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OVERSHOOTING OF AGRICULTURAL PRICES*

1. Introduction

A review of the agricultural economics literature over the past 15 years reveals a growing interest in the effects of macroeconomic aggregates, especially monetary instruments, on the U. S. farm sector. The possibility that the prosperity of U. S. agriculture in the early 1970s and its demise during the early 1980s could be linked to major changes in the macroeconomic environment during those periods induced several researchers to take a closer look at the interaction between agriculture and the rest of the U. S. economy.

The high correlation between degree of "easiness" in monetary policy and the behavior of relative prices of farm products during the early 1970s, and again in the late 1970s, appears to support this view. The expansion of the U. S. money supply to accommodate oil price increases has often been associated with a dramatic increase in real commodity prices. In contrast, the squeeze in the credit markets resulting from a tight money supply and the high budget deficit during the early 1980s is associated with a depression in real agricultural prices and incomes.

Although casual observation suggests a relationship between money supply and relative farm prices, two other sources of impact on the agricultural sector should be recognized before the effects of monetary policy may be accurately assessed: (1) exogenous shocks to demands and supplies of agricultural commodities not related to macroeconomic policy and (2) public policy directed at the farm sector. Exogenous shocks during the early 1970s include the move to flexible exchange rates and the ensuing dollar devaluation, the decrease in barriers between agriculture and other sectors of the economy, and the growth in demand for U. S. exports by less developed and communist countries; all could be associated with increases in real farm prices. At the same time, agricultural policy led to the elimination of the large governmental grain stocks that had accumulated during the 1960s which also contributed to the increase in real farm prices.

Similarly, the experience of the early 1980s could be associated with several other factors related to (1) and (2) above, besides the tight monetary policy environment. One important exogenous factor is the effort of foreign governments to support farm income which resulted in subsidies that encouraged production increases and caused export markets for U. S. products to shrink. And U. S. agricultural policy in the 1980s brought large income transfers to the farm sector through deficiency payments combined with relatively ineffective supply control schemes which are at least partially responsible for several record crops.

While the stylized facts establish a correlation between money and relative farm prices, no agreement exists on the significance of this relationship. Empirical results range from a significant relationship between the size of the money supply and real commodity prices (Chambers and Just, 1982) to no relationship at all (Batten and Belongia, 1984). Part of the explanation for these opposite outcomes is the alternative theoretical macroeconomic paradigms which imply quite different price behaviors. Within a strict monetarist framework, for instance, monetary changes should have no effect on relative prices either in the short or long run.

It is important to stress relative prices for two reasons: (1) A policy that leaves relative prices of agricultural products unchanged is of no interest from a policy perspective. (2) Admitting monetary policy effects on relative prices requires identification of the special characteristics that separate or distinguish the farm sector from other sectors of the economy. Therefore, a model is needed that distinguishes agriculture from other sectors so that the effects of monetary policies on the farm sector can be isolated.

In what follows, a theoretical model is constructed that allows the separation between fix-price and flex-price markets. Agriculture is assumed to be a flex-price sector while manufactures and services are assumed to be sticky-price markets. But this classification is not a tight one. There are nonagricultural markets characterized by price flexibility, and there are cases in which farm prices exhibit downward stickiness (e.g., when supported prices for grains constitute price floors).

Despite these exceptions, the above distinction underlines the basic characteristics of agricultural and nonagricultural markets. In agriculture, day-to-day trading, widely disseminated information, and use of several agricultural commodities as financial assets make prices sensitive to changes in demands, supplies, and expectations. In manufactures and services, long-term contacts and costly adjustments to changes in market conditions, limit price responsiveness.

In a world in which all prices are flexible, a monetary shock is instantly translated into proportional changes of prices in all markets--leaving relative prices unchanged. Money neutrality, in that case, holds for both the short run and the long run. But where some prices are sticky, a change in nominal money is also a change in real money. For an increase in the money supply, the reduction in the interest rate causes portfolio shifts between storable commodities, financial assets, and currency. Under certain conditions, the prices of commodities overshoot their long-run equilibrium. Using a variant of a model originally developed by Dornbusch (1976) to explain exchange-rate fluctuations, we show that, following a monetary shock, prices of agricultural commodities may overshoot their long-run equilibrium if prices in the rest of the economy are sticky.

In Section 2, the basic model of price adjustment is presented along with the conditions necessary for the overshooting result to arise. By relaxing some of the assumptions in the basic model, it is shown that, even in the presence of inflexible prices for some sectors, overshooting of flexible prices may not occur if certain conditions hold. Thus, whether overshooting occurs or not becomes an empirical question. In Section 3, empirical evidence on differential price adjustment to changes in money growth is presented. Brief reviews of past findings are included along with some new empirical evidence. In Section 4, concluding remarks are made and some policy implications are given.

2. The Basic Model

The theoretical model presented in this section is a variant of Dornbusch's (1976) overshooting model constructed to explain movements in flexible exchange rates. In Dornbusch's model, the prices of all goods are assumed to be sticky, adjusting less rapidly than asset prices. While our analysis also focuses on exchange rate fluctuations, Dornbusch's model is altered to include a flexible commodity market. In a similar analysis, Frankel and Hardouvelis (1985) expressed the model in terms of prices of commodities and manufactures.

As in Dornbusch (1976), we assume that uncovered interest parity holds; i.e.,

$$r = r^* + x \tag{1}$$

for

r = the domestic short-term moninal interest rate

r* = the foreign short-term nominal interest rate

x = the expected rate of depreciation or appreciation of the domestic currency where the exchange rate (E) is defined as the domestic currency price of the foreign country's currency (for the case of the U. S., dollars per unit of foreign currency).

In this simplified version of the model, we consider the "domestic" country to be a small country which implies that the nominal interest rate adjusted for expected depreciation equals the (given) foreign rate. Implicit in the equation are the assumptions of perfect substitutability between domestic and foreign interest-bearing instruments (one-bond world), absence of risk premia, and perfect capital mobility.

