Nonneutral Effects of Money Supply on Farm and Industrial Product Prices

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Working Paper 86-WP 16
November 1986

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Introduction

Changes in relative prices or terms of trade, i.e., the ratio of farm output to farm input or nonfarm output prices, have significant implications for the farm economy. If the prices farmers receive for their outputs increase (decrease) relative to the prices they pay for their inputs, the economic well being of farmers is enhanced (diminished). The terms of trade are likely to change if general price inflation changes. Thus, movements in general price inflation can affect farm income significantly.

Recent macroeconomics literature postulates that to the extent that general inflation can in and of itself generate relative price changes, it is only the unanticipated inflation can do so. And, fully anticipated inflation has no effect on relative prices. This study examines the effect of unanticipated inflation generated by unanticipated changes in the money supply's growth rate on relative prices, and derives the implications for farm income.

Section II presents a brief survey of past studies on this issue. Section III explains the Vector Autoregression (VAR) technique, developed and popularized by Sims, which is used for the analysis. Section IV discusses empirical results obtained from the VAR methods. Finally, Section V sets forth the conclusions.

Previous Research

A considerable amount of work has been completed on the effects of inflation or money supply on relative prices; yet there remain significant differences of opinion about how relative prices change in response to money supply or inflation shocks.

Changes in relative prices occur continuously in response to changes in real income, family composition, and many other determinants of demand, on the one hand, and to changes in technology, resource availability, and other determinants of supply on the other hand. In addition to these demand and supply effects, it has been argued that money growth has significant effects on relative prices. In an early work, Cairnes (1873) clearly explained that, in the short-run, movements in commodity prices largely depend on demand and supply elasticities and on the first round effects of monetary changes. Cairnes predicted that prices of crude products would respond more rapidly than those of manufactured goods because of the fixity in supply of crude products. Furthermore, the short-run effects of new gold on different commodity prices depended upon who received the new money (the first round), and on the commodities on which this new money was spent.

Using contract theory, Bordo (1980) extended Cairnes' traditional approach to explain the pattern of commodity price adjustment to monetary change in a fix-flex price framework. His proposition is that the more variable the prices are, with other aspects constant, the greater the risk inherent in maintaining long term contracts, and hence, the shorter the contract negotiated. The shorter the contract, the more responsive (more flexible) would that industry's price be to the monetary change. Bordo's empirical results, consistent with his hypothesis, revealed that agricultural commodity prices tend to respond more rapidly than industrial commodity prices to monetary changes. That is, agricultural products are traded in well-developed auction markets on shorter contracts and agricultural prices are more variable and, hence, respond more rapidly to monetary changes.

Parks (1978) tested a proposition, widely believed among macroeconomists, that the anticipated monetary expansion and resulting anticipated inflation will not have an effect on movements in relative prices. Only unanticipated inflation can cause changes in relative prices. The results in Park's study clearly showed that fully anticipated inflation had no effect on changes in relative prices, whereas unanticipated inflation had a distinct effect on relative prices.

The following studies reflect the development of this subject in agricultural economics literature.

Using the Granger causality test, Barnett, Bessler, and Thompson found that money supply causes agricultural prices and that a causality link from agricultural prices to money supply does not exist. Their study looked at only the causal relationship between money and agricultural prices and did not examine the nonneutrality of money supply on relative prices.

Tweeten (1980, 1983), in a series of studies, presented evidence that the general inflation raised prices paid by farmers more than it raised prices received by farmers and thus the terms of trade are worsened by general price inflation. Prentice and Schertz (1981) regressed the ratio of prices received to prices paid on the GNP deflator. They found that the terms of trade are not significantly related to GNP deflator. Gardner and Chambers (1983) did not find a significant empirical relationship between general price level changes and farm output-farm input price ratios.

Chambers (1984), using the Vector Autoregression Technique, examined the effects of money supply shocks on relative prices--the ratio of food consumer price index to nonfood consumer price index. He also included farm net exports and farm income in the estimation. His results indicated that, in the short run, money supply shocks have positive impacts on relative prices.

Bessler (1984), applying Vector Autoregression to Brazilian data, investigated the dynamic relationships between money supply, agricultural product prices, and industrial product prices. He found that under a usual monetarist ordering (money first, then prices) agricultural prices do not adjust faster than industrial prices. But under an ordering that places money last in a contemporary causal chain, the hypothesis that agricultural price adjusts faster than industrial price was weakly supported.

In a recent study, Starleaf, Meyers, and Womack (1985) examined the impact of inflation on relative prices. In their study, they regressed the growth rate of farm output prices on a constant and on growth rate of farm input (or nonfarm) output prices. The point estimates of the slope coefficients in these regressions are significantly greater than one, indicating that a 1 percent increase (decrease) in the farm input or nonfarm output price inflation rate is systematically associated with a more than 1 percent increase (decrease) in the farm output price inflation rate. Their results present evidence that farmers are benefited by an acceleration of the general price inflation rate.

Falk, Devadoss, and Meyers (1986) applied Sims' (1980) innovation accounting methods to examine the inflation effects on terms of trade. They also included relative outputs of the farm and nonfarm sectors to account for the supply effects, and farm exports to account for demand effects in their Vector Autoregression model. Falk, et al., concluded that unanticipated increases (decreases) in the general inflation rate have had a significant and favorable (unfavorable) impact on the terms of trade for farmers.

