



## Commodity Prices, Money Surprises and Fed Credibilit

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## 1. INTRODUCTION

STRICT MONETARIST THEORY, IN AN EXTREME FORM, holds that excessive money growth, or the expectation of future money growth, shows up immediately in the rapid inflation of goods prices. However, it is widely argued that for most goods prices are in fact sticky in the short run and reflect money growth only in the long run. If one seeks a sensitive market measure of the perceived looseness or tightness of monetary policy, one must look elsewhere than at the general price level.

Interest rates, being determined in quickly adjusting financial markets, *are* free to respond immediately to expectations regarding monetary policy. In 1981 and 1982, every Friday at 4:10 P.M. Eastern Standard Time the Federal Reserve Board would announce the money stock for the week ending nine days previously. If the announced money stock was different from what the market had been expecting, interest rates generally jumped in the same direction. Clearly they were responding to revisions of the expected future path of the money stock. But nominal interest rates are an ambiguous indicator of expectations. On the one hand, an announced increase in the money stock may be received by the market as indicating a higher

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Fed target money growth rate. The higher expected growth rate would then imply a higher expected inflation rate, and the rise in interest rates would then be explained as an inflation premium. On the other hand, the market may have confidence in the Fed's commitment to stick to its money growth target and may interpret the money stock change as an unintended fluctuation originating in money demand or the banking system. The market would then expect the Fed to contract the money supply in the near future to get back to the target path. The rise in nominal interest rates would be explained as an increase in *real* interest rates, without any necessary change in expected inflation.

Arthur Okun (1975), among others, drew a distinction between manufactured goods (and other "customer goods" and services) and basic commodities (or "auction goods"). The former have sticky prices: they are differentiated products traded in imperfectly competitive markets where there is no instantaneous arbitrage to ensure perfect price flexibility. But the latter have flexible prices: they are homogenous products traded in competitive markets where arbitrage does ensure instantaneous price adjustment. Commodities are more like assets in this respect. Since their prices are free to adjust from day to day, and even from minute to minute, they offer a potential measure of the market's perception of current monetary policy. And, unlike interest rates, they are an unambiguous indicator of the direction in which monetary expectations are revised. If expectations are revised in the direction of faster future monetary growth, and consequently higher inflation, investors to protect themselves will instantly shift out of money and into commodities, thus driving up current commodity prices. If expectations are revised in the direction of slower future monetary growth, and consequently lower inflation, investors will instantly shift into money and out of commodities, thus driving down commodity prices.<sup>1</sup>

In this paper we look at the reactions to money supply announcements in the prices of nine commodities (gold, silver, sugar, cocoa, cattle, feeders, wheat, soybeans, and corn), to assess the degree of market credibility that the Fed has in its commitment to money growth targets. Several papers have looked at the reactions in bond markets, stock markets, and foreign exchange markets, but none to our knowledge has looked at the reactions to the weekly money announcement in commodity markets.<sup>2</sup>

## 2. THE THEORY RELATING MARKET PRICES TO MONETARY EXPECTATIONS

We begin with a simple money demand equation:

$$m_t - p_t = a_t - \lambda i_t, \quad (1)$$

<sup>1</sup>Bordo (1980) shows empirically that prices of raw goods respond more quickly to monetary growth than do prices of manufactured goods.

<sup>2</sup>The positive reaction of interest rates to the weekly money announcements has been documented by Grossman (1981), Roley (1983), Urich and Wachtel (1981), Urich (1982), Naylor (1982), Cornell (1982), Hardouvelis (1984a) and Shiller, Campbell, and Schoenholtz (1983). A negative reaction in the price of foreign exchange has been found by Engel and Frankel (1982, 1984), Cornell (1982), and Hardouvelis (1984a) and in the equity markets by Pearce and Roley (1983).

where  $m_t$  and  $p_t$  are the logs of the money supply and price level, respectively;  $i_t$  is the very short-term interest rate; and  $a_t$  represents the influence of real income and other exogenous shifts in money demand. The market in storable commodities will be subject to the condition that the expected rate of change of commodity prices  $E_t(cp_{t+1} - cp_t)$ , minus storage costs  $sc$ , is equal to the short-term interest rate:

$$E_t cp_{t+1} - cp_t - sc = i_t. \quad (2)$$

We assume that the risk premium is either zero or is subsumed in the storage costs, which are assumed constant.<sup>3</sup>

