Was the Disinflation of the Early 1980s Anticipated?

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The United States experienced a rise in inflation from 5.5 percent in the first quarter of 1976 to 9.4 percent in the first quarter of 1980. This steep increase was followed by the desire to stem inflation and to reverse its course. Therefore, soon after Paul Volcker was appointed chairman of the Federal Reserve Board in August 1979, the Federal Reserve (the Fed) announced new operating procedures and put in place a disinflationary policy.

During the implementation of that policy, two recessions came in rapid succession. The first began in January 1980 and lasted through the middle of that year. Although short in duration, the recession was deep, with real GDP falling at an annual rate of 10.4 percent in the second quarter of 1980, the largest postwar decline on record. The second recession followed almost immediately, beginning in July 1981 and ending in November 1982. At approximately the same time, the Fed's aggressive disinflationary policy ended. Some economists have calculated the cost in terms of cumulative output lost to be roughly 24 percent of total output over the period 1980:1 to 1983:4.[1] But during that period, inflation was brought down from 10.1 percent in 1980 to 4.4 percent in 1982.

This episode was dramatic because of both the significant loss of output and the equally significant decline in inflation. Also, the policy of disinflation was announced and was carried out over a period of three years. Thus, the episode has the potential to shed light on a number of competing macroeconomic theories that attempt to explain the linkage between real economic activity and

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[1] Using somewhat different procedures, both Fischer (1986) and Ball (1993) arrive at this conclusion.

nominal disturbances. The usefulness of the 1980's experience in this purpose depends critically on whether the decline in inflation was anticipated. If the disinflation was largely unexpected, even after the policy had been in place for some time, then it will be difficult to discriminate between the theories.

The first set of theories can broadly be classified as Keynesian and are characterized by elements of nominal rigidities in prices and wages. Specifically, we have in mind models like those of Fischer (1977), Taylor (1980), or Ball, Mankiw, and Romer (1988). In these models, staggered price setting slows the adjustment of the price level to changes in the money stock. Thus, inflation has inertia, and anticipated monetary contractions can precipitate a recession by causing aggregate demand to fall. The fall in aggregate demand will of course be greater if the disinflationary policy is unanticipated, since even those firms in the process of resetting their prices will make mistakes.

Other models in which unanticipated changes in monetary policy have an effect on real economic activity are the neoclassical monetary business-cycle models of Lucas (1973), McCallum (1980), and Sargent and Wallace (1975). In these models, agents partially infer nominally induced movements in prices as being driven by real disturbances. Thus, an unanticipated fall in money causes prices to be lower than expected, resulting in a decline in the supply of output. If policy is anticipated, however, and there is no confusion about the impulses driving prices, agents are not induced to supply less output. The entire effect of policy is nominal.

Economists have varying opinions concerning the extent to which disinflation was anticipated during the 1980-83 period, and these views partially determine their preferred theory. For example, in discussing a number of policy changes, including the one in which we are interested, Akerlof, Rose, and Yellen (1988) argue that

> Mr. Volcker's similar policy produced changes in equilibrium output long after the policies were announced (and seem to be credible). The changes persisted sufficiently long after their announcement that it is extraordinarily difficult to believe that the changes in employment and output they caused were due to the slow propagation of unanticipated shocks. (P. 68)

Their view is that the Fed possessed sufficient credibility, implying that the policy change was believed either immediately or soon thereafter and hence that the disinflation was largely anticipated. If that was indeed the case, then their conclusion that the episode was more in line with Keynesian-style theories than neoclassical ones is well taken.

The degree of Fed credibility, and hence the extent to which the disinflation was anticipated, is open to question. Goodfriend (1992), in his description of the Fed's fight against inflation, divides the period into three distinct parts: the aborted fight against inflation from October 1979 to April 1980, when short-term interest rates rose by over 600 basis points; an easing of policy during the first recession, when rates fell by 800 basis points; and a second aggressive disinflationary policy from August 1980 to October 1982, when rates were eventually pushed up by 1000 basis points over their July 1980 levels. This last sustained tightening broke the inflationary environment. Thus Federal Reserve policy was far from uniform and this lack of uniformity may have impaired the Fed's credibility, implying that the disinflation could very well have been unanticipated. Thus, how well the public anticipated the disinflation can help measure the Federal Reserve's credibility during that period.

1. DESCRIPTION OF THE 1976–1983 PERIOD

We begin with a brief overview of the period in question, confining ourselves to a description of the behavior of inflation, real GDP growth, M1 growth, and the federal funds rate (see Figures 1a to 1c). Inflation is measured by quarterly changes in the GDP deflator and all quarterly growth rates are annualized.

As Figure 1a illustrates, the period was characterized by a run-up in inflation from 5.5 percent in 1976:1 to 11.1 percent in 1981:1 and then by a rapid decline to 4.09 percent in 1983:4. Associated with this rapid disinflation were two recessions (Figure 1b). The first one began in January 1980 and was accompanied by a 10.4 percent annualized decline in real GDP during the second quarter of that year, and the second one began in July 1981.