The expected rate of depreciation or appreciation is defined as being proportional to the gap between the exchange rate and its long-run equilibrium value (bars denote long-run values)

$$x = \Theta\ (\bar{e} - e), \qquad \Theta > 0 \tag{2}$$

where e is the logarithm of the exchange rate. The above regressive expectations scheme simply says that if the spot rate exceeds its long-run value, which is assumed known, then investors expect the rate to gradually appreciate at a speed of adjustment equal to θ. In the long run, and in the absence of disturbances, $e = \bar{e}$ and $x = 0$. Equations (1) and (2) together imply that, for long-run equilibrium, $r = r^*$.

For the money market, a standard money demand equation is assumed (Except for r, lower case letters denote logs.):

$$m - q = \phi y - \lambda r \tag{3}$$

m = money supply

q = a composite price index described below

y = real output

λ = the interest rate semielasticity of demand for real balances.

We construct q on the assumption that the economy consists of two sectors (goods)--a flexible-price good and a fix-price good. For the flex-price good (presumably an agricultural or other primary commodity), Purchasing Power Parity (PPP) holds both in the long and the short run. In other words, if by P_A we denote the price of the flex-price commodity and let P_A^* denote its foreign counterpart, the PPP simply says that (in logs):

$$e = p_A - p_A^*. \tag{4}$$

The small country assumption permits us to set an arbitrary value for P^*_A. By setting $P_A^* = 1$, then $p_A^* = \log(P_A^*) = 0$ and equation (4) simply becomes:

$$p_A = e. \tag{5}$$

To construct q, we assume that the underlying utility functions are the Cobb-Douglas type and that construction of the price index requires that prices for the two commodities be weighted by their expenditure shares:

$$Q = (P_N^{\alpha})\ P_A^{(1-\alpha)} \tag{6}$$

and in log form

$$\begin{aligned} q &= \alpha\, p_N + (1 - \alpha)\ p_A \\ &= \alpha\, p_N + (1 - \alpha)\ e \qquad \text{for } 0 \leq \alpha \leq 1 \end{aligned} \tag{7}$$

where P_N is the price of the fix-price good.

When we take into account the whole price index, then real-money demand becomes:

$$m - \alpha\, p_N - (1 - \alpha)e = \phi y - \lambda r. \tag{8}$$

Combining equations (1), (2), and (8), we get:

$$m - \alpha\, p_N - (1 - \alpha)\ e = -\lambda\theta(\bar{e} - e) - \lambda r^* + \phi y. \tag{9}$$

At this stage, we assume a stationary money supply which implies that $m = \bar{m}$ and that interest rates are equalized in the long run ($r = r^*$).

Thus, the long-run version of equation (9) becomes:

$$\bar{m} - \alpha\bar{p}_N - (1 - \alpha)\ \bar{e} = -\lambda r^* + \phi y. \tag{10}$$

From equations (9) and (10) substituting $-\lambda r^* + \phi y$ from equation (10) and assuming that output is fixed (i.e., $y = \bar{y}$), we get:

$$\alpha\,(\bar{p}_N - \bar{p}_N) + (1 - \alpha)\ (\bar{e} - e) = -\lambda\ \theta(\bar{e} - e)$$

or (11)

$$e = \bar{e} - \lambda[(1 - \alpha) + \lambda\ \phi]^{-1}\ (p_N - \bar{p}_N).$$

2.1 Overshooting

Equation (11) states that the spot rate deviates from its long-run equilibrium value by an amount proportional to the deviation of prices in the sticky-price sector from their long-run equilibrium values. The factor of proportionality, $\alpha/[(1 - \alpha) + \lambda\theta]$, depends positively on the relative weight of sticky prices in the price index while it is a decreasing function of the relative weight of flexible prices. From (11), by differentiating with respect to m and noting that $dp_N/dm = 0$ (from the short-run stickiness assumption) and also that $d\bar{P}_N/dm = d\bar{e}/dm = 1$ (long-run neutrality), we find:

$$\frac{de}{dm} = 1 + \frac{\alpha}{(1 - \alpha) + \lambda\,\theta} > 1, \qquad (12)$$

i.e., the exchange rate overshoots its long-run equilibrium following a monetary change. For extreme values of α, we obtain the following:

For $\alpha = 1$, $$\frac{de}{dm} = 1 + \frac{1}{\lambda\Theta}(p_N - \bar{p}_N),$$

which is the result reached by Dornbusch, and

for $\alpha = 0$, $$\frac{de}{dm} = \frac{d\bar{e}}{dm} = 1$$

which is to be expected since, with all prices flexible, a monetary shock causes all prices to return instantly to their long-run equilibrium.

To derive the "overshooting coefficient," $\alpha/[(1 - \alpha) + \lambda\Theta]$, in terms of the parameters of the model, we need to solve for the coefficient of adjustment (θ) of sticky prices. Again, assuming output to be constant in the short run, we specify the rate of change of sticky prices to be a function of the gap between real output and aggregate demand, i.e., we assume disequilibrium in the fix-price markets in which prices adjust to changes in the "inflationary gap" (see also, Dornbusch). Aggregate demand for fix-price output is thus defined as:

$$\ln (D) = u + \delta(e - p_N) + \gamma y - \sigma r \tag{13}$$

where $e - p_N$ is the relative price of domestic output. Excess demand is defined as the difference between actual and potential income or by $(\ln (D) - y)$. Thus, positive excess demand exerts an upward pressure on prices of both inputs and outputs, thereby increasing the price level, while the opposite holds for slack demand.