Imagine for a moment that the prices of all goods in the consumption basket are perfectly flexible, not just those of basic commodities, and that as a consequence the relative price of commodities and other goods is invariant with respect to monetary factors. The general price level in this hypothetical case,  $\bar{p}_t$ , is proportional to the price of commodities. (Of course, real commodity prices are determined by weather and a whole host of other factors—most of them peculiar to the commodity in question—that probably overwhelm the monetary factors considered here. Our monetary model is intended to be nothing more than a model of how commodity prices move *relative* to their real equilibrium. As long as such real factors do not change at 4:10 P.M. on Fridays, our model will be appropriate for the study of money announcements.<sup>4</sup>)

Equating  $\bar{p}_t$  with  $cp_t$  and substituting (2) into (1) gives

$$m_t - \bar{p}_t = a_t - \lambda(E_t \bar{p}_{t+1} - \bar{p}_t - sc). \quad (3)$$

Solving for  $\bar{p}_t$ ,

$$\bar{p}_t = \left( \frac{1}{1 + \lambda} \right) (m_t - a_t) + \left( \frac{\lambda}{1 + \lambda} \right) (E_t \bar{p}_{t+1} - sc). \quad (4)$$

Rational expectations imply

$$E_t \bar{p}_{t+1} = \left( \frac{1}{1 + \lambda} \right) E_t (m_{t+1} - a_{t+1}) + \left( \frac{\lambda}{1 + \lambda} \right) (E_t \bar{p}_{t+2} - sc). \quad (5)$$

<sup>3</sup>For present purposes of studying the money announcement phenomenon, it is not necessary to rule out a risk premium or storage costs that can change from week to week, or even that change before and after October 1979. It is necessary only to rule out that they change at 4:10 P.M. on Friday afternoons. Hardouvelis (1984b) offers one piece of evidence that they do not.

<sup>4</sup>There is a problem with assuming that commodity prices  $cp_t$  move proportionally to the general price level in the long run. If storage costs are positive, equation (2) implies that the expected rate of change of  $cp_t$  is greater than the nominal interest rate  $i_t$ . Yet the expected rate of change of  $p_t$  must be less than the nominal interest rate most of the time if the real interest rate is to be positive, as it is believed to be.

There are two possible resolutions to the problem. First, for a seasonal agricultural commodity,  $cp_t$  may gradually increase relative to  $p_t$  (monetary expectations aside) during most of the year, as long as some of the previous harvest peak is being stored, and fall discontinuously when the new harvest comes in. In anticipation, the stocks held would dwindle to zero before the new harvest. Thus there is no long-run trend in  $cp_t - p_t$ . Alternatively, for a nonperishable, nonrenewable commodity such as gold or oil, there may indeed be a long run trend in relative prices, à la Hotelling. We are grateful to Peter Berck and Rudiger Dornbusch for both of these explanations. They are examples of the sort of exogenous real factors that have been excluded from the formal monetary model in the text.

We substitute (5) into (4), then substitute for  $E_t \bar{p}_{t+2}$ , and continue recursively:

$$\bar{p}_t = (1/(1 + \lambda)) \sum_{\tau=0}^{\infty} (\lambda/(1 + \lambda))^{\tau} E_t (m_{t+\tau} - a_{t+\tau}) - \lambda sc. \quad (6)$$

Thus  $\bar{p}_t$  should be viewed as the present discounted sum of the entire expected future path of the money supply, relative to money demand.

If one believes literally the hypothesis that prices of all goods are perfectly flexible and move alike in response to monetary developments, then equation (6) can be used directly to interpret the reactions of commodity prices to monetary announcements. In this case the rationale for looking at the prices of standard commodities, as opposed to the other goods and services in the CPI, would presumably be that they are the only ones measured frequently enough to be observed before and after the weekly money announcements.

We now consider the more general case in which the prices of most goods and services are believed to be sticky in the short run. Equation (6) cannot be used to indicate the reaction of either the general price level  $p_t$  (which will be zero except to the extent that commodity prices — or other perfectly flexible prices such as those of imports — directly enter the consumption basket) or of commodity prices  $cp_t$ . We assume now that  $p_t$  adjusts gradually over time to eliminate excess demand, and in the long run moves with  $\bar{p}_t$ . Then it can be shown that  $cp_t$  will react in the same direction as  $\bar{p}_t$ , but will move more than proportionally in the short run:

$$\Delta cp_t = \left(1 + \frac{1}{\theta\lambda}\right) \Delta \bar{p}_t \quad (7)$$

(where  $\theta$  is defined as the fraction of the deviation from long-run equilibrium  $\bar{p}_t$  that  $p_t$  can be expected to close each period). In the special case of instantaneous adjustment of all prices,  $\theta$  is infinite and (7) reduces to the case considered above,  $\Delta cp_t = \Delta \bar{p}_t$ .