One crucial point to note is that most of the studies fail to distinguish between unanticipated and anticipated general price inflation. This distinction is very important because, as mentioned earlier, it is only the unanticipated inflation that can generate changes in relative price changes.

Model

The relationship among the money supply and farm and nonfarm product prices can be represented by an n-th order vector autoregression (VAR):

$$(1) \qquad A(L) \begin{bmatrix} MS(t) \\ FPP(t) \\ IPP(t) \end{bmatrix} = \varepsilon(t)$$

where A(L) is a matrix polynomial equal to $I + A_1L + \ldots + A_nL^n$ in the lag operator (L), and $A_1, \ldots, A_n$ are 3 × 3 matrices of parameters. MS is the U.S. M1 money supply, FPP is U.S. farm product prices, and IPP is U.S. industrial product prices. $\varepsilon(t)$ is 3 × 1 innovation vector of contemporaneously correlated, normally distributed error terms with zero mean and finite covariance matrix Σ.

Even though the above autoregressive (AR) representation of the model is convenient unambiguous interpretation of money supply shocks is difficult because of (a) contemporaneous correlation across the elements of the innovation vector and (b) complicated interrelationships across coefficients in the three equations (see Falk, Devadoss, and Meyers for further details).

Contemporaneous correlation among the elements of the innovation vector can be solved by transforming $\varepsilon(t)$ to an orthogonal innovation vector $\xi(t)$ whose elements are contemporaneously uncorrelated. This transformation is done by premultiplying the innovation vector $\varepsilon(t)$ by a lower trianglar matrix Z^{-1} such that $\xi(t) = Z^{-1}\varepsilon(t)$ has a variance-covariatance matrix equal to the identity I. The common approach used to obtain Z is to apply Cholesky factorization to decompose the contemporaneous covariance (Σ) of the untransformed innovations, i.e., $\Sigma = ZZ'$.

Multiplying the system (1) by Z^{-1} we get

$$(2) \qquad Z^{-1} A(L) \begin{bmatrix} MS(t) \\ FPP(t) \\ IPP(t) \end{bmatrix} = \xi(t).$$

The above transformation involves triangularizing the system so that the innovations of the first variable in the given ordering contemporaneously affect the values of all other variables, while the innovation of the second variable contemporaneously affects the values of all but the first variable in the system, and so on. In other words, the effect of this transformation is to recast the VAR into Wold causal chain form. Consequently, an unambiguous interpretation to shocks in any one element of $\xi(t)$ is possible because of the orthogonality of the disturbances across equations.

The second problem of complicated interrelationships across coefficients is solved, as suggested by Sims, by transforming the system (2) into a moving average (MA) representation. If the matrix polynomial A(L) is invertible (see, for example, Granger and Newbold (1971) for invertibility conditions), we can rewrite the system (2) as MA representation

$$(3) \qquad \begin{bmatrix} MS(t) \\ FPP(t) \\ IPP(t) \end{bmatrix} = \left[\bar{A}^{1} (L)\ Z\right] \xi(t) = B(L)\ \xi(t),$$

where $\left[A^{-1}(L)\ Z\right] = B(L) = B(0) + B(1) + B(2)L^2 + \ldots\ldots$.

The (i,j) element of Bs can be interpreted as the impact or impulse response of variable i to an orthogonal unit shock in variable j. Thus, the MA representation makes it easier to identify the effects of shocks in the innovations.

One important point to note is that the matrix Z is not unique. Rather, it depends on the ordering of the variables. Thus, impulse responses could change significantly if the ordering of the variable changes. In this study two orderings (MS - FPP - IPP and FPP - IPP - MS) were considered. The first of these two orderings is consistent with the existent theory that money supply is "more exogenous" and thus it appears first. The second ordering is justified from the point of view that monetary authority considers movements of prices in setting money supply targets.

Empirical Results

Monthly data of M1, FPP, and IPP for the period January 1960 through December 1985 were used for the analysis. The data for M1 (million $) was obtained from St. Louis Federal Reserve Bank. The FPP data measured at the farm level as prices received by farmers were obtained from the Division of Agricultural Statistics of the U.S. Department of Agriculture. The IPP measured at the wholesale level was collected from the various issues of the Economic Report of the President. All the variables were represented in natural logs and a constant term was included in each regression. The RATS computer program by Doan and Litterman (1983) was used to estimate the VAR model. Since the disturbance vector in (1) is serially uncorrelated and each of the three dynamic equations includes the same regressors, OLS estimators are efficient estimators.

Since coefficients in B matrices in (3) are not directly estimable, one approach is to estimate the autoregressive model by unconstrained least squares and then invert the estimated A(L) to obtain the Bs. The first step in estimating A(L) is to determine the order of A(L). In the absence of prior knowledge of n, there is no widely accepted procedure to estimate its value. Consequently, numerous test procedures (Anderson, 1971; Sims, 1980; and Tiao and Box, 1981) have been suggested to choose the lag length order. In this study, we use Sims' likelihood ratio test. The test statistic $(T-k)(\ln \det \Sigma_{n_1} - \ln \det \Sigma_{n_2})$ is 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 ($k = 3n_2 + 1$), $n_2 > n_1$), and q is the total number of restrictions tested ($q = (n_2 - n_1) \times 9$). The test was conducted for lag 2 vs. lag 1, lag 3 vs. lag 2, and so on. The resulting statistic for lags 13 vs 12 is 33.798 with 9 degrees of freedom, which suggests that the autoregression matrices for lag 13 are highly significantly different from zero. Thus, the autoregressive order of 13 is chosen for the analysis.