Figure 1a GDP Deflator Inflation: 1970 to 1986

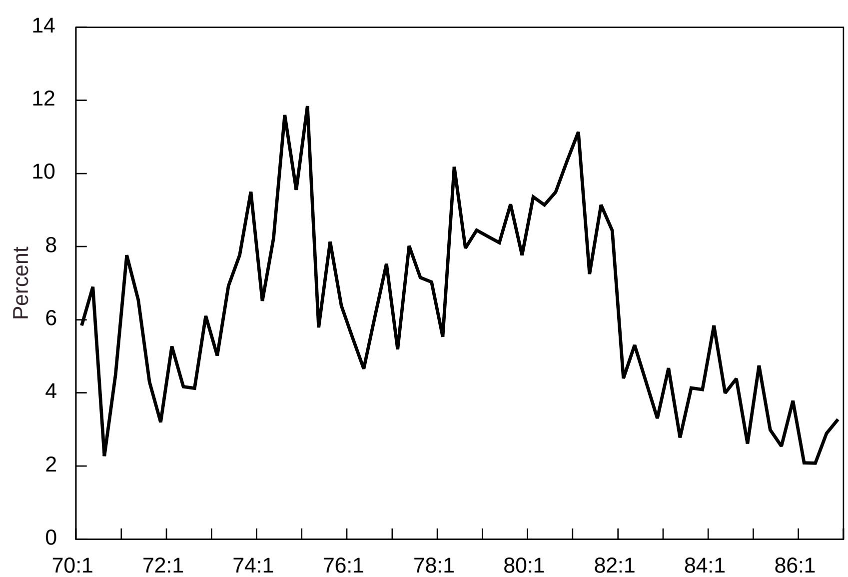
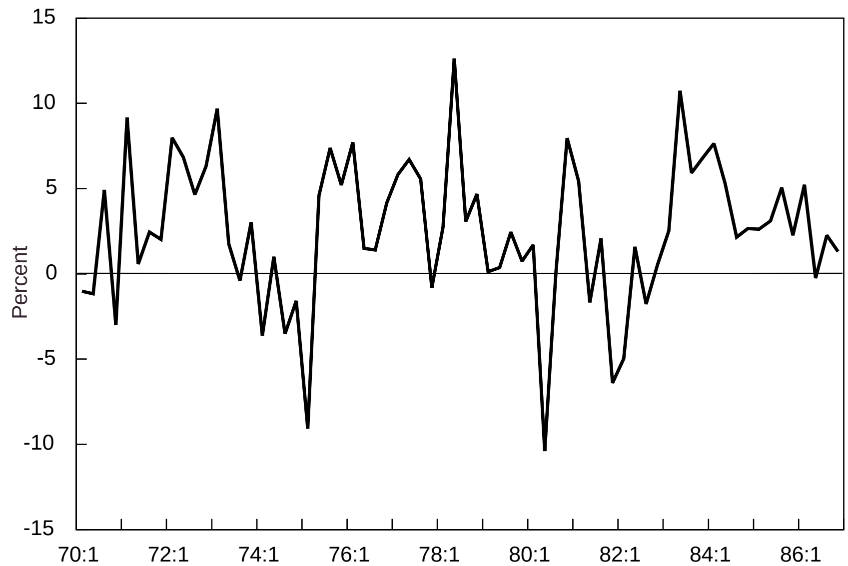


Figure 1b Real GDP Growth: 1970 to 1986



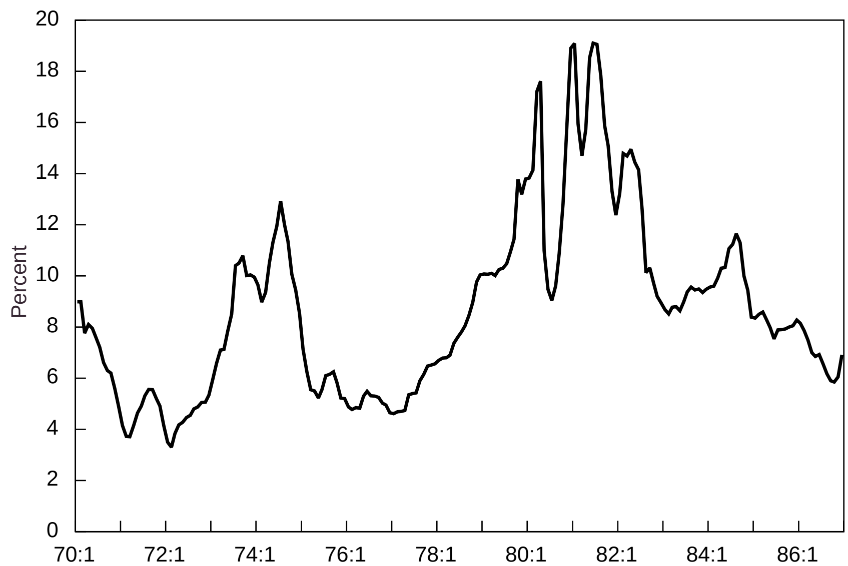
In response to the increase in inflation, the Federal Reserve announced a change in operating procedures in October 1979 and raised the funds rate from 11.4 percent in September to 17.6 percent in April 1980 (Figure 1c). The steep decline in economic activity caused the Fed to temporarily back off from its disinflationary policy, and the funds rate fell to 9.03 percent in July 1980. As a result, not much headway was made in curbing inflation.