Equation (7) was developed by Dornbusch (1976) in a continuous-time context, to show how the spot price of foreign currency (in place of  $cp_t$ ) reacted more-than-proportionally to a sudden permanent change in the money supply, that is, how the exchange overshoot its long-run equilibrium. In the case of a sudden permanent change in  $m$ , (6) in difference form reduces to  $\Delta \bar{p}_t = \Delta \bar{m}_t$ . But the celebrated “overshooting” result is easily generalized to include any sort of discrete-time monetary process. Equations (6) and (7) are derived in Engel and Frankel (1982, 1984) for a general money supply process, with the purpose of studying the reactions to the weekly money announcements in the spot price of the deutschemark.<sup>5</sup> Applying that derivation to the present problem is a simple matter of replacing the price of foreign exchange with the price of commodities.<sup>6</sup>

<sup>5</sup>When the exchange rate appears in place of  $cp_t$ , the foreign interest rate appears in place of  $-sc$ .

<sup>6</sup>If commodity prices (and/or the exchange rate via import prices) enter the CPI with weight  $\beta$ , it can be easily shown that equation (7) generalizes to

$$\Delta cp_t = \left[ \left(1 + \frac{1}{\theta\lambda}\right) / \left(1 + \frac{\beta}{\theta\lambda}\right) \right] \Delta \bar{p}_t.$$

## 3. THE RELATIONSHIP BETWEEN REVISIONS IN MONETARY EXPECTATIONS AND THE WEEKLY ANNOUNCEMENTS

We combine equations (6) and (7) to obtain

$$\Delta cp_t = \left(1 + \frac{1}{\theta\lambda}\right) \Delta \left[ \frac{1}{(1+\lambda)} \sum_{\tau=0}^{\infty} \left(\frac{\lambda}{(1+\lambda)}\right)^\tau E_t(m_{t+\tau} - a_{t+\tau}) \right]. \quad (8)$$

We assume that the Friday revision in the expected future monetary path, as represented by the term in brackets, is linearly related to the unanticipated money announcement. Mussa (1975) shows that this linear form is the rational one for market expectations to take, in a money supply process with permanent disturbances to the trend and transitory disturbances to the level. (The effects of the announcement on the estimates of the trend and level depend on the relative variances of the two kinds of disturbances.) Thus the reaction in commodity prices is linearly related to the money announcement. Before we attempt to verify this relationship empirically, several observations are in order.

The first observation is that to get a negative relationship it is not sufficient that the change in the money supply that is announced to have taken place in the preceding week be believed to be transitory. It is necessary also that the change in the money demand term  $a_t$ , which includes real income and exogenous shifts in money demand, is believed to be at least partly permanent. This point, which has been made by Engel and Frankel (1982) and Nichols, Small, and Webster (1983), is easily seen as follows. Assume that the money demand equation (1) holds instantaneously and that  $i_t$  is contemporaneously observable. Then market participants always know  $m_t - a_t$ . But in a week when the interest rate is observed to be, say, low, they do not know whether that is due to a high  $m_t$  or a low  $a_t$ . They find the answer the following Friday. When they learn that the week's  $m_t$  was high, they simultaneously learn that  $a_t$  was high (or else they find out that  $m_t$  and  $a_t$  were both low). If the change in  $m_t$  is thought to be more transitory than the change in  $a_t$ , then the revision in  $\bar{p}_t$ , that is, the bracketed expression in equation (8), will be negative. In the polar case where the change in  $m_t$  is thought to be purely transitory, and the change in  $a_t$  to be permanent, the revision in  $\bar{p}_t$  reduces to  $-\lambda/(1+\lambda)$  times the unanticipated money announcement. (In the opposite polar case in which the announced change in  $m_t$  is thought to signal a one-for-one increase in the Fed's targeted growth rate, the revision in  $\bar{p}_t$  reduces to  $+\lambda$  times the unanticipated money announcement.)