The problem of interest in this investigation is the dynamic responses of farm and industrial product prices to a unit shock in the orthogonal innovations of money supply, i.e., unanticipated money supply (equal to unanticipated inflation) shock. The simulated impulse responses for the ordering MS-FPP-IPP are given in Table 1 and Figure 1. The future money supply responses to a unit shock of its own innovations are significantly positive and show a decline from the first period. This indicates that the U.S. monetary system works so that money supply shocks are carried over for more than two years.

The impulse responses of agricultural and industrial prices to the money supply shock are positive. More important, in each period

Table 1. Impulse responses of MS, FPP, and IPP to a one period MS shock of triangularization-order MS, FPP, and IPP (Monthly data, lag length = 13).

Period	MS	FPP	IPP
0	0.0036	0.0018	0.0001
1	0.0045	0.0034	0.0003
2	0.0044	0.0046	0.0005
3	0.0047	0.0058	0.0006
4	0.0040	0.0060	0.0009
5	0.0040	0.0068	0.0015
6	0.0041	0.0084	0.0022
7	0.0038	0.0093	0.0031
8	0.0038	0.0126	0.0034
9	0.0040	0.0128	0.0037
10	0.0037	0.0138	0.0040
11	0.0034	0.0138	0.0042
12	0.0028	0.0137	0.0042
13	0.0023	0.0141	0.0042
14	0.0025	0.0138	0.0044
15	0.0025	0.0138	0.0045
16	0.0026	0.0138	0.0049
17	0.0027	0.0135	0.0051
18	0.0025	0.0132	0.0054
19	0.0026	0.0132	0.0059
20	0.0026	0.0129	0.0064
21	0.0025	0.0125	0.0069
22	0.0025	0.0122	0.0073
23	0.0026	0.0115	0.0078
24	0.0026	0.0112	0.0081

the agricultural prices adjust faster than the industrial process. Bessler (1984) argued that these dynamic relationships among money supply, agricultural prices, and industrial prices are not peculiar to any particular country or to any period of economic conditions. Further, to substantiate his claim, he cited the example of Bordo's findings for the U.S. of substantially the same results as Cairnes' for several countries, on data separated by almost a century. However, Bessler's empirical results for the Brazilian economy over the period 1964-81 rejected Cairnes' theory that agricultural prices adjust faster than industrial prices under usual monetary ordering of money and prices. Thus, his results did not present evidence for his claim that the above described dynamic relationships among money supply, agricultural prices, and industrial product prices is universal. On the other hand, our results present strong evidence to substantiate Cairnes' and Bordo's proposition that agricultural prices adjust faster than industrial prices.

Bessler also considered an ordering that places money last in a contemporary causal chain (FPP-IPP-MS). For this ordering his empirical results weakly support Cairnes' hypothesis. We present our results for the same ordering in Table 2 and Figure 2. From our results, it is very clear that even under the ordering of FPP-IPP-MS the agricultural product prices adjust faster than the industrial product prices in every period. Once again, our results strongly support Cairnes' and Bordo's hypothesis. Our findings are also consistent with the conclusions of Chambers, S-M-W, and F-D-M. The main difference between the impulse responses of both ordering is that in ordering FPP-IPP-MS the responses to a money shock occur with a lag of one period whereas in ordering MS-FPP-IPP they are instantaneous. This is a consequence of the ordering itself, i.e., with prices placed before money supply in the ordering it is not possible for an MS shock to instantaneously affect prices.

In addition to the empirical analysis of dynamic relationships among the three variables, as a further extension of the analysis we examined the effect of money supply shocks on relative prices, RP (the ratio of agricultural product prices to industrial product prices). The simulated responses of the relative prices to the orthogonal money supply are summarized in Table 3 and are also plotted in Figure 3 for the ordering MS-RP. The results for RP-MS ordering are given in Table 4 and Figure 4. For the results to be consistent with Cairnes' hypothesis, we would expect that, regardless of ordering, the impulse responses of RP would be positive. In fact, that is the case with the results presented in Tables 3 and 4. Thus, we are led to conclude that money supply influences relative prices in a positive direction. The implication of these results is that unanticipated money supply changes (inflation) are an important determinant of relative prices or terms of trade for agriculture, such that unanticipated increases (decreases) in the money supply tend to improve (worsen) the terms of trade for the farmers.

In addition to using monthly data to examine this issue, we also conducted the same analysis using quarterly data for the same

Table 2. Impulse responses of MS, FPP, and IPP to a one period MS shock of triangularization-order FPP, IPP, and MS (Monthly data, lag length = 13).