As the economy recovered in the fourth quarter of 1980, the Fed resumed its policy of disinflation. The funds rate was raised from 10.8 percent in September 1980 to as high as 19.10 percent in June 1981. This second attempt at reversing the inflationary trend in the economy was successful. The economy experienced its second recession, but inflation also fell from 11.1 percent in 1981:1 to 4.4 percent in 1982:1.[2]

The go-stop-go nature of the Fed's fight against inflation is also depicted in the growth of effective M1 against its targets. When gauging the tightness of monetary policy by the discrepancy between money growth and monetary targets, effective M1 is the appropriate aggregate to look at. Effective M1 is a measure of actual M1 adjusted for the effects of deregulation and was the

[2] For a much more detailed description of this period, see Goodfriend (1992).

Figure 1c Federal Funds Rate: 1970 to 1986



monetary variable of primary concern to the Fed over this period.[3] In 1980, when the Fed relaxed its disinflationary policy, effective M1 grew at a rate of 6.9 percent, which exceeded the top of the target range by 0.4 percent. Also, much of this growth took place in the second half of the year after policy had eased. In 1981, however, effective M1 grew by only 2.4 percent, a full 1.1 percent below the bottom of the target range. This decline in M1 growth was a reflection of the reinstitution of tight monetary policy and served to further signal the Fed's renewed anti-inflationary stance.

Thus, an examination of the two most relevant economic series for depicting monetary policy during the early 1980s—the funds rate and effective M1—indicates that the fight against inflation was somewhat discontinuous. It is, therefore, highly possible that the credibility of the Fed's policy was achieved only gradually.

The discontinuous nature of policy led to renewed inflation in 1980 as well as to a sharp increase in long-term bond rates relative to the funds rate—what Goodfriend calls an "inflation scare"—earlier in the year. From Goodfriend's account, one may conclude that the Fed did not achieve credibility until the

[3] For more detail on effective M1 behavior and its construction, see Broaddus and Goodfriend (1984).

summer of 1982. It is thus entirely possible that although the Fed announced its resolve to fight inflation as early as October 1979, the policy was not fully credible until mid-1982. Thus, it may be that much of the disinflation was unexpected and that the 1980-83 period is perfectly consistent with the neoclassical model.

To shed further light on the degree to which the disinflation was anticipated, we adopt the innovative empirical methodology of Hamilton (1992). By combining information in commodity futures markets with the macroeconomic information readily available at the time, we decompose actual inflation into its anticipated and unanticipated components. Our results imply that a substantial portion of the disinflation was unanticipated and that the Fed suffered from a credibility problem.

2. METHODOLOGY[4]

To analyze the degree to which the disinflation of the early 1980s was anticipated, we must construct a series depicting the public's expectations of inflation. The methodology we use for constructing such a series is that of Hamilton (1992). His procedure incorporates publicly available aggregate data and financial market data on commodity futures contracts to estimate price-level expectations. The data on futures contracts are optimally weighted in an effort to uncover information possessed by the public but not by the econometrician. The use of future changes in commodity prices from their expected values represents a novel way to uncover what agents believed at any given moment. Because the change in policy was a major one, these data are potentially useful for uncovering beliefs about inflation since financial markets often react aggressively to changing inflationary expectations.[5]

Specifically, suppose that the public's expectation of next period's price level, p_{t+1}, is given by

$$p^e_{t+1} = x_t'\delta + \alpha_t, \tag{1}$$

where the superscript e denotes an expectation, x_t is a vector of all relevant aggregate information, and α_t represents information that agents find valuable in forecasting prices but that is unavailable to the econometrician. For example, x_t could include economic time series published by the Commerce Department or the Federal Reserve, while α_t could involve disaggregated information that individuals observe but that is unpublished.

[4] The description in this section draws heavily on Hamilton (1992), who provides a more detailed and technically rigorous description.

[5] The model does not explicitly incorporate regime changes and to some extent suffers from the same problems as a standard VAR when regimes actually do change.

Let the public's true expectational error be defined by $a_{t+1} \equiv p_{t+1} - p^e_{t+1}$. Note that under rational expectations a_{t+1} is white noise and uncorrelated with time t information. Next, consider the forecasting error, u_{t+1}, that occurs from the prediction of p_{t+1} using only the information in x_t. Specifically, u_{t+1} is the error term in

$$p_{t+1} = x_t'\delta + u_{t+1}, \tag{2}$$

which is a typical forecasting equation. From equation (1) and the definition of a_{t+1}, u_{t+1} is equal to $\alpha_t + a_{t+1}$. By including enough own lags of p_t in x_t, u_{t+1} can be made white noise. A simple and consistent assumption is to treat α_t as white noise as well.

Because the variance of u_{t+1}, σ^2_u is equal to $\sigma^2_\alpha + \sigma^2_a$, we observe that if the econometrician uses only the information in x_t to forecast p_{t+1}, the variance of the forecast errors will exceed that of the true forecast errors. Improving upon these forecasts requires inferences of α_t. The better the inference of α_t the closer the econometrician's forecast will coincide with the public's. Hamilton proposes that data from commodities markets be used to help form an optimal prediction of α_t.