The second point to be emphasized is that it is only the unanticipated component of the announcement that matters. If markets are efficient, whatever component of the announcement that was predictable will already have been incorporated into the financial market prices. The market's expectations are determined not only by past money stock figures, but by official pronouncements and many other factors as well. Any attempt to measure expected money growth by, for example, an *ARIMA* model of the money stock time series, is unlikely to be accurate. Fortunately, a convenient measure of market expectations is provided by the weekly survey conducted by

Money Market Services, Inc., of sixty individuals who make predictions of what the week's money announcement will be.<sup>7</sup> We measure the market reaction as the change in the futures price from the close (3:00 P.M. E.S.T.) of the market just before the Friday announcement to the open on Monday.<sup>8</sup> We have grounds to hope that relatively little will happen in between to affect market prices, other than the money announcement. Of course there will always be an error term consisting of neglected factors, notably other relevant news that comes out over the weekend. But other factors will be far less important than they would be in a context of week-to-week or month-to-month changes. Furthermore, there is good reason to believe that the money surprise is predetermined, that is, that the error term arising from other weekend news will be independent of the money surprise: both the money announcement and the expectations survey are committed to paper before the Friday market close. Thus simultaneity problems vanish.

#### 4. EMPIRICAL RESULTS

In Tables 1–3 we show the results of regressing various market prices against the money surprise for the period from July 1980 to November 1982. The money surprise is defined as the logarithmic difference between the newly announced money supply and the level predicted by the survey. The latter is the change predicted by the survey plus the money supply announced one week previously. The dependent variable is the logarithmic change in the market price, times 100, to get the change in percentage.<sup>9</sup> The period was chosen to coincide with a new monetary regime: the Fed announced a change in operating procedures on October 6, 1979, and (in cooperation with the administration) imposed credit controls from March to July 1980, in an effort to get the money growth rate under control.

We begin with the results for bond and foreign exchange markets in Table 1, territory that has been covered in other papers. The highly significant negative

<sup>7</sup>The proposition that Money Market Services numbers do in fact represent market expectations, and that these expectations are rational, is supported in Grossman (1981) and in Engel and Frankel (1982), by a demonstration that one cannot use exchange rates or interest rates on the morning of the announcement, or relevant lags, to improve on the survey number as a predictor of what the money announcement will be.

<sup>8</sup>The price is the price of the nearest maturing futures contract. The data on opening (9:00 A.M. E.S.T.) and closing (3:00 P.M. E.S.T.) prices are taken from the *Wall Street Journal*. The data for cattle and feeders are from the Chicago Mercantile Exchange; for cocoa and (world) sugar from the New York Coffee, Sugar, and Cocoa Exchange; for gold and silver from the New York Commodity Exchange; and for foreign currencies and Treasury bills from the International Money Market at the Chicago Mercantile Exchange. Corn, soybeans and wheat are from the Chicago Board of Trade. Whenever a futures contract was traded during the same month that it matured, we skipped to the next maturing contract. Whenever the month of the maturing contract changed, we made sure that the change did not occur between Friday close and Monday close. We did not use cash price data because they are not available at precise times before and after the 4:10 money announcements. The reaction in the futures price presumably incorporates a small positive interest rate effect beyond the reaction in the spot price of equation (8). Given that the interest rate is known to react positively to the money announcements, the use of futures contracts biases our results slightly *away* from our findings of a negative reaction in the post-1979 period.

<sup>9</sup>On a few occasions, the Fed did not announce the money supply until Monday. In that case we used the change in market price in the Tuesday open from the Monday close. When Friday or Monday was a market holiday, we used the preceding market close or the next market opening, respectively.

TABLE 1

TREASURY BILLS AND FOREIGN CURRENCY (standard errors in parentheses)

Market	Constant	Coefficient of Money Growth Surprise	R <sup>2</sup>	D-W	SSR
Treasury bill	0.077* (0.033)	-0.347* (0.062)	0.206	1.78	15.64
Swiss franc	0.049 (0.075)	-0.408* (0.143)	0.063	2.12	83.09
Deutsche mark	-0.018 (0.053)	-0.140 (0.100)	0.016	1.92	41.33
Pound sterling	-0.079 (0.048)	-0.041 (0.090)	0.002	2.05	33.33
Japanese yen	0.018 (0.070)	-0.043 (0.133)	0.001	1.77	71.69
Canadian dollar	0.009 (0.021)	-0.077* (0.039)	0.031	1.88	6.25
5-currency average % change	-0.004 (0.034)	-0.126* (0.063)	0.032	2.05	16.28

NOTES: Dependent variable: percentage change in market price from close Friday to open Monday.  
Independent variable: percentage money growth announced Friday in excess of expectations. Sample: July 7, 1980–November 5, 1982 (123 observations).