Period	MS	FPP	IPP
0	0.0036	0.0000	0.0000
1	0.0045	0.0015	0.0001
2	0.0043	0.0025	0.0003
3	0.0047	0.0039	0.0003
4	0.0040	0.0044	0.0006
5	0.0040	0.0052	0.0011
6	0.0042	0.0069	0.0018
7	0.0039	0.0078	0.0026
8	0.0038	0.0109	0.0029
9	0.0040	0.0110	0.0031
10	0.0037	0.0122	0.0034
11	0.0034	0.0119	0.0035
12	0.0029	0.0117	0.0034
13	0.0024	0.0121	0.0034
14	0.0026	0.0118	0.0035
15	0.0027	0.0120	0.0036
16	0.0027	0.0121	0.0039
17	0.0028	0.0119	0.0041
18	0.0027	0.0116	0.0043
19	0.0028	0.0117	0.0048
20	0.0028	0.0114	0.0052
21	0.0027	0.0111	0.0057
22	0.0027	0.0109	0.0062
23	0.0028	0.0101	0.0065
24	0.0028	0.0099	0.0069

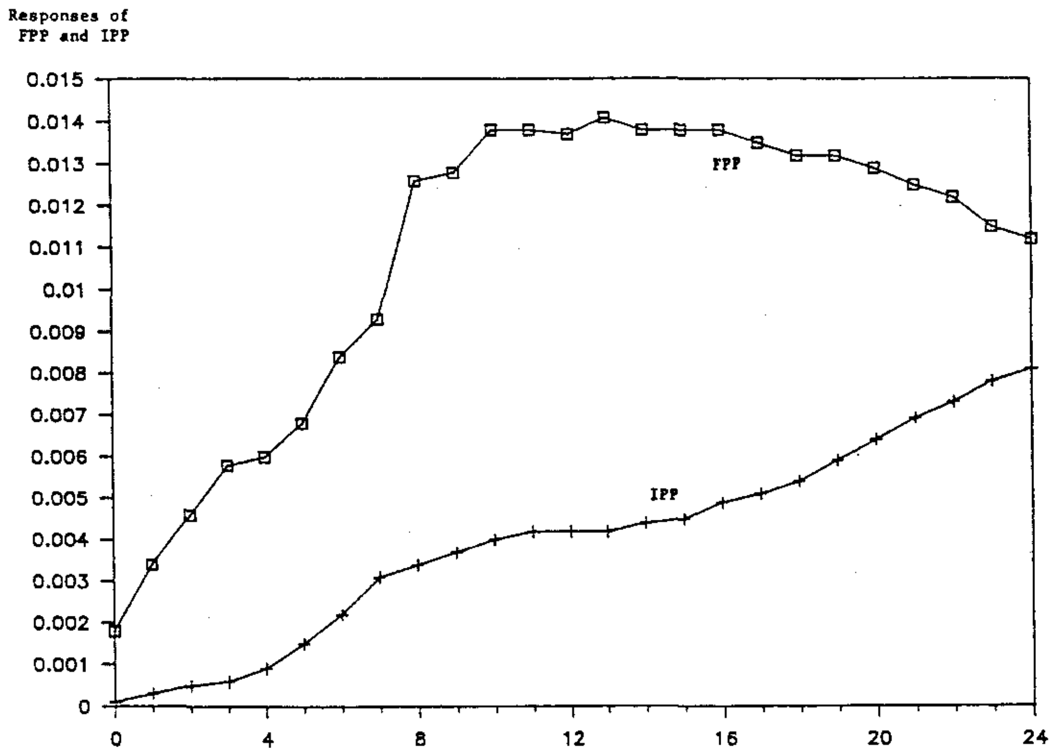

Figure 1. Effect of innovation in MS on FPP and IPP for the ordering MS, FPP and IPP (monthly data).

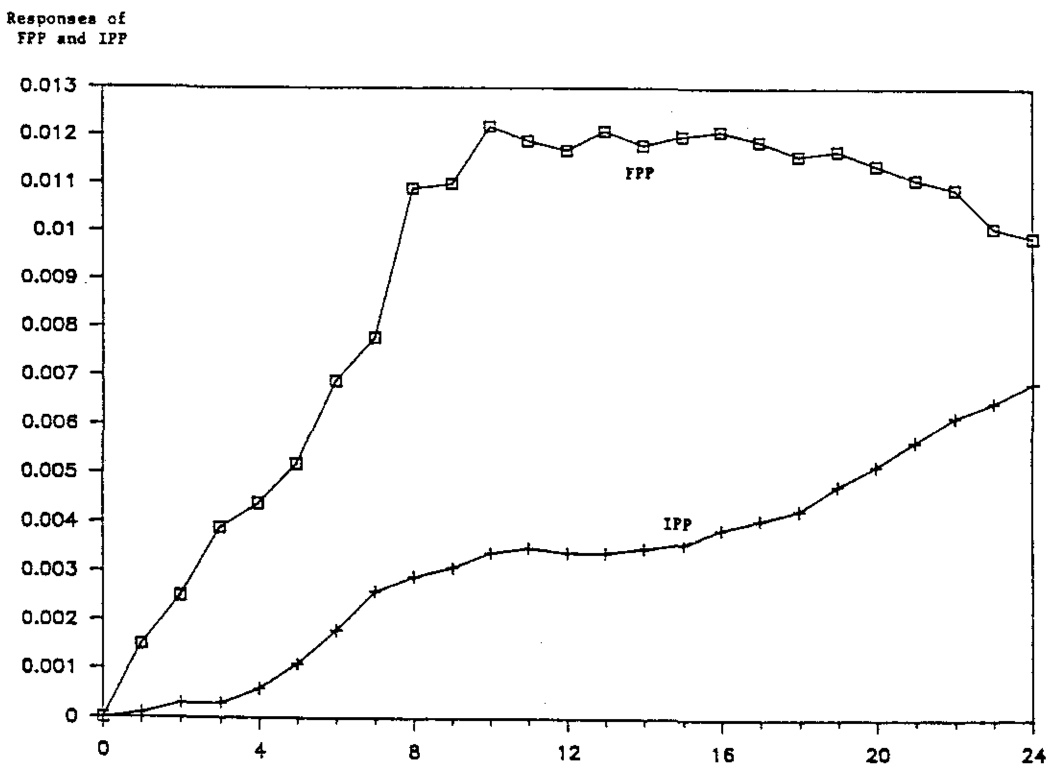

Figure 2. Effect of innovation in MS on FPP and IPP for the ordering FPP, IPP, and MS (monthly data).

