR(p) process, then, under suitable regularity conditions, it can also be represented as an MA(∞) process. In this case, the anticipated component of money supply growth would be perfectly correlated with past innovations.

2. Sims (1980) suggested that unconstrained vector autoregressions can provide a very useful basis for the interpretation of economic time series in the absence of credible and widely agreed upon prior structural restrictions.

3. This condition is simply a generalization of the condition that for an AR(1) process to be covariance stationary it is necessary that the AR coefficient be less than one in absolute value.

4. The most common way to perform the decomposition is through a Choleski factorization.

5. This assumes that the equations are initially ordered as they are written in (1).

6. This follows because the disturbance vector in (1) is serially uncorrelated and each equation in (1) has the same explanatory variables.

7. The results we report are based upon regressions that included a zero-one dummy variable in the first equation of (1) to account for the Nixon wage-price freeze during the early 1970s. None of our results changed substantially when the dummy was excluded. We also considered the system for the post WWII period and the results were very similar to the results reported in Tables 2 and 3.

8. The proportion of the k-step ahead forecast error variance in x(t) attributable to shocks in y(t) will converge to the proportion of the total variance in x(t) attributable to shocks in y(t) as k becomes sufficiently large.

9. An exogenous variable will be characterized by nearly all of its forecast error variance being self determined when the variable appears first in the causal order. See Doan and Litterman (1983, p. 11-18).

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