\*Significant at the 95 percent level.

TABLE 2

COMMODITIES (standard errors in parentheses)

Commodity	Constant	Coefficient of Money Growth Surprise	R <sup>2</sup>	D-W	SSR
Gold	-0.107 (0.163)	-0.658* (0.308)	0.036	2.28	386.97
Silver	-0.345 (0.202)	-0.629 (0.381)	0.022	2.34	590.69
Sugar	-0.341 (0.188)	-0.358 (0.354)	0.008	1.88	510.24
Cocoa	-0.102 (0.144)	-0.017 (0.271)	0.000	1.64	299.24
Cattle	0.016 (0.094)	-0.363* (0.177)	0.033	2.24	127.69
Feeders	0.018 (0.068)	-0.240 (0.128)	0.028	2.18	66.82
Wheat	0.024 (0.096)	-0.134 (0.181)	0.005	2.14	133.12
Corn	0.018 (0.077)	-0.041 (0.145)	0.001	2.15	86.16
Soybeans	0.049 (0.074)	-0.136 (0.139)	0.008	2.08	79.03
9-commodity average % change	-0.085 (0.061)	-0.286* (0.115)	0.049	2.40	53.98
14-market average % change	-0.056 (0.043)	-0.229* (0.081)	0.061	2.37	27.02

NOTES: Dependent variable: percentage change in market price from close Friday to open Monday.  
Independent variable: percentage money growth announced Friday in excess of expectations.  
Sample: July 7, 1980–November 5, 1982 (123 observations).

\*Significant at the 95 percent level.



TABLE 3  
STACKED REGRESSIONS (standard errors in parentheses)

Market	Number of Observations	Change in Price Is from	Constant	Coefficient of Money Growth Surprise	R <sup>2</sup>	SSR
5 foreign currencies: Swiss franc, mark, pound, Canadian dollar, yen	615	1. Close Fri. to Open Mon.	-0.004 (0.026)	-0.126* (0.048)	0.011	240.36
		2. Open Mon. to Close Mon.	-0.009 (0.020)	0.024 (0.038)	0.000	151.80
		3. Close Fri. to Close Mon.	-0.013 (0.033)	-0.102 (0.062)	0.004	395.33
		4. Close Fri. to Open Mon.	-0.224* (0.088)	-0.415* (0.165)	0.013	1803.12
		5. Open Mon. to Close Mon.	-0.349* (0.104)	0.121 (0.197)	0.001	2560.45
		6. Close Fri. to Close Mon.	-0.572* (0.135)	-0.294 (0.254)	0.003	4261.47
		7. Close Fri. to Open Mon.	0.025 (0.037)	-0.183* (0.069)	0.011	495.04
		8. Open Mon. to Close Mon.	-0.105* (0.046)	-0.220* (0.088)	0.010	794.93
		9. Close Fri. to Close Mon.	-0.080 (0.055)	-0.402* (0.105)	0.024	1128.45
4 commodities: gold, silver, sugar, cocoa	492	1. Close Fri. to Open Mon.	-0.004 (0.026)	-0.126* (0.048)	0.011	240.36
		2. Open Mon. to Close Mon.	-0.009 (0.020)	0.024 (0.038)	0.000	151.80
		3. Close Fri. to Close Mon.	-0.013 (0.033)	-0.102 (0.062)	0.004	395.33
		4. Close Fri. to Open Mon.	-0.224* (0.088)	-0.415* (0.165)	0.013	1803.12
		5. Open Mon. to Close Mon.	-0.349* (0.104)	0.121 (0.197)	0.001	2560.45
		6. Close Fri. to Close Mon.	-0.572* (0.135)	-0.294 (0.254)	0.003	4261.47
		7. Close Fri. to Open Mon.	0.025 (0.037)	-0.183* (0.069)	0.011	495.04
		8. Open Mon. to Close Mon.	-0.105* (0.046)	-0.220* (0.088)	0.010	794.93
		9. Close Fri. to Close Mon.	-0.080 (0.055)	-0.402* (0.105)	0.024	1128.45
5 commodities: cattle, feeders, wheat, soybeans, corn	615	1. Close Fri. to Open Mon.	-0.004 (0.026)	-0.126* (0.048)	0.011	240.36
		2. Open Mon. to Close Mon.	-0.009 (0.020)	0.024 (0.038)	0.000	151.80
		3. Close Fri. to Close Mon.	-0.013 (0.033)	-0.102 (0.062)	0.004	395.33
		4. Close Fri. to Open Mon.	-0.224* (0.088)	-0.415* (0.165)	0.013	1803.12
		5. Open Mon. to Close Mon.	-0.349* (0.104)	0.121 (0.197)	0.001	2560.45
		6. Close Fri. to Close Mon.	-0.572* (0.135)	-0.294 (0.254)	0.003	4261.47
		7. Close Fri. to Open Mon.	0.025 (0.037)	-0.183* (0.069)	0.011	495.04
		8. Open Mon. to Close Mon.	-0.105* (0.046)	-0.220* (0.088)	0.010	794.93
		9. Close Fri. to Close Mon.	-0.080 (0.055)	-0.402* (0.105)	0.024	1128.45