Table 3. Impulse responses of MS and RP to a one period MS shock of triangularization-order MS and RP (Monthly data, lag length = 13).

Period	MS	RP
0	0.0038	0.0017
1	0.0047	0.0036
2	0.0046	0.0049
3	0.0050	0.0061
4	0.0044	0.0064
5	0.0045	0.0067
6	0.0047	0.0077
7	0.0045	0.0077
8	0.0045	0.0110
9	0.0048	0.0110
10	0.0045	0.0123
11	0.0042	0.0124
12	0.0037	0.0127
13	0.0033	0.0132
14	0.0034	0.0125
15	0.0034	0.0120
16	0.0034	0.0111
17	0.0034	0.0106
18	0.0034	0.0096
19	0.0034	0.0094
20	0.0034	0.0086
21	0.0033	0.0081
22	0.0033	0.0076
23	0.0034	0.0067
24	0.0034	0.0064

Table 4. Impulse responses of MS and RP to a one period MS shock of triangularization-order RP and MS (Monthly data, lag length = 13).

Period	MS	RP
0	0.0038	0.0000
1	0.0047	0.0016
2	0.0046	0.0027
3	0.0050	0.0041
4	0.0043	0.0048
5	0.0045	0.0050
6	0.0047	0.0062
7	0.0044	0.0061
8	0.0044	0.0093
9	0.0047	0.0094
10	0.0044	0.0108
11	0.0042	0.0109
12	0.0037	0.0111
13	0.0033	0.0116
14	0.0034	0.0108
15	0.0034	0.0105
16	0.0034	0.0097
17	0.0035	0.0094
18	0.0034	0.0085
19	0.0034	0.0082
20	0.0034	0.0075
21	0.0033	0.0070
22	0.0033	0.0066
23	0.0034	0.0058
24	0.0035	0.0055

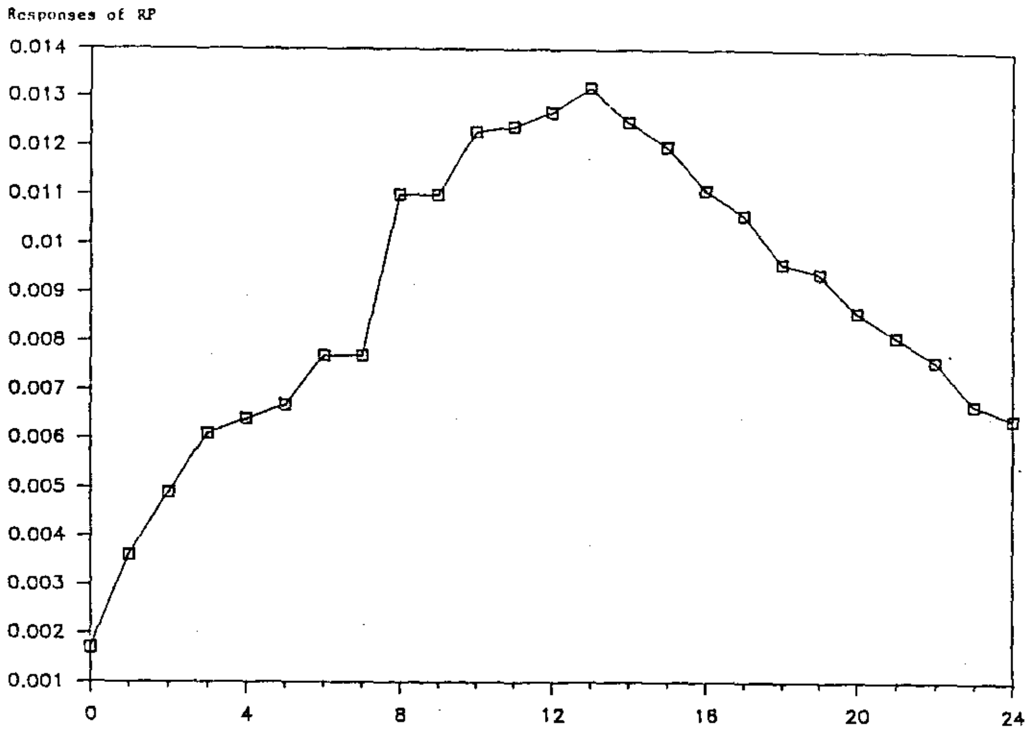

Figure 3. Effect of innovation in MS on RP for the ordering MS and RP (monthly data).