We can express the above relationship as:

$$\begin{aligned} \dot{p}_N &= \pi[u + \delta(e - p_N) + \gamma y - \sigma r - y] \\ &= \pi[u + \delta(e - p_N) + (\gamma - 1) y - \sigma r]. \end{aligned} \tag{14}$$

Substituting r with $r^* + \theta(\bar{e} - e)$, and recalling that $\bar{e} - e = \alpha[(1 - \alpha) + \lambda\theta]^{-1} (p_N - \bar{p}_N)$ from (11), we have:

$$\dot{p}_N = -\pi\left[\frac{\delta(1 - \lambda\theta) + \alpha\sigma\theta}{(1 - \alpha) + \lambda\theta}\right](p_N - \bar{p}_N). \tag{15}$$

Differentiating (11) with respect to time and substituting $\dot{p}_N$ from (15), we obtain:

$$\dot{p}_A = \dot{e} = \frac{\alpha}{[(1 - \alpha) + \lambda\theta]}\left\{\frac{-\pi[\delta(1 + \delta\theta) + \alpha\sigma\theta]}{[(1 - \alpha) + \lambda\theta]}\right\}(p_N - \bar{p}_N) . \tag{16}$$

By rearranging (11), $(p_N - \bar{p}_N) = \frac{1}{\alpha}[(1 - \alpha) + \lambda\theta] (\bar{e} - e)$, and thus (16) becomes:

$$\dot{p}_A = \dot{e} = \pi \left[\frac{\delta(1 + \lambda\Theta) + \alpha\sigma\Theta}{(1 - \alpha) + \lambda\Theta} \right] (\bar{e} - e) \tag{17}$$

which shows the actual rate of depreciation of the currency and actual rate of growth of p_A. The expected rate of depreciation x is given by (2) as

$$x = \Theta(\bar{e} - e).$$

Perfect foresight expectations requires that both actual and expected rates of depreciation be equal. Thus, the perfect foresight speed of adjustment (Θ) of the system to its long-run equilibrium can be derived from the solution of the quadratic equation:

$$\Theta = \pi \left[\frac{\delta(1 + \lambda\,\Theta) + \alpha\sigma\Theta}{(1 - \alpha) + \lambda\Theta} \right]. \tag{18}$$

From (18), solving for Θ,

$$\Theta = \frac{\pi(\lambda\delta + \alpha\sigma) - (1 - \alpha) \pm \sqrt{(1 - \alpha) - \pi(\lambda\Theta + \alpha\sigma)^2 + 4\lambda\pi}}{2\lambda}. \tag{19}$$

Substitution of (19) into (12) gives the overshooting coefficient in terms of the parameters of the model.

The above model shows that, in a world in which some prices are sticky, the burden of adjustment to a monetary shock is borne by the flexible price sectors. It is also worthwhile to notice that short-run nonneutrality of money holds even though agents have perfect foresight about future price paths.

2.2 Over- vs. Undershooting

It is possible to demonstrate that the fix-price, flex-price separation is a necessary but not sufficient condition for flexible prices to overshoot their long-run equilibrium. Specifically, if we relax the assumption of a fixed real output, it can be shown that the prices in flexible markets may <u>undershoot</u> their long-run equilibrium values following a monetary shock [see also Dornbusch (1976), Appendix]. All the assumptions of section 2.1 hold except that real income is assumed to be sensitive to changes in interest rates over the short run. Thus, the goods markets clear in the short-run, although short-run equlibrium output and prices are different than long-run ones. It is exactly this difference that causes p_N to change. Under the new assumption, (13) becomes:

$$\ln (D) = y = u + \gamma y - \sigma r + \delta(e - P_N) \qquad (20)$$

or

$$y = (\frac{1}{1 - \gamma}) [u - \sigma r + \delta(e - p_N)]. \qquad (21)$$

Prices adjust at a rate π proportional to the difference between short-run and long-run output:

$$\dot{p} = \pi(y - \bar{y}). \qquad (22)$$

Equations (21) and (22) summarize the adjustment to long-run equilibrium of output and prices as a series of short-run equilibria. In the long run, $q = \bar{q}$, $\dot{p}_A = \dot{p}_N = 0$, $y = \bar{y}$. Following a solution process similar to the one in the previous case, the key relationships of the model become:

$$(e - \bar{e}) = -\left\{ \frac{\alpha - \phi\delta\mu}{[(1 - \alpha) + \phi\mu(\delta + \sigma\Theta) + \lambda\Theta]} \right\} (p_N - \bar{p}_N) \qquad (23)$$

where

$$\mu = \frac{1}{1 - \gamma}$$

and α, δ, ϕ, θ, and σ are as defined in the previous section; and

$$\frac{de}{dm} = 1 + \frac{\alpha - \phi\delta\mu}{(1 - \alpha) + \phi\mu(\delta + \sigma\Theta) + \lambda\Theta} \quad . \tag{24}$$

Since the denominator of (24) is always positive, overshooting occurs when $\alpha - \phi\delta\mu > 0$ or $\alpha > \phi\delta\mu$. Equation (24) shows that (for positive Θ) the speed of adjustment of prices does not determine whether or not overshooting occurs but the extent to which flexible prices overshoot their long-run equilibrium.

Comparison of (12) and (24) reveals that the additional terms in (24) summarize the output response to short-run changes in relative prices and the interest rate (δ, σ) as well as the changes in the demands for money and goods caused by the change in output (ϕ, μ).

The perfect foresight solution for Θ (the coefficient of adjustment of prices) is determined by solving the quadratic equation

$$\Theta = \pi \left\{ \frac{\frac{1}{1 - \gamma}\left[\delta(1 + \lambda\Theta) + \alpha\sigma\Theta\right]}{(1 - \alpha) + \phi\mu(\delta + \sigma\Theta) + \lambda\Theta} \right\} . \tag{25}$$

An intuitive explanation of the results in sections 2.1 and 2.2 is as follows: A shock in nominal money that leaves part of the price level unchanged is a shock in real money. The interest rate falls to equilibrate the asset markets that are assumed to be always in equilibrium. The exchange rate depreciates because of the incipient capital outflow and p_A, the price of the commodity, rises instantly due to the PPP condition. Depreciation continues until the expectation of future appreciation justifies the domestic-foreign nominal interest rate disparity. The fall in the interest rate causes demand for domestic output to rise while the fall in the value of the currency causes export demand to rise. As a result, aggregate demand rises along with real output causing sticky prices to rise gradually. As prices rise, real money balances fall, the interest rate rises, and the process is reversed for e and p_A until the system returns to long-run equilibrium.