For ease of exposition, we will analyze the case in which there is one commodity. Using data on the log of the commodity's forward price at date t, f_t, and the log of its expected future spot price next period, $E_t s_{t+1}$, a simple efficient markets model implies that

$$f_t = E_t s_{t+1} - k, \tag{3}$$

where k incorporates the variance of s_t and a constant risk premium. Equation (3) implies that the forecast error of the spot price is observable and given by

$$s_{t+1} - f_t = k + v_{t+1}, \tag{4}$$

where v_{t+1} is the forecast error. Under rational expectations, v_{t+1} is uncorrelated with time t information. In particular, it is uncorrelated with the elements of x_t and α_t. It is reasonable, however, to believe that the forecast error for a given commodity and the aggregate price level are correlated. For example, any demand shock (such as a monetary policy shock) could influence all prices, including commodity prices, in a similar way. This relationship is given by

$$v_{t+1} = q^a a_{t+1} + e_{t+1}. \tag{5}$$

Hence, observation of v_{t+1} implies some knowledge of a_{t+1}.

Next, consider a regression of the forward price on information available to the econometrician,

$$f_t = x_t'\beta + \omega_t. \tag{6}$$

In this regression, ω_t represents information that agents find relevant for pricing a commodity and that is unavailable to the econometrician, because f_t is observed at time t, and if the econometrician had all the relevant information then ω_t would be zero. Thus, ω_t has an interpretation similar to α_t, and the two should be related. Let this relationship be described by the linear projection

$$\omega_t = q^{\alpha}\alpha_t + \varepsilon_t, \tag{7}$$

where ε_t denotes information that agents have about future commodity price movements that is uncorrelated with aggregate price movements.

The statistical problem is to form an optimal forecast of α_t given knowledge of u_{t+1}, v_{t+1}, and ω_t, because it is these three observed disturbances that contain information about α_t. This optimal forecast allows us to form the expectation of the aggregate price level that best represents the one formed by the public. Using data on aggregate prices, commodity spot and forward prices, and x_t, construct the error terms u_{t+1}, v_{t+1}, and ω_t according to equations (2), (4), and (6). The optimal predictor of α_t can then be formulated as

$$E_{t+1}\alpha_t = A_1 u_{t+1} + A_2\omega_t + A_3 v_{t+1}, \tag{8}$$

where

$$\begin{bmatrix} A_1 \\ A_2 \\ A_3 \end{bmatrix} = \begin{bmatrix} \sigma_a^2 + \sigma_\alpha^2 & q^\alpha\sigma_\alpha^2 & q^a\sigma_a^2 \\ q^\alpha\sigma_\alpha^2 & (q^\alpha)^2\sigma_\alpha^2 + \sigma_\varepsilon^2 & 0 \\ q^a\sigma_a^2 & 0 & (q^a)^2\sigma_a^2 + \sigma_e^2 \end{bmatrix}^{-1} \begin{bmatrix} \sigma_\alpha^2 \\ q^\alpha\sigma_\alpha^2 \\ 0 \end{bmatrix}. \tag{9}$$

The coefficients in equation (8) are population regression coefficients. The matrix in (9) is the variance-covariance matrix of the disturbances $u_{t+1} = a_{t+1} + \alpha_t$. In deriving this matrix, various orthogonality conditions implied by rational expectations were used. The vector $[\sigma_\alpha^2,\, q^\alpha\sigma_\alpha^2,\, 0]'$ is the covariance between α_t and the three observed disturbance terms.

The optimal forecast of next period's price level is then depicted by

$$p^e_{t+1} = x_t'\delta + A_1(p_{t+1} - x_t'\delta) + A_2(f_t - x_t'\beta) + A_3(s_{t+1} - f_t - k). \tag{10}$$

In calculating the public's expectations of next period's price level, the econometrician uses time $t+1$ information from commodity spot markets. This information is needed to extract the optimal forecast of α_t, which contains relevant information available to the public but not to the econometrician.

Unfortunately, there is one technical difficulty. To estimate the coefficients A_1, A_2, and A_3, we must have estimates of q^a, q^α, σ_a^2, σ_α^2, σ_e^2, and σ_ε^2. The variance-covariance matrix in (9), however, has only five independent pieces of information, which means that the system is not identified. An additional restriction is needed, and we follow Hamilton by imposing $q^a = q^\alpha$.[6]

[6] The solution is $A_1 = (1/\Delta)[q^2\sigma_\alpha^2\sigma_\varepsilon^2(\sigma_a^2 + \sigma_e^2)]$
$A_2 = (1/\Delta)q\sigma_a^2\sigma_\alpha^2\sigma_e^2$
$A_3 = -(1/\Delta)q\sigma_a^2\sigma_\alpha^2\sigma_\varepsilon^2$ and $\Delta = (\sigma_a^2 + \sigma_\alpha^2)\sigma_e^2\sigma_\varepsilon^2 + q^2\sigma_a^2\sigma_\alpha^2(\sigma_e^2 + \sigma_\varepsilon^2)$.

This restriction has some intuitive appeal. Suppose, for example, that the relevant aggregate information that agents possess is a demand shock that affects commodity prices and the aggregate price level in similar ways. That is, anticipated and unanticipated movements affect s_{t+1} and p_{t+1} proportionately, although the absolute effects of an anticipated movement need not be the same as those of an unanticipated movement. Then q^a and q^α should be equal. Under the restriction $q^a = q^\alpha$, the ratio of the covariance of u_{t+1} and v_{t+1} to the covariance of u_{t+1} and ω_t is equal to $\sigma_a^2/\sigma_\alpha^2$, which reflects the extent that agents are actually surprised by movements in the aggregate price level.