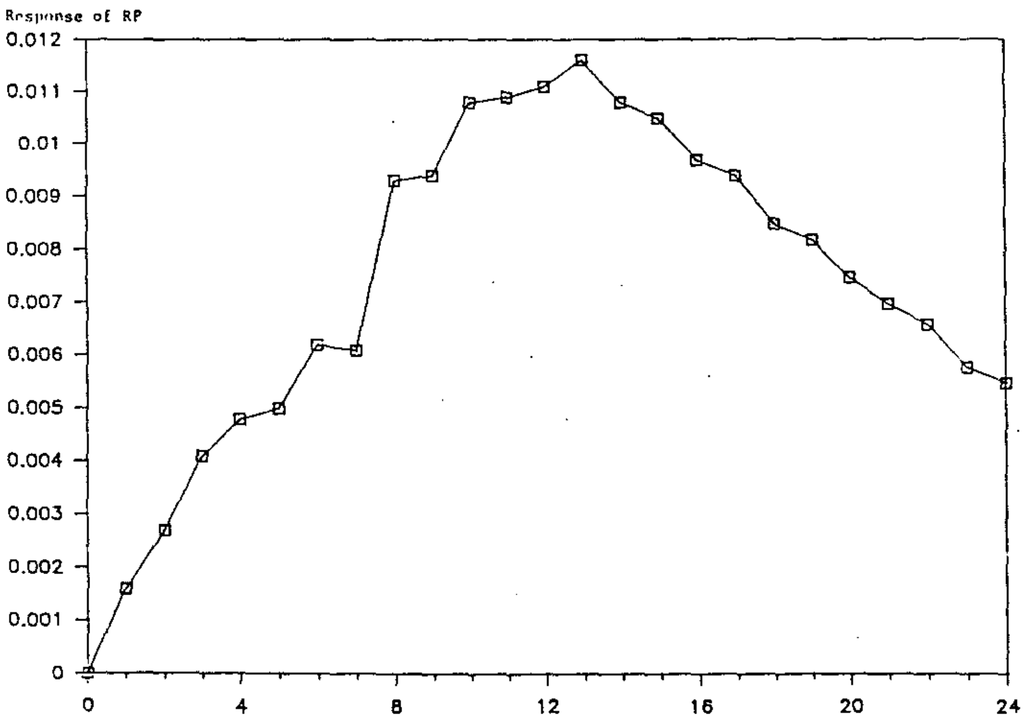

Figure 4. Effect of innovation in MS on RP for the ordering RP and MS (monthly data).

period as that of monthly data. First, we applied the Sims likelihood ratio test, as described above, to determine the lag length for the quarterly model. A 5 lag model was selected, based on the test statistic of 30.586 with 9 degrees of freedom. The results for various orderings and measures of prices are given in Tables 5, 6, 7, and 8, and Figures 5, 6, 7, and 8. Once again, the Once again, the results from the quarterly data confirm Cairnes' and Bordo's hypothesis that agricultural prices adjust faster to money suppy shocks than industrial product prices.

Conclusions

This study examines the effects of unanticipated money supply or unanticipated inflation on relative prices. Using both monthly and quarterly data for the period 1961/85 and the innovation accounting methods developed by Sims, we find results that are consistent with Cairnes' and Bordo's hypothesis that money supply shocks have nonneutral effects on relative prices because agricultural prices respond faster than industrial prices. Our results also support the proposition of other contemporary studies on the relationship between money and relative prices by Chambers (1984); Starleaf, Meyers, and Womack (1985); and Falk, Devadoss, and Meyers (1986). However, a very similar study by Bessler for the Brazilian economy contradicts the results of these studies.

Specifically, we have presented evidence in this paper that unanticipated money supply is an important determinant of terms of trade for agriculture. Furthermore, a rise (fall) in unanticipated money supply tends to increase (decrease) the terms of trade to farmers. Thus, the economic wellbeing of farmers is enhanced by an increase in unanticipated inflation.

Table 5. Impulse responses of MS, FPP, and IPP to a one period MS shock of triangularization-order MS, FPP, and IPP (Quarterly data, lag length = 5).

Period	MS	FPP	IPP
0	0.0063	0.0100	0.0012
1	0.0073	0.0125	0.0029
2	0.0065	0.0199	0.0064
3	0.0062	0.0250	0.0087
4	0.0041	0.0292	0.0098
5	0.0035	0.0274	0.0112
6	0.0035	0.0261	0.0132
7	0.0032	0.0241	0.0155
8	0.0033	0.0211	0.0178
9	0.0031	0.0188	0.0191
10	0.0028	0.0176	0.0198
11	0.0026	0.0163	0.0200

Table 6. Impulse responses of MS, FPP, and IPP to a one period MS shock of triangularization-order FPP, IPP, and MS (Quarterly data, lag length = 5).

Period	MS	FPP	IPP
0	0.0060	0.0000	0.0000
1	0.0071	0.0036	0.0006
2	0.0066	0.0107	0.0034
3	0.0062	0.0158	0.0049
4	0.0045	0.0187	0.0046
5	0.0042	0.0179	0.0050
6	0.0043	0.0175	0.0064
7	0.0041	0.0165	0.0084
8	0.0043	0.0139	0.0102
9	0.0044	0.0123	0.0113
10	0.0042	0.0120	0.0119
11	0.0041	0.0118	0.0124

Table 7. Impulse responses of MS and RP to a one period MS shock of triangularization-order MS and RP (Quarterly data, lag length = 5).

Period	MS	RP
0	0.0066	0.0105
1	0.0080	0.0137
2	0.0076	0.0186
3	0.0076	0.0225
4	0.0060	0.0275
5	0.0052	0.0251
6	0.0052	0.0203
7	0.0051	0.0162
8	0.0053	0.0116
9	0.0054	0.0086
10	0.0053	0.0069
11	0.0052	0.0054

Table 8. Impulse responses of MS and RP to a one period MS shock of triangularization-order RP and MS (Quarterly data, lag length = 5).