The basic difference between the two cases of overshooting and (possible) undershooting [summarized in (12) and (24)], is the response of output to interest rate changes and the subsequent effects on the demand for real balances. As output rises following the drop in the interest rate, part of the increase in the supply of money is absorbed, thus reducing the excess supply of money.

A smaller excess supply of money means that a smaller decrease in the interest rate is needed to clear the asset markets. Consequently, the initial domestic-foreign interest rate gap, the currency depreciation, and the rise in p_A will all be smaller than in the case of fixed short-run output.

In summary, the overshooting parameter depends on both the income elasticity of money demand and the interest elasticity of aggregate output. From (24), as ϕ and σ rise, the overshooting parameter falls. Given the share of sticky prices in the price index (α), a positive monetary shock can cause undershooting of flex-prices if ϕ and σ are sufficiently large.[1]

Following the exchange-rate literature, similar models could be constructed in which flexible prices may not overshoot because of wealth effects (Driskill, 1980; Engel and Flood, 1985) or because of sluggish capital mobility, imperfect bond substitutability, etc.[2] It is also possible to imagine situations in which overshooting of the exchange rate does not necessarily imply commodity price overshooting. Grain prices in the United States constitute a good example. Given the structure of the farm sector policy in the United States until 1985, in some instances support prices constituted a lower limit for grain prices. Thus, a drop in the supply of money may not cause grain prices to overshoot downward to the extent that they are close to or at support rates before the shock occurred. In general, any reason that would cause the purchasing power parity assumption to be violated will imply that exchange-rate overshooting will not imply overshooting of commodity prices (Obstfeld, 1986).

3. Price Stickiness, Monetary Policy, and Relative Price Changes

Although the possibility of overshooting of commodity prices could have important implications for commodity-price variability, the single most important implication of the overshooting model is that it provides the theoretical basis for examining the existence of short-run real effects of money and monetary policy on the agricultural sector. While neutrality of money in the long run is widely accepted, less agreement exists among economists as to the short-run relationship between money and relative prices. In his survey of price adjustment studies, Gordon (1982) considers the short-run inertia of prices to be the main point of contention between "auction market theorists" and "disequilibrium theorists."

The overshooting model provides the necessary conditions for monetary policy to have short-run effects on relative prices of different sectors in the economy exhibiting differing degrees of price flexibility. The speed of adjustment of prices was shown to be a function of several parameters characterizing the economic system even in the most simplistic version of the model. Thus, some evidence is needed that would justify the assumption of price stickiness and/or differential price responses (across sectors) to changes in money. To be more specific, for the case of agriculture, some evidence is needed to justify characterizing the agricultural sector as the flexible price sector when compared to manufacturing and services sectors.

Although little doubt exists about the price flexibility of agricultural commodities, evidence (both theoretical and empirical) is needed to justify the assumption of price stickiness of other sectors in the economy. The costliness of continuous adjustment of prices seems to be the prevalent reason for price stickiness in the literature dealing with the microfoundations of macroeconomics.

Mussa (1981) recognizes the theoretical problems that arise in imposing rational expectations on models with sticky prices. He develops a price-adjustment rule that ". . . circumvents these theoretical difficulties and analyzes the essential economic characteristics of this rule" (p. 1021). The rule is derived from a microeconomic model in which there is an explicit cost in continuously changing prices, and thus it is optimal to adjust individual prices only at discrete intervals and by finite amounts. Prices change at such a frequency as to have the marginal gains associated with reducing disequilibrium, equal to the marginal costs of continuous price changing. Also based on the "cost of adjustment" principle is the model by Rotenberg (1982). Like Mussa, he assumes that there are costs associated with changing prices, a fact that makes actual prices slowly respond to desired prices. He builds a dynamic model in which he incorporates a perceived cost of adjustment by firms, and he arrives at a form of the stickiness hypothesis amenable to empirical testing. Estimation of the theoretically derived price path satisfies all the relevant theoretical constraints and seems fairly robust to alternative specifications. The empirical results support the sticky-price hypothesis. A nested hypothesis of a "Walrasian adjustment" (instantaneous price adjustment to contemporaneous changes of money balances) is rejected by the data. As reasons for the sluggish price adjustment, he sites: (1) a small response of aggregate demand to changes in real-money balances and (2) high costs of changing prices perceived by firms. Another important implication comes from the strength that his results gain when food prices and fuel prices are removed from the price index (gross domestic product price deflator). This further supports the fix-price, flex-price separation and the characterization of agriculture as a flex-price sector.

On the empirical side, Gordon (1975) examined the Sargeant-Wallace-Lucas proposition of instantaneous price response to money supply by regressing the quarterly percentage change in the nonfood price deflator on a distributed lag of money supply growth. Although these results show a strong relationship between price changes and money is revealed (lagged coefficients sum up to 1.366 after 28 quarters), only 14 percent of that change is felt by the end of two years and only 35 percent within four years. Gordon's conclusion was that much of the inertia lies in the influence of unemployment on wages.

Bordo (1980) constructed a model in which he related price variability in different sectors to contract length. He concluded that sectors with longer contract lengths exhibit lower price variability. Using price variability as a proxy for price flexibility, he classified commodities as flexible price markets while commodity prices were found to respond more rapidly than prices of manufactures to monetary changes. His empirical results show significant differences between the price behavior of "auction" as compared to "customer" markets as classified by Ocun.