NOTES: Dependent variable: percentage change in market price.  
Independent variable: percentage money growth announced Friday in excess of expectations.  
Sample: July 7, 1980–November 5, 1982.  
\*Significant at the 95 percent level.

coefficient on the price of three-month Treasury bills illustrates once again the well-documented fact that the interest rate reacts positively to a money surprise.

The dollar prices of all five foreign currencies also react negatively to the money surprise, and the Swiss franc and Canadian dollar are statistically significant. The unweighted average of the percentage changes in the five currency prices also shows a significant negative reaction. These results in themselves constitute evidence that the market expects the Fed to correct deviations from its money growth rate target; the anticipation of future money contraction reduces the price of foreign exchange, or raises the value of the dollar.

The new results are those for the nine commodities, reported in Table 2. In each case the reaction is again negative. Only the reactions of gold and cattle are significant at the 95 percent level, though silver and feeders are significant at the 90 percent level. An average of the changes in all nine commodity prices is highly significant.

To get more efficient estimates, we stacked the observations for different commodities in a single regression. In other words, we constrained the reaction coefficients to be the same. This constraint comes out of the theory. Equation (7) implies that a change in monetary expectations causes commodity prices to react to an extent determined only by  $\theta$ , the speed of adjustment of the sticky manufacture prices, and by  $\lambda$ , the semielasticity of the money demand with respect to the interest rate — not by any characteristic of the individual commodities. Only if a change in the steady-state inflation rate implied a change in the relative price of commodities in the long-run equilibrium, that is, only if money were nonneutral even in the long run, would expected inflation have more effect on some commodity prices than on others.<sup>10</sup> The same is true of effects on foreign exchange prices. Row 1 of Table 3 reports a regression for all five exchange rates stacked. The joint negative reaction is highly significant. Row 4 represents the first four commodities stacked, and row 7 the other five commodities stacked.<sup>11</sup> In both cases the joint negative reaction is again highly significant. Overall the evidence strongly supports the proposition that announcements of high money growth induce market expectations of future contractions.

It is of some interest to see what happens Monday *after* the opening. If the commodity prices were to continue to move in the same direction during the course of trading on Monday, this would constitute evidence of less-than-perfect efficiency in the market and an opportunity for speculative profits. A sharp movement in the opposite direction would constitute evidence of the same.<sup>12</sup> The coefficients reported

<sup>10</sup>One cannot rule out this possibility a priori. For example, in a model with risk, gold and silver might be considered the only effective hedge against hyperinflation (or nuclear war); their relative prices might rise permanently in response to an increase in inflationary fears. However, Table 2 shows that the tendency of their prices to move in the opposite direction from the money surprise is even stronger than that for the other commodities.

<sup>11</sup>The sum of squared residuals in Table 2 varies considerably from one commodity to the next, indicating that the stacked regressions in Table 3 may suffer from heteroskedasticity. A correction for heteroskedasticity reduces the coefficient estimate and its standard error slightly. Significance levels are about the same. The results are reported in Frankel and Hardouvelis (1983).

<sup>12</sup>The overshooting theory tells us that the commodity prices will come back, gradually over time, as the entire price level of the economy adjusts to excess supply. This countermovement should not show up in one day of trading. But some market observers claim that prices in fact overshoot by far more than is rational.