However, this restriction may not be valid. If, for example, the unanticipated disturbances that affect commodity prices are largely idiosyncratic, while the information that agents actually possess affects both markets similarly, then q^a would not equal q^α. In any event, the restriction can be tested. And with multiple commodities, the restriction need only be placed on one commodity to achieve identification.

3. ESTIMATION

Before estimating the analogous multivariate system given by (1), (4), (6), and the variance-covariance matrix in (9), we describe our commodity price data and perform some necessary diagnostic tests. We used data on wheat, corn, oats, and soybean futures, since these were the only commodity data available for our sample period. In what follows, we use the price of a futures contract that is about to expire as the measure of the spot price. Because the futures contracts are four months in duration, the data set is three times per year (such intervals are denoted by roman numerals).

Commodity Price Behavior

Expected and actual inflation rates for the four commodities are given in Table 1. Actual inflation in a commodity market is calculated as the change in the log of the spot price during the period in question, while expected inflation is represented by three times the average log difference between the four-month futures price and the spot price at each four-month interval. From the table it is evident that expected commodity price increases greatly exceeded actual increases during the 1981-83 period. Further, graphs of expected commodity price inflation versus actual commodity price inflation (Figures 2a to 2d) show that, with the exception of oats, expected inflation was generally higher than actual inflation. These results foreshadow the main results of the statistical model: the overestimate of commodity price inflation will be mirrored in an overprediction of the aggregate inflation rate.

Commodity Market Efficiency

One of the maintained hypotheses of the model discussed in Section 2 is that the commodity market is efficient. This was depicted by equation (4) in which

Table 1 Expected and Actual Inflation Rates for Four Commodities

	1978 to 1980	
Commodity	Expected	Actual
Wheat	4.01	10.16
Corn	14.82	17.24
Oats	31.11	13.79
Soybeans	9.93	6.44

	1981 to 1983	
Commodity	Expected	Actual
Wheat	19.78	−0.39
Corn	11.08	6.05
Oats	3.34	−5.48
Soybeans	10.80	9.01

Sources: Commodity prices were obtained from the Chicago Board of Trade Statistical Annual. Actual inflation figures represent the change in the log of the spot price between September 1978 and September 1980 (upper panel) and September 1981 and September 1983 (lower panel) divided by three, while the expected inflation figures represent three times the average log difference between the four-month future price at time t and the spot price at time t, where t is indexed three times per year from September 1978 to May 1980 (upper panel) and from September 1981 to May 1983 (lower panel).

the expectational error, v_{t+1}, is normally distributed white noise. We therefore test to determine whether v_{t+1} is indeed normal and whether it is correlated with time t information. P-values for the skewness and kurtosis tests indicated that in the cases of wheat and soybeans, we can reject normality. Furthermore, the error terms were correlated with a menu of available time t information. We thus cannot proceed under the assumption that equation (4) provides an adequate description of commodity market behavior. Instead we allow for time varying risk premiums and replace equation (4) with

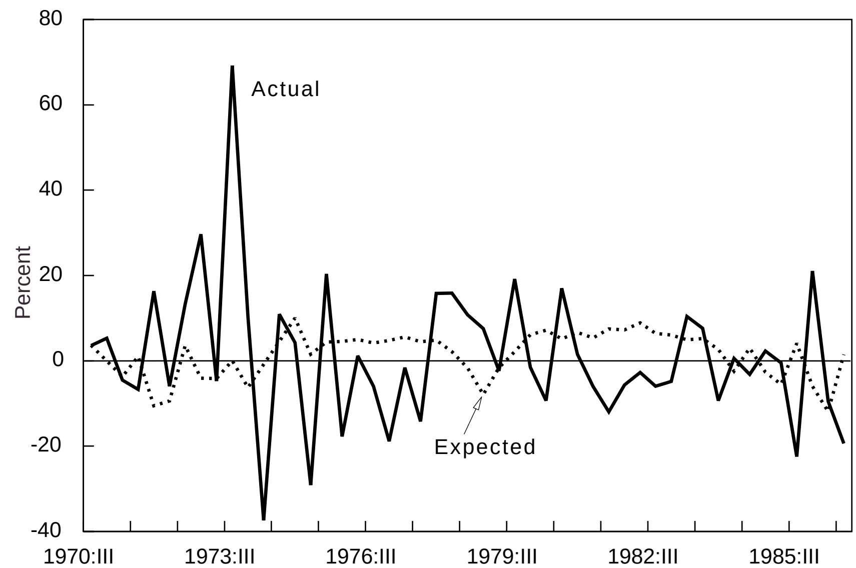
$$s_{t+1} - f_t = x_t'\kappa + v_{t+1} \qquad (4')$$

for each commodity. Upon doing so, we cannot reject the normality of v_{t+1} and we also find that v_{t+1} is uncorrelated with interest rates, forward commodity prices, and its own lagged values.

Estimating and Testing the Model

Before formally estimating the model, we performed augmented Dickey-Fuller tests on aggregate prices, spot prices, and forward commodity prices over

Figure 2a Expected and Actual Commodity Price Inflation for Wheat: 1970 to 1985



Note: Roman numerals denote four-month intervals.