Frankel and Hardouvelis (1985) found that, when a surprise occurs, nominal interest rates and commodity prices move in opposite directions. They argue that this can only be explained using a fix-price, flex-price model. They argue that, if the flex/flex specification were correct, either both rise (if the announcement causes the public to revise upward its expectations of future money growth) or else both fall (if the public revises downward its expectation of future money growth). The only hypothesis that explains the reactions in both the interest rate and commodity markets is that the increase in the nominal interest is also an increase in the real interest rate. This is presumably because the public anticipates that the Federal Reserve will reverse the recent fluctuations in money stock thus increasing interest rates and depressing the real prices of commodities. Lombra and Mehra, in examining the effects of monetary and fiscal policy on different prices, found a larger but slower effect of money on food prices along the marketing chain.

Stamoulis (1985, chapter 3) used the overshooting model to derive testable hypotheses concerning the relationship between the degree of overshooting of farm prices and the number of flexible price markets in the economy. These results corroborated the predictions of the theoretical model in Section 2 and indicated that, as the number of flexible prices increases or, alternatively, as the weight of flexible prices in the general price index increases (α goes down), the degree of overshooting is reduced. This result becomes obvious in equation (12).

Using a combined macroeconomic-agricultural sector model of the U. S. economy, Rausser et al. (1986) demonstrated that monetary policy could have strong short-run effects on relative prices of basic agricultural commodities (wheat, corn, and livestock products). Their results suggest strong real effects of monetary and fiscal policies on the farm sector of the U. S. economy. Finally, Frankel (1986) constructed a theoretical model in which he considered storeable agricultural commodities as assets, linking their prices to the financial markets by the basic arbitrage condition of stockholding (i.e., that the expected rate of change of commodity prices should not exceed the rate of interest). The model produces results similar to those of Section 2 (i.e., if some prices in the economy are characterized by stickiness and if real output is constant in the short run, then flexible prices overshoot their long-run equilibrium).

To test for differential effects of money growth on prices in different sectors, the following model was estimated using percentage changes:

$$\dot{p}_{it} = \alpha_0 + \delta\dot{p}_{i,t-1} + \sum_{j=0}^{K} \beta_j \dot{m}_{t-j} + \sum_{j=0}^{3} \gamma_j \dot{g}_{t-j} \tag{26}$$

where:

$\dot{p}_{it}$ = the growth rate of price index i at time t

$\dot{m}_t$ = the growth rate of money at t

$\dot{g}_t$ = the growth rate of real gross national product (GNP) at t.

The lag length, K, was chosen by maximizing $\bar{R}^2$ over the range of models (differing by the lag length on m) in which money neutrality could not be rejected. A maximum of 12 lags was tried. The index of prices received by farmers (IPRF) was chosen to represent flexible prices while the nonfood component of the consumer price index (CPINF) represented the sticky prices in the economy. Results were also obtained for the consumer price index for food (CPIF). Quarterly dummies were included in all models, and a lagged dependent variable was used to capture partial adjustment effects. The magnitude and significance of that variable could also serve as an indicator of price flexibility.

To account for any possible short-run cyclical effects of output on the path of prices, real GNP growth variables were included in the equations.

Although one could use the above model to classify prices in terms of their flexibility, the focus was on establishing a basis for examining how monetary policy causes relative price changes which affect the farm sector. Thus, results obtained using the IPRF are distinguished from results obtained using the consumer price index for food and beverages (CPIF) which contains a sizable marketing margins component.

Regression results obtained using OLS are reported in Table 1. To test for the neutrality of money, the null hypothesis is that the sum of the coefficients of lagged money equals $(1 - \delta)$ where δ is the coefficient of the lagged dependent variable. The test can be derived from equation (26) by observing that in the long run:

$$\dot{p}_{i,t} = \dot{p}_{i,t-1}$$

and that

$$\dot{m}_{t-j} = \dot{m}_{t-\ell}, \qquad \dot{g}_{t-j} = \dot{g}_{t-\ell}, \qquad \text{for all } j, \ell;$$

thus, the long-run effect of money on prices can be derived as:

$$\dot{p}_{lr}(1 - \delta) = \sum_j \beta_j \dot{m}_{lr} + \sum_j \gamma_j \dot{g}_{lr}$$

and

$$\frac{d\dot{p}_{lr}}{d\dot{m}_{lr}} = \frac{\sum_j \beta_j}{1 - \delta} .$$

So

$$H_0 : \frac{\sum_j \beta_j}{1 - \delta} = 1 \qquad \text{or} \qquad \sum_j \beta_j + \delta = 1. \tag{27}$$

TABLE 1

Regression Results for DIPRF and DCPINF

Variable	DIPRF	DCPINF
C	-4.877 (2.329)[a]	-0.815 (0.720)
$\dot{p}_{t-1}$	0.113 (0.147)	0.692 (0.147)
$\dot{g}_t$	0.267 (0.721)	0.051 (0.135)
$\dot{g}_{t-1}$	0.190 (0.694)	0.068 (0.125)
$\dot{g}_{t-2}$	-0.293 (0.691)	-0.025 (0.120)
$\dot{g}_{t-3}$	1.046 (0.662)	0.043 (0.124)
$\dot{m}_t$	1.568 (0.953)	0.104 (0.189)
$\dot{m}_{t-1}$		-0.099 (0.180)
$\dot{m}_{t-2}$		-0.077 (0.167)
$\dot{m}_{t-3}$		-0.033 (0.172)
$\dot{m}_{t-4}$		0.028 (0.166)
$\dot{m}_{t-5}$		0.144 (0.199)
$\dot{m}_{t-6}$		0.260 (0.176)

(Continued on next page.)

Table 1--continued.