TABLE 4  
 WITHIN-MONDAY REACTIONS (standard errors in parentheses)

Market	Constant	Coefficient of Money Growth Surprise	R <sup>2</sup>	D-W	SSR
Gold	-0.341 (0.224)	0.002 (0.423)	0.000	1.89	728.52
Silver	-0.282 (0.210)	0.460 (0.397)	0.011	2.04	640.80
Sugar	-0.476* (0.241)	0.244 (0.456)	0.002	1.83	847.30
Cocoa	-0.297* (0.151)	-0.223 (0.286)	0.005	1.89	332.11
Cattle	-0.154 (0.080)	-0.009 (0.150)	0.000	2.04	91.73
Feeders	-0.142 (0.090)	-0.134 (0.180)	0.005	1.89	132.49
Wheat	-0.085 (0.124)	-0.190 (0.234)	0.005	2.11	222.16
Corn	-0.109 (0.098)	-0.248 (0.186)	0.015	1.93	140.53
Soybeans	-0.038 (0.118)	-0.518* (0.223)	0.043	2.04	202.73

NOTES: Dependent variable: percentage change in market price from open Monday to close Monday.  
 Independent variable: percentage money growth announced Friday in excess of expectations.  
 Sample: July 7, 1980–November 5, 1982 (123 observations).  
 \*Significant at the 95 percent level.

in Table 4 show no particular sign pattern. One is significant: soybeans seem to experience most of their negative reaction to the money surprise with a slight delay. When the total reactions from the close of the market on Friday to the close on Monday are computed, the extra noise from the within-Monday movements reduces the significance levels of most of the coefficients relative to Table 2, though their signs are still all negative (as in Frankel and Hardouvelis 1983). Even the stacked regressions for the foreign currencies and the first set of commodities (reported in rows 3 and 6, respectively, of Table 3) are no longer significant at the 95 percent level. This illustrates the importance of observing the market prices as close as possible, before and after, to the Friday money announcements, in order to minimize noise. The stacked regression for the second set of commodities (reported in row 9 of Table 3) is still significant, reflecting the strong negative reaction of soybeans within Monday.

It is also of interest to see how the markets reacted to money growth surprises in earlier periods. The *Wall Street Journal* only began reporting the necessary market prices for agricultural commodities in November 1978, but the prices for Treasury bills, the foreign currencies, and the two precious metals were available earlier. Tables 5 and 6 show the reactions to the money surprises for the period before the Fed's change in operating procedures on October 6, 1979. (The money supply announcements were made on Thursday afternoons during this period. The market reactions are reported from Thursday close to Friday open.) This was, of course, a period of inflationary fears. As one might expect, most of the commodities now react *positively* to the money surprises. Gold and cocoa, and the Swiss franc among the foreign currencies, are significant.

TABLE 5  
PRE-OCTOBER 1979 REACTIONS, FINANCIAL MARKETS (standard errors in parentheses)

Market	Constant	Coefficient of Money Growth Surprise	R <sup>2</sup>	D-W	SSR
Swiss franc	-0.097 (0.092)	0.480* (0.212)	0.047	1.65	89.41
Deutsche mark	-0.014 (0.071)	0.304 (0.162)	0.033	2.22	52.43
Pound sterling	0.001 (0.095)	-0.133 (0.218)	0.004	2.09	94.73
Japanese yen	-0.088 (0.074)	-0.143 (0.170)	0.007	1.88	57.65
Canadian dollar	-0.033 (0.022)	-0.011 (0.050)	0.000	2.10	4.93
Gold	-0.044 (0.094)	0.483* (0.215)	0.047	2.10	92.09
Silver	0.058 (0.117)	0.038 (0.268)	0.000	1.73	143.78

NOTES: Dependent variable: percentage change in market price from close Thursday to open Friday.

Independent variable: percentage money growth announced Thursday in excess of expectations.

Sample: September 29, 1977–October 4, 1979 (105 observations).

\* Significant at the 95 percent level.