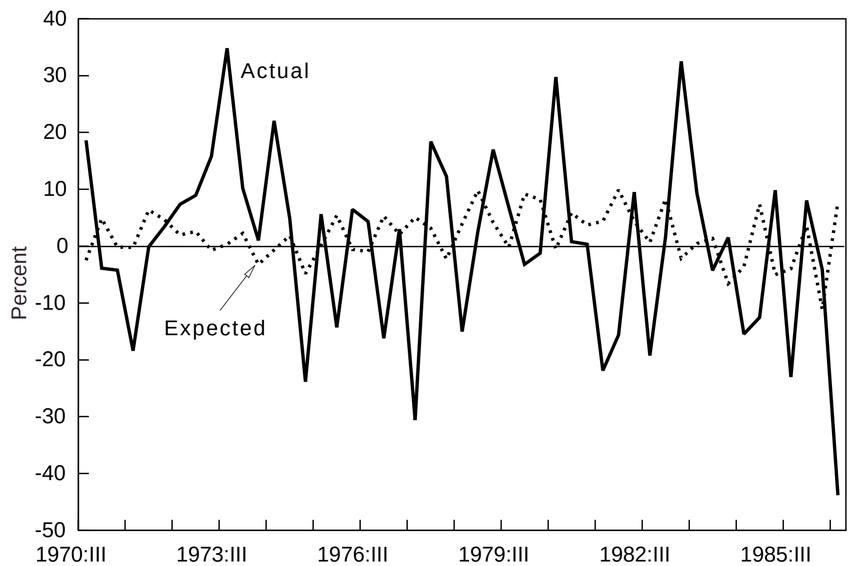
the period 1970:II to 1986:III. We could not reject nonstationarity of the price level, but we were able to reject nonstationarity of commodity prices. Also, for u_{t+1} to be white noise required the inclusion of two lags of the inflation rate. The system that we estimate is depicted by

$$\begin{bmatrix} \Delta p_{t+1} \\ f_t \\ s_{t+1} - f_t \end{bmatrix} = \begin{bmatrix} \delta' \\ \beta' \\ \kappa' \end{bmatrix} x_t + \begin{bmatrix} u_{t+1} \\ \omega_t \\ v_{t+1} \end{bmatrix}, \tag{11}$$

where f and s are 4 by 1 vectors, δ is a 9 by 1 coefficient vector, β and κ are 9 by 4 matrices of coefficients, and u, ω, and v are the disturbance terms. The vector of explanatory variables x_t includes a constant term, two seasonal dummies (d1 and d2), two lags of the inflation rate, and the four commodity spot prices.[7]

[7] This is a fairly parsimonious statistical model. In principle, other variables such as income or money could be included, but doing so would greatly increase the computational burden. Our representation of the inflation process follows Hamilton (1992).

Figure 2b Expected and Actual Commodity Price Inflation for Corn: 1970 to 1985



Note: Roman numerals denote four-month intervals.

The variance-covariance matrix in (9) is now 9 by 9 and is given by

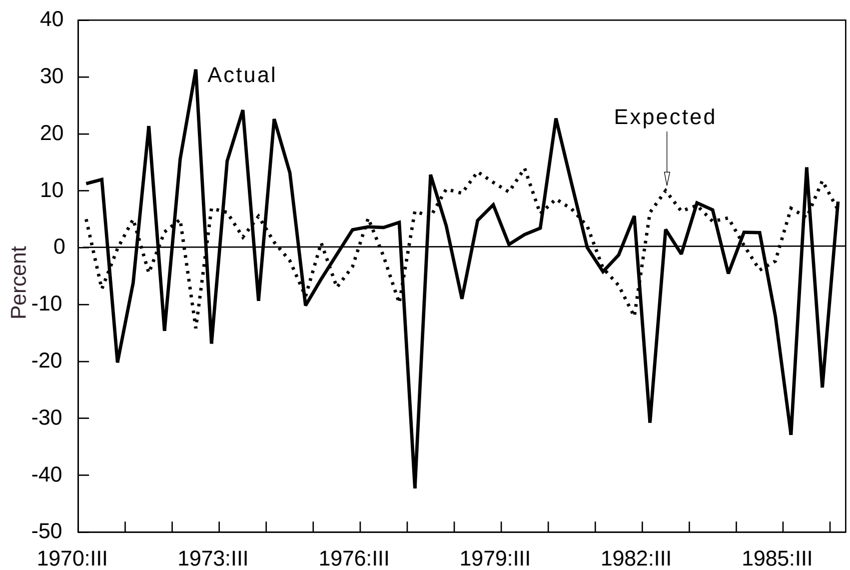
$$\Omega = \begin{bmatrix} \sigma_a^2 + \sigma_\alpha^2 & \sigma_\alpha^2 (q^\alpha)' & \sigma_a^2 (q^a)' \\ \sigma_\alpha^2 (q^\alpha)' & \sigma_\alpha^2 q^\alpha (q^\alpha)' + \Sigma & 0 \\ \sigma_a^2 (q^a)' & 0 & \sigma_a^2 q^a (q^a)' + S \end{bmatrix}, \tag{12}$$

where $\Sigma = E[\varepsilon_t \varepsilon_t']$ and $S = E[e_t e_t']$. We estimate equations (11) and (12) by full-information maximum-likelihood and jointly test the orthogonality conditions assumed under rational expectations and the identifying restriction $q^\alpha = q^a$. We use the Sims (1980) adjusted likelihood-ratio test, which is distributed $\chi^2(19)$.[8] The p-value for the test statistic was 0.45, implying that we cannot jointly reject the restrictions at standard confidence levels. However, for the system using all four commodities, there is not significant covariation between ω_t and u_{t+1}, and ω_t and v_{t+1}. As a result, we cannot reject the hypothesis that $q^a = q^\alpha = 0$.