Variable	DIPRF	DCPINF
$\dot{m}_{t-7}$		0.310 (0.167)
m_{t-8}		0.195 (0.174)
m_{t-9}		-0.170 (0.196)
m_{t-10}		0.076 (0.186)
	$\bar{R}^2$ DIPRF = 0.067	$\bar{R}^2$ DCPINF = 0.516

H_0 : $\delta + \beta_0 = 1$ $\qquad$ H_0 : $\delta + \sum_{i=0}^{10} \beta_i = 1$

$F_{1,33}$: 0.482, P > F = 0.491 $\qquad$ $F_{1,33}$: 1.031, P > F = 0.317

[a]Figures in parentheses are standard errors.

Equation (27) thus becomes the null hypothesis for the neutrality test. On the basis of this test and the R^2 criterion, a model with only contemporaneous effects of money growth was chosen for the IPRF index while the results showed that, for the CPINF, a model with 10 lags on money growth was appropriate.

In analyzing the empirical results, several aspects relating to predictions of the theoretical model are of interest. Namely, tests were performed on the differential effects of money on the several price indices, the neutrality hypothesis [as expressed in (27)], the overshooting hypothesis $\left(dp_t^{IPRF}/dm_t > 1\right)$, and the differential speed of adjustment of the various indices (as expressed by the coefficient of the lagged dependent variable).

The instantaneous effect on flexible farm prices is estimated to be 1.57 which suggests overshooting. While the associated standard error is large, the point estimate and the small and insignificant partial adjustment effect are consistent with the price flexibility assumption. In contrast, for the CPINF, both the instantaneous effect and the coefficient and significance of the lagged dependent variable suggest slower adjustment. The sum of the coefficients on money growth and the lagged dependent variable coefficient is not significantly different from 1 by construction. Later lags on money are more significant than earlier ones.

The distinction between a rapid adjustment of farm prices as opposed to a slow one for nonfarm ones is consistent across lag lengths. In fact, a model for farm prices with 10 lags features a larger and more statistically significant instantaneous effect of money growth. To test hypotheses across equations, a second set of results was derived by jointly estimating the preferred models using Zellner's Seemingly Unrelated Regressions (SUR) technique. Note that the results for this approach shown in Table 2 are not substantially different from those presented in Table 1. The joint test for an equal instantaneous response of the two prices to the monetary shock cannot be rejected at the 10 percent significance level.

In the theoretical model of Section 2, overshooting of flex prices to a shock was defined in reference to the long-run equilibrium in which the whole system reaches equilibrium simultaneously (both flex and fixed prices). Since for the case of 10 lags on money growth, the sum of the coefficients does not significantly differ from 1 for either price index and given the selection criterion for lag length, the parameters of the two models were jointly estimated using SUR assuming a lag length of 10 for both. Results are shown in Table 3. The magnitude and significance of the instantaneous effect of money on the IPRF are as suggested by theory. Both the magnitude of the coefficients and t-statistics suggest a strong and significant reaction of IPRF to changes in money growth. An F-test at the 5 percent level revealed that the instantaneous responses of the two prices differ significantly, a result that supports the assumption in the theoretical model. A joint test that the sum of the coefficients on money in each of the models is equal to 1 cannot be rejected at the 5 percent significance level. Results of the tests are also presented in Table 3.

Table 4 includes the results for the best-fitting model for the CPIF. The behavior of this regression is closer to that of the CPINF than it is to the IPRF. Lombra and Mehra (1983) found a larger but slower effect of money growth on food prices the further along the marketing chain, so this is consistent with their results. Table 4 shows that the fourth lag on money growth is the most important of the 12 lags and that the neutrality hypothesis is

TABLE 2

Regression Results for DIPRF and DCPINF

Variable	DIPRF	DCPINF
C	-4.954 (2.329)[a]	-0.883 (0.716)
$\dot{p}_{t-1}$	0.144 (0.146)	0.671 (0.146)
$\dot{g}_t$	0.238 (0.721)	0.059 (0.135)
$\dot{g}_{t-1}$	0.177 (0.695)	0.083 (0.125)
$\dot{g}_{t-2}$	-0.295 (0.691)	-0.027 (0.120)
$\dot{g}_{t-3}$	1.048 (0.662)	0.045 (0.124)
$\dot{m}_t$	1.591 (0.953)	0.109 (0.189)
$\dot{m}_{t-1}$		-0.137 (0.179)
$\dot{m}_{t-2}$		-0.082 (0.166)
$\dot{m}_{t-3}$		-0.045 (0.171)
$\dot{m}_{t-4}$		0.053 (0.165)
$\dot{m}_{t-5}$		0.122 (0.198)
$\dot{m}_{t-6}$		0.296 (0.174)

(Continued on next page.)

Table 2--continued.

Variable	DIPRF	DCPINF
m_{t-7}		0.327 (0.165)
m_{t-8}		0.220 (0.172)
m_{t-9}		-0.175 (0.194)
m_{t-10}		0.120 (0.184)

H_0 : $DM_{IPRF} = DM_{CPINF}$

$F_{1,76}$: 2.016, $P > F = 0.159$

[a]Figures in parentheses are standard errors.

TABLE 3

Regression Results for DIPRF and DCPINF

Variable	DIPRF	DCPINF
C	-8.469 (5.261)[a]	-0.820 (0.720)
$\dot{p}_{t-1}$	0.212 (0.169)	0.667 (0.145)
$\dot{g}_t$	0.474 (1.012)	0.054 (0.135)
$\dot{g}_{t-1}$	1.066 (0.904)	0.068 (0.125)
$\dot{g}_{t-2}$	-0.452 (0.873)	-0.025 (0.120)
$\dot{g}_{t-3}$	1.403 (0.891)	0.040 (0.124)
$\dot{m}_t$	2.778 (1.255)	0.090 (0.188)
$\dot{m}_{t-1}$	-2.192 (1.305)	-0.103 (0.180)
$\dot{m}_{t-2}$	-0.060 (1.234)	-0.079 (0.167)
$\dot{m}_{t-3}$	-0.902 (1.237)	-0.030 (0.172)
$\dot{m}_{t-4}$	1.591 (1.193)	0.026 (0.166)
$\dot{m}_{t-5}$	-1.917 (1.500)	0.151 (0.200)
$\dot{m}_{t-6}$	1.828 (1.226)	0.267 (0.176)

(Continued on next page.)