Period	MS	RP
0	0.0064	0.0000
1	0.0078	0.0036
2	0.0074	0.0091
3	0.0074	0.0134
4	0.0060	0.0190
5	0.0053	0.0176
6	0.0054	0.0139
7	0.0054	0.0109
8	0.0056	0.0074
9	0.0057	0.0053
10	0.0056	0.0042
11	0.0056	0.0033

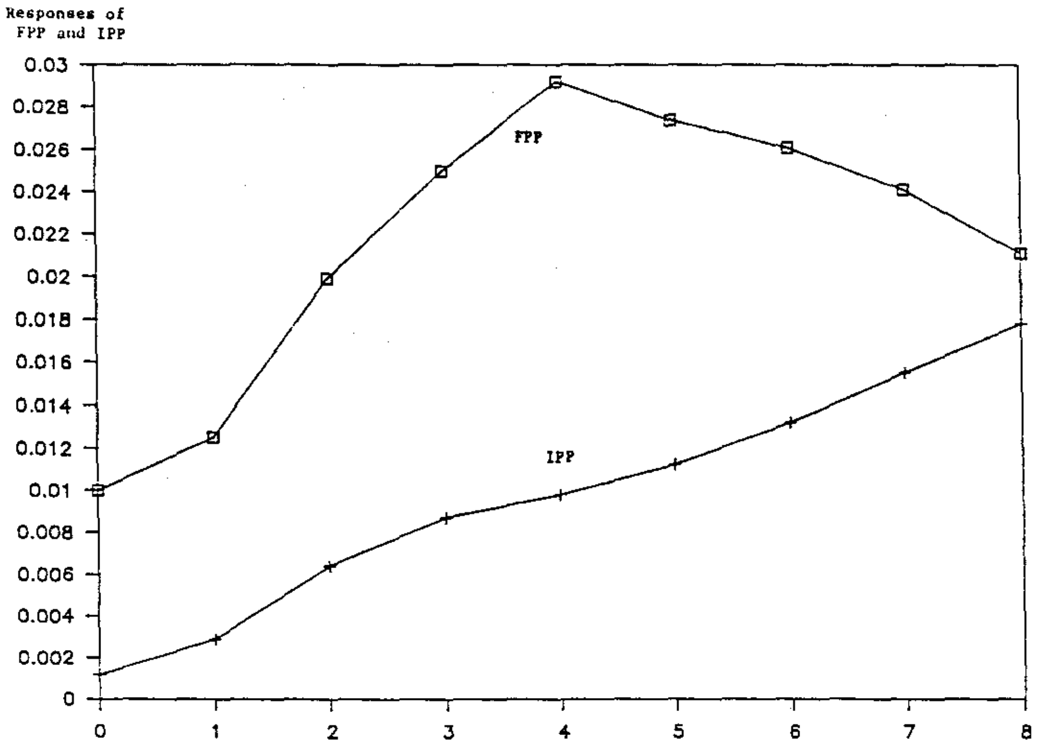

Figure 5. Effect of innovation in MS on FPP and IPP for the ordering MS, FPP, and IPP (quarterly data).

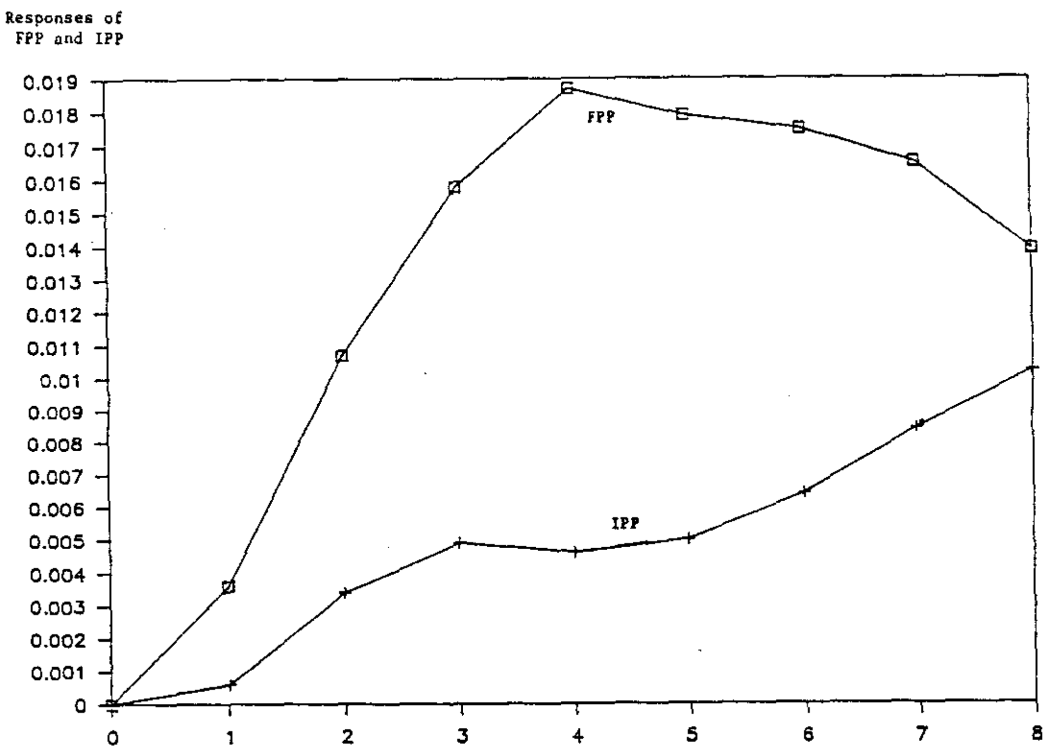

Figure 6. Effect of innovation in MS on FPP and IPP for the ordering FPP, IPP, and MS (quarterly data).