This lack of rejection is due largely to the inclusion of wheat. Figure 2a shows that actual wheat inflation is volatile, especially early in the sample

[8] The test statistic is $2(\frac{T-k}{T})$ (likelihood [unrestricted]-likelihood [restricted]).

Figure 2c Expected and Actual Commodity Price Inflation for Oats: 1970 to 1985



Note: Roman numerals denote four-month intervals.

period. For a system containing only corn, oats, and soybeans, the covariation between the relevant error terms is more significant, and the hypothesis that $q^a = q^\alpha = 0$ can be rejected at the 9 percent significance level. Furthermore, the joint hypothesis involving $q^a = q^\alpha$ and the rational expectations orthogonality conditions has a p-value of 0.66.

The estimation results for the model are displayed in Table 2. The variance of the inflation forecast u_{t+1}, σ_u^2, is 0.538, most of which is due to $\sigma_a^2 = 0.52$. This result implies that most of the residual, u_{t+1}, took people by surprise.

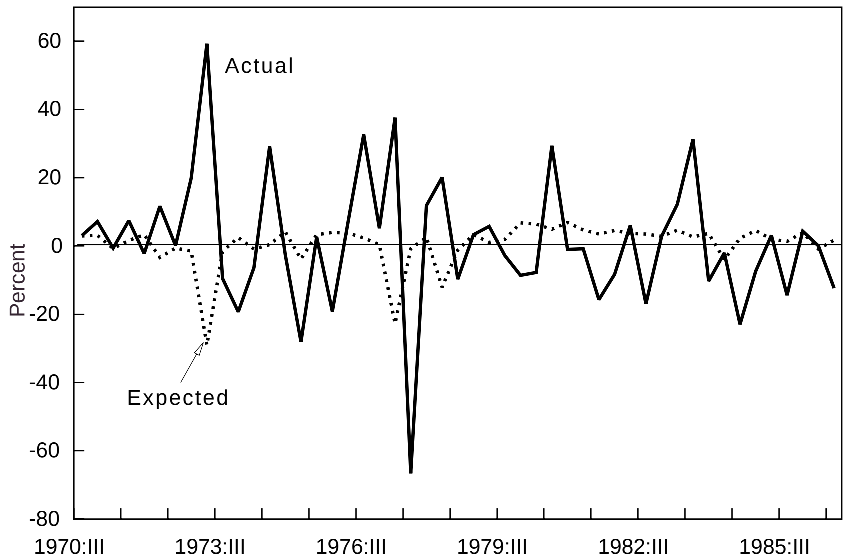
4. PREDICTION

The predictions of inflation over the period 1971:I to 1986:III are calculated using

$$\Delta p^e_{t+1} = x_t'\delta + E_{t+1}\alpha_t. \tag{13}$$

The last term in (13) is derived from the optimal prediction formula given in (10). Thus,

Figure 2d Expected and Actual Commodity Price Inflation for Soybeans: 1970 to 1985



Note: Roman numerals denote four-month intervals.

$$\begin{aligned}\Delta p^e_{t+1} = & -1.76 - 0.08d1_t - 0.08d2_t + 0.35\Delta p_t + 0.14\Delta p_{t-1} \\ & -0.006s_{c,t} - 0.012s_{o,t} + 0.018s_{s,t} \\ & +0.0045(p_{t+1} - x'_t\delta) \\ & -0.011(f_{c,t} - x'_t\beta_c) - 0.012(f_{o,t} - x'_t\beta_o) \\ & +0.041(f_{s,t} - x'_t\beta_s) \\ & -0.000041(s_{c,t+1} - x'_t\kappa_c) - 0.000027(s_{o,t+1} - x'_t\kappa_o) \\ & -0.000013(s_{s,t+1} - x'_t\kappa_s),\end{aligned} \tag{14}$$

where the subscripts c, o, and s refer to corn, oats, and soybeans.

Using (14) we can decompose the forecasts of inflation into simple forecasts, $x'_t\delta$, and the individual contributions from the price term $(p_{t+1} - x'_t\delta)$, the three futures terms $(f_t - x'_t\beta)$, and the three commodity market surprise terms $(s_{t+1} - f_t - x'_t\kappa)$. These decompositions are given in Table 3. Examining the entire sample period, the contributions of the price term and the futures term can at times be meaningful, affecting the forecasts by an annual rate as high as 87 and 51 basis points, respectively. The commodity market surprise

Table 2 Estimation Results[+]

unrestricted log likelihood : -760.43

restricted log likelihood : -765.55
($q^a = q^\alpha$ and orthogonality conditions imposed)

restricted log likelihood : -769.46
($q^a = q^\alpha = 0$ and orthogonality conditions imposed)

$$\sigma_\alpha^2 = 0.017 \quad \sigma_a^2 = 0.52 \quad q' = \begin{bmatrix} 4.60 & 2.59 & 23.41 \\ (0.65) & (0.60) & (0.39) \end{bmatrix}$$

$$\Sigma = \begin{bmatrix} 5.84 & 4.62 & 3.18 \\ 4.62 & 25.42 & 9.09 \\ 3.18 & 9.09 & 4.80 \end{bmatrix} \qquad S = \begin{bmatrix} 171.08 & 72.26 & 45.97 \\ 72.26 & 123.17 & -69.94 \\ 45.97 & -69.94 & 3712.3 \end{bmatrix}$$