Table 3--continued.

Variable	DIPRF	DCPINF
m_{t-7}	0.554 (1.164)	0.318 (0.167)
m_{t-8}	0.847 (1.173)	0.206 (0.174)
m_{t-9}	-1.268 (1.238)	-0.153 (0.195)
m_{t-10}	2.501 (1.330)	0.080 (0.186)

H_0 : $DM_{IPRF} = DM_{CPINF}$

$F_{1,66}$: 4.330, $P > F = 0.041$

$$H_0 : \frac{1}{1-\delta} * \sum_{i=0}^{10} \beta_i^{DIPRF} = 1, \quad \frac{1}{1-\delta} * \sum_{i=0}^{10} \beta_i^{DCPINF} = 1$$

$F_{2,66}$: 1.1998, $P > F = 0.308$

[a]Figures in parentheses are standard errors.

TABLE 4

Regression Results for DCPIF

Variable	DCPIF
C	-0.981 (1.401)[a]
$\dot{P}_{t-1}$	0.532 (0.158)
$\dot{g}_t$	0.100 (0.199)
$\dot{g}_{t-1}$	0.459 (0.196)
$\dot{g}_{t-2}$	-0.166 (0.213)
$\dot{g}_{t-3}$	0.072 (0.197)
$\dot{m}_t$	0.066 (0.281)
$\dot{m}_{t-1}$	-0.305 (0.262)
$\dot{m}_{t-2}$	-0.375 (0.276)
$\dot{m}_{t-3}$	-0.028 (0.312)
$\dot{m}_{t-4}$	0.607 (0.245)
$\dot{m}_{t-5}$	-0.005 (0.317)
$\dot{m}_{t-6}$	0.227 (0.269)

(Continued on next page.)

Table 4--continued.

Variable	DCPIF
$\hat{m}_{t-7}$	0.195 (0.267)
$\hat{m}_{t-8}$	0.396 (0.267)
$\hat{m}_{t-9}$	-0.102 (0.274)
$\hat{m}_{t-10}$	0.193 (0.273)
$\hat{m}_{t-11}$	0.447 (0.283)
$\hat{m}_{t-12}$	-0.396 (0.310)

$$H_0 \quad : \frac{1}{1 - \delta} * \sum_{i=0}^{12} \beta_i = 1$$

$F_{1,31}$: 0.344, P > F = 0.562

[a]Figures in parentheses are standard errors.

rejected for shorter lag lengths. Also indicating the stickiness of the CPIF is the large and significant coefficient on the lagged dependent variable.

Finally, Table 5 presents results from the joint estimation (using SUR) of the three equations. For reasons explained above, a 10th order lag was specified for all the equations. No substantial change in the results and the conclusions derived in the previous models occurs although the significance of the instantaneous effect of money on the flexible price index is reduced. Pairwise F-tests for the equality of instantaneous response coefficients across price indices are also shown in Table 5. The hypothesis of equal instantaneous responses between IPRF and CPINF is rejected at the 10 percent significance level. The equality of the IPRF and CPIF responses is rejected at the 5 percent level while the hypothesis of equal instantaneous responses of CPIF and CPINF cannot be rejected.

The extent to which flexible prices overshoot their long-run equilibrium following a monetary shock depends on several parameters, as shown in (12). It is increasing in α (the share of fixed prices in the price index) and decreasing in λ (the semielasticity of money demand with respect to the interest rate). Thus, changes in the economy affecting these parameters can be expected to cause changes in the relationship between price changes and money growth.

It was hypothesized that changes in monetary policy such as the shift to floating exchange rates and the targeting of reserves in October of 1979 could show up as shifts in these parameters. To the extent that moving to floating exchange rates reduced the degree of insulation of some sectors from world prices, α might have fallen in the early 1970s. Similarly, apparent increases in λ over time that were found when a simple money demand equation was estimated suggested that λ had risen with interest rates after 1979.

TABLE 5

Regression Results for DIPRF, DCPINF, and DCPIF

Variable	DIPRF	DCPINF	DCPIF
C	-9.633 (5.232)[a]	-0.824 (0.720)	-1.044 (1.091)
$\dot{p}_{t-1}$	0.000 (0.136)	0.643 (0.145)	0.459 (0.129)
$\dot{g}_t$	0.847 (0.997)	0.056 (0.135)	0.113 (0.205)
$\dot{g}_{t-1}$	1.181 (0.903)	0.068 (0.125)	0.372 (0.189)
$\dot{g}_{t-2}$	-0.287 (0.869)	-0.025 (0.120)	-0.114 (0.189)
$\dot{g}_{t-3}$	1.235 (0.888)	0.036 (0.124)	0.118 (0.185)
$\dot{m}_t$	2.343 (1.298)	0.076 (0.188)	0.065 (0.265)
$\dot{m}_{t-1}$	-1.902 (1.298)	-0.107 (0.180)	-0.279 (0.270)
$\dot{m}_{t-2}$	-0.437 (1.222)	-0.082 (0.167)	-0.224 (0.253)
$\dot{m}_{t-3}$	-0.801 (1.236)	-0.028 (0.172)	-0.180 (0.258)
$\dot{m}_{t-4}$	1.547 (1.193)	0.025 (0.166)	0.513 (0.250)
$\dot{m}_{t-5}$	-1.215 (1.463)	0.159 (0.199)	0.032 (0.315)
$\dot{m}_{t-6}$	1.843 (1.226)	0.274 (0.175)	0.417 (0.264)

(Continued on next page.)