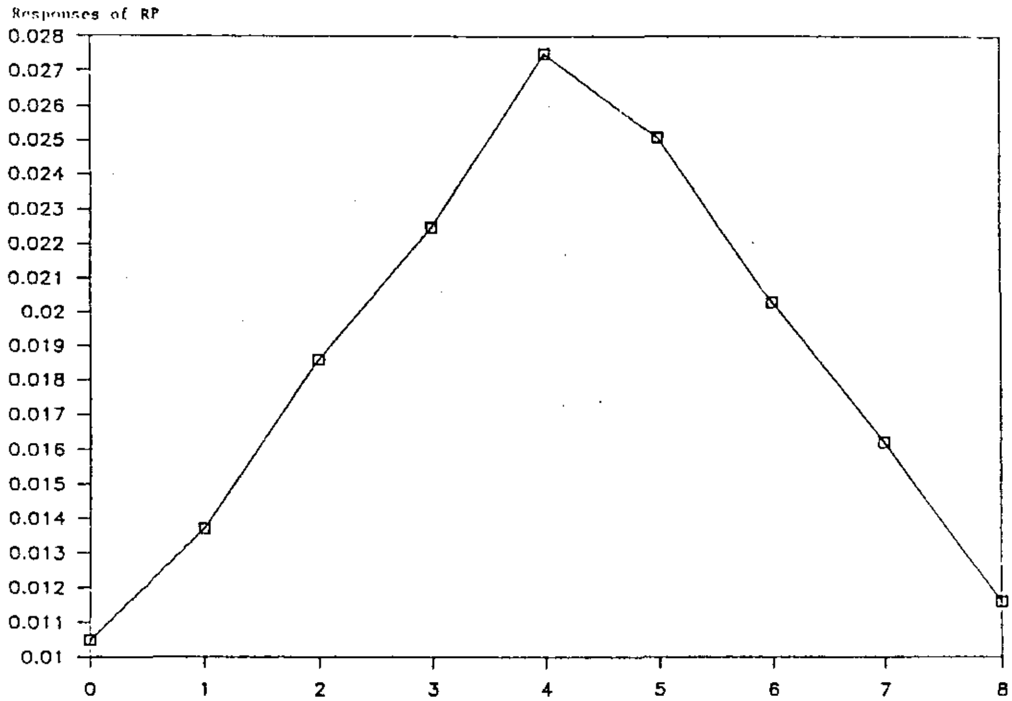

Figure 7. Effect of innovation in MS on RP for the ordering MS and RP (Quarterly data).

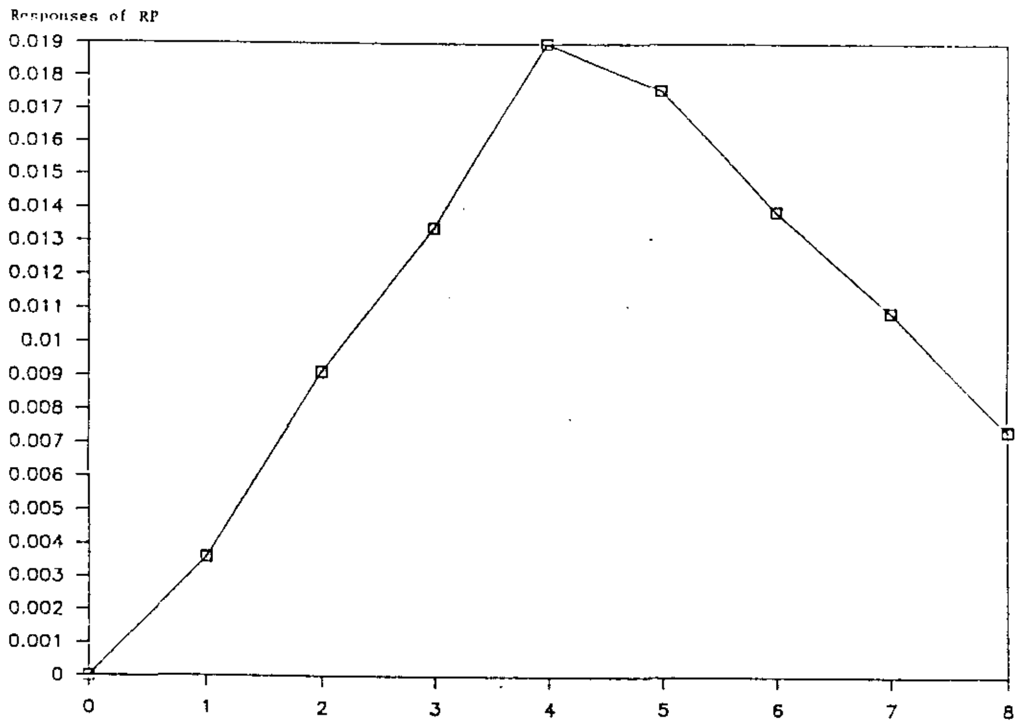

Figure 8. Effect of innovation in MS on RP for the ordering RP and MS (Quarterly data).

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