TABLE 6  
PRE-OCTOBER 1979 REACTIONS, COMMODITIES (standard errors in parentheses)

Commodity	Constant	Coefficient of Money Growth Surprise	R <sup>2</sup>	D-W	SSR
Sugar	0.192 (0.113)	-0.133 (0.250)	0.006	1.74	26.04
Cocoa	0.160 (0.124)	0.676* (0.272)	0.112	2.04	30.86
Cattle	0.046 (0.149)	0.322 (0.328)	0.021	2.03	44.76
Feeders	-0.088 (0.155)	0.015 (0.341)	0.000	2.23	48.30
Wheat	0.118 (0.135)	0.057 (0.297)	0.001	1.76	36.60
Corn	0.088 (0.153)	-0.347 (0.336)	0.023	2.67	46.95
Soybeans	0.079 (0.114)	0.080 (0.252)	0.002	1.86	26.34

NOTES: Dependent variable: percentage change in market price from close Thursday to open Friday.

Independent variable: percentage money growth announced Thursday in excess of expectations.

Sample: November 3, 1978–October 4, 1979 (48 observations).

\* Significant at the 95 percent level.

On the whole, the evidence suggests that the market during this period did not have faith in the Fed's commitment to achieve its preannounced yearly money growth targets. Unanticipated announcements of increases in the money supply were interpreted as indicating more of the same in the future. However, the evidence is not as strong as it was for the contrary finding during the later period.

The period of regime transition began October 6, 1979, and ended in July 1980 with the removal of the last of the credit controls.<sup>13</sup> Reactions of the foreign ex-

<sup>13</sup>"Domestic Financial Developments in the Second Quarter of 1980," *Federal Reserve Bulletin* 66 (August 1980), 629. The dates were chosen ex ante to demarcate this transitional period, not ex post to get the significant regression results reported for the other two subsamples.

change and commodities markets during this transition period, as one might expect, show no clear sign pattern and no coefficients are significant (reported in Frankel and Hardouvelis 1983).

To sum up, the contrast between the pre-October 1979 results and post-July 1980 results is striking. Gold, for example, goes from a significant positive coefficient of 0.483 to a significant negative coefficient of  $-0.658$ . The switch supports the proposition that commodity (and foreign exchange) prices are good indicators of Fed credibility.

## 5. CONCLUSIONS

The reactions of the various markets to the money announcements can be used for two distinct purposes: (1) they support the proposition that during the 1980–82 period, the market had confidence in the Fed's commitment to correct deviations from money growth rate targets; and (2) they support the proposition that movements in the nominal interest rate during this period were primarily movements in the real interest rate rather than the expected inflation rate, as in the overshooting model cited in section 2.

The reactions in the prices of foreign exchange and commodities support the first proposition, whether one believes in an overshooting model or not. If one believes that all prices are perfectly flexible, even those of manufactured goods, then monetary policy should be instantly reflected in all prices. If one believes that some prices are sticky in the short run, then monetary prices should be reflected in the prices of foreign exchange and commodities that much more. Either way, the negative reaction of these prices to positive money announcements, documented in Tables 1–3, indicates that during the 1980–82 period the market expected the Fed to correct deviations from its targets. Similarly the positive reaction before October 1979, documented in Tables 5 and 6, indicates that the market attributed money surprises to revisions in the Fed's target rate of growth during this period.

The second proposition above follows from the first proposition *together* with the observed reactions of interest rates to the money announcements. During the 1980–82 period, interest rates reacted positively to money announcements, as documented in many other papers and in the first row of Table 1 in this paper (in the form of a negative reaction of the price of Treasury bills). If one did not know about the reactions of the foreign exchange and commodity markets, one could conceivably interpret the positive reactions in the nominal interest rate as increases in the expected rates of money growth and inflation. But given our finding that the market had confidence in the Fed's commitment to stick to its money growth rate target during this period, that avenue is not open. If increases in the expected inflation are ruled out as an explanation for increases in the nominal interest rates, as a matter of definition that leaves only increases in the real interest rate. Hence the second proposition.<sup>14</sup>

<sup>14</sup>The overshooting model of section 2 offers a specific explanation for the changes in the real interest rates. When the general price level is not free to respond fully to market expectations, a contraction in

*Data for this paper are available from the JMCB editorial office.*

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the nominal money supply is a contraction in the real money supply. It has the real effects of tightened liquidity, in particular an increase in the real interest rate and overshooting of commodity prices. Recall that within the framework of equation (7), the model in which there is no variation in the real interest rate is the special case in which  $\theta$ , the speed of adjustment of sticky goods prices, is infinite. Engel and Frankel (1982, 1984) explain at greater length how the observation that interest rates and foreign exchange prices (or commodity prices) react to money announcements in opposite directions constitutes a rejection of the special case of flexible prices in favor of the more general sticky price model.

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