Table 5--continued.

Variable	DIPRF	DCPINF	DCPIF
m_{t-7}	0.736 (1.161)	0.325 (0.167)	0.003 (0.248)
m_{t-8}	1.023 (1.170)	0.216 (0.173)	0.530 (0.244)
m_{t-9}	-0.980 (1.230)	-0.137 (0.195)	-0.088 (0.273)
m_{t-10}	2.398 (1.329)	0.083 (0.186)	0.267 (0.278)

H_0 : $DM_{IPRF} = DM_{CPINF}$

$F_{1,99}$: 3.208, $P > F = 0.076$

H_0 : $DM_{IPRF} = DM_{CPIF}$

$F_{1,99}$: 4.515, $P > F = 0.036$

H_0 : $DM_{CPINF} = DM_{CPIF}$

$F_{1,99}$: 0.001, $P > F = 0.973$

[a]Figures in parentheses are standard errors.

Chow tests were performed to see if expected changes in price flexibility followed. In the preferred model for farm prices, no statistically significant change in the coefficient on money growth was found, but the sign accorded with expectations indicating a positive relationship. That is, the effect of money on prices appears to have increased slightly after 1973 and decreased in 1979 and after.

4. Summary, Conclusions, and Policy Implications

In Section 2, a theoretical model was presented to show that, when prices in various sectors differ in their speed of adjustment to different shocks, money growth changes could cause flexible prices to overshoot their long-run equilibrium. However, the importance to agricultural economics is not the overshooting result per se but the possibility that relative prices of farm products be affected by monetary policy.

Empirical results for the United States reported here lend support to the proposition that monetary changes cause short-run changes in relative farm prices although the overshooting hypothesis could not be confirmed. This is not surprising given that farm prices differ between commodities as to the degree of flexibility. Several prices entering the index of prices received by farmers exhibit inflexibility especially in the downward direction due to government price supports. The results obtained by Frankel and Hardouvelis (1985) for specific commodities would support the observation that the price index data used here to represent flexible prices probably understate the distinction between those commodities that actually have perfect price flexibility and those of the other sectors of the economy.

The main empirical result (i.e., that changes in relative prices follow a change in money growth) seems to be well supported by other evidence found in the literature. In addition to the reduced form regressions presented here, more structured single-equation models (Stamoulis, 1985) seem to support this hypothesis. In addition, results obtained using Australian data (Chalfant et al., 1986) also support the main assumptions of the theoretical model.

Changes in relative prices following monetary changes may partly explain the drastically different environments facing the farm sector during the early 1970s vs. 1980s. According to the model, the "easy money" policies of the early 1970s should have contributed to the rise in relative prices of commodities. On the other hand the tight monetary policies of the early 1980s should have contributed to the decline in relative farm prices.

According to Rausser et al. (1986), "A fair characterization of the monetary and fiscal policies of the early 1970s and the early 1980s is that the first period represented a subsidy period for agriculture while the latter regime taxed the sector!" In other words, stickiness in other sectors caused agriculture to prosper in the early 1970s and decline in the early 1980s.

The relevant question for policymakers is whether or not there is need for policy action when monetary policy creates an adverse environment for the farm sector. If monetary policy causes problems to agriculture for reasons outside the sector (i.e., stickiness in other sectors), is agricultural policy legitimized?[3] In other words, can we consider farm policy as correcting the externality that monetary policy imposes on the farm sector due to stickiness in other sectors?

There is no clear-cut answer to this question for since the answer depends on the objectives of agricultural policy itself. If monetary policy is long-run neutral and the short-run effects will eventually be reversed, then, conceivably, no policy action needs to be taken.

But there are possible exceptions: Specifically, if farmers have myopic expectations and build capacity on the basis of short-run movements in relative prices and agriculture is characterized by asset fixity. If both hold, it is conceivable that farmers would build excess capacity when relative farm prices are high, following a series of monetary shocks. Then, when the initial effects of money start reversing themselves, resources in the farm sector cannot adjust because of asset fixity. The result is overcapacity, excess supply and--in the absence of policy action--further price declines.

In such a case, a policy combination of income enhancement and supply control may be needed. The danger is that a scheme of price supports associated with ineffective supply control will inhibit adjustment of resources to their long-run equilibrium.

It is in the above sense that one could make the claim that the policies of the 1970s set the stage for the events of the early 1980s. Although the evidence is overwhelming that monetary policy has a strong short-run effect on the agricultural sector, if money is neutral in the long run, then agricultural sector policies are likely to have a more significant influence on the farm sector.

It is worth noticing that there is an asymmetry in the types of public policy actions triggered by alternative macroeconomic environments. In periods of favorable macroeconomic environments, no action is taken toward reducing relative farm prices. Then in periods of macroeconomic conditions that "tax" the farm sector, the most costly farm programs are implemented.

A possible course of action for agricultural policy is a flexible policy scheme as proposed by Just and Rausser (1984). According to that concept, farm policy should be designed conditional on macroeconomic conditions facing agriculture. The basic concept in those policies is the flexible character of both storage and target policies. Conceptually, a flexible policy should impose a self-regulating tax during "subsidy type" macroeconomic environments while a self-regulating subsidy will be imposed during a "tax type" macroeconomic environment.

Footnotes

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[1]Note that undershooting does not mean that relative prices in the economy do not change following a monetary shock. It simply means that they deviate from the long-run equilibrium by less than in the case of overshooting. For a hypothetical change in m of, for example, 10 percent overshooting implies that e and p_A will change more than 10 percent while undershooting implies that they change by less than 10 percent.

[2]For a derivation of alternative overshooting coefficients and adjustment paths under different assumptions about output adjustment and expectations, see Rausser, Nishiyama, and Stamoulis (1986).

[3]We assume here that no one is concerned about implementation of agricultural policy to deal with periods that are "too good" for the farm sector.

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