$$\Omega = \begin{bmatrix} 0.54 & 0.08 & 0.04 & 0.40 & 2.40 & 1.35 & 12.22 \\ 0.08 & 6.21 & 4.82 & 5.03 & 0 & 0 & 0 \\ 0.04 & 4.82 & 25.53 & 10.13 & 0 & 0 & 0 \\ 0.40 & 5.03 & 10.13 & 14.19 & 0 & 0 & 0 \\ 2.40 & 0 & 0 & 0 & 182.1 & 78.48 & 102.2 \\ 1.35 & 0 & 0 & 0 & 78.48 & 126.7 & -38.3 \\ 12.22 & 0 & 0 & 0 & 102.2 & -38.3 & 39.98 \end{bmatrix}$$

[+] Standard errors for the elements of q' are in parentheses. The commodities are ordered corn, oats, and soybeans.

term, however, rarely has much effect on the forecasts, which is attributable to the small covariance between u_{t+1} and v_{t+1}. Expectations of inflation are displayed in Table 4. The first two columns give the four-month actual and expected inflation rates at annualized rates, the third and fourth columns give eight-month actual and expected inflation at annualized rates, and the fifth and sixth columns give the annual actual and expected inflation rates. The first expectation reported in each instance is the one that is conditional on 1979:III information, since this is the period in which the Fed announced its disinflationary objectives. For example, 13.78, the first number in column 6, is the inflation rate expected for 1980 given 1979:III information.

The eight-month-ahead and the one-year-ahead forecast errors strongly imply that a significant part of the disinflation in the early 1980s was unanticipated. Expected inflation exceeds actual inflation in all but three periods in the eight-month forecasts and in every period in the one-year forecast. On average, agents

Table 3 Decomposition of Expectation of Inflation

Period Ending	Actual	Simple Forecast[1]	Price Term[2]	Futures Term[3]	Surprise Term[4]
1970:III	1.77	1.43	0.049	0.0005	0.008
1971:I	1.00	1.38	−0.055	−0.028	0.015
1971:II	1.23	1.56	−0.047	−0.072	0.017
1971:III	0.98	1.54	−0.081	0.046	0.002
1972:I	0.97	1.25	−0.040	0.033	0.013
1972:II	1.19	1.58	−0.055	−0.11	−0.006
1972:III	1.42	1.35	0.010	0.002	−0.011
1973:I	2.77	1.44	0.19	0.17	−0.006
1973:II	2.92	3.28	−0.052	−0.009	−0.023
1973:III	3.48	3.29	0.027	−0.041	0.010
1974:I	3.77	7.84	0.13	0.046	0.004
1974:II	4.03	3.27	0.11	0.065	−0.026
1974:III	3.30	3.53	−0.033	−0.012	0.007
1975:I	1.52	3.15	−0.23	0.021	0.013
1975:II	2.79	2.04	0.11	0.071	−0.011
1975:III	2.17	1.70	0.068	−0.048	0.008
1976:I	1.07	1.80	−0.10	−0.060	−0.012
1976:II	2.11	1.27	0.12	−0.041	−0.014
1976:III	1.89	1.58	0.04	0.023	0.006
1977:I	2.52	2.11	0.060	0.049	−0.010
1977:II	1.81	2.92	−0.16	−0.014	0.032
1977:III	2.26	2.37	−0.016	−0.055	−0.002
1978:I	2.83	2.16	0.10	0.075	−0.008
1978:II	3.05	2.87	0.025	0.049	0.015
1978:III	2.96	3.16	−0.028	−0.007	0.012
1979:I	4.15	3.21	0.14	−0.047	−0.000
1979:II	4.12	3.57	0.078	−0.066	0.003
1979:III	4.73	3.91	0.12	0.072	0.004
1980:I	4.63	3.94	0.10	−0.026	0.001
1980:II	2.66	4.08	−0.20	−0.074	−0.021
1980:III	3.86	3.36	0.072	0.009	0.002
1981:I	2.83	2.73	0.013	0.005	−0.003
1981:II	3.72	2.97	0.118	−0.067	0.011
1981:III	1.39	2.64	−0.18	0.025	0.009
1982:I	1.58	2.18	−0.086	−0.039	−0.011
1982:II	1.86	1.27	0.084	−0.013	0.014
1982:III	0.20	1.57	−0.20	0.080	0.004
1983:I	1.32	1.11	0.030	−0.11	−0.010
1983:II	1.20	0.89	0.044	−0.05	0.021
1983:III	1.68	1.68	−0.001	−0.13	−0.001
1984:I	1.36	1.55	−0.027	0.003	−0.007
1984:II	1.15	1.74	−0.085	0.059	−0.005
1984:III	0.95	1.10	−0.021	0.069	0.001
1985:I	1.41	0.83	0.083	−0.066	−0.006
1985:II	.084	1.13	−0.042	0.099	0.019
1985:III	1.65	1.34	0.045	0.036	−0.007
1986:I	−0.82	1.22	−0.29	−0.031	0.016
1986:II	0.91	1.13	−0.031	0.11	0.015
1986:III	1.35	0.49	0.12	−0.071	−0.019

[1]The simple forecast is equal to $x_t'\hat{\delta}$.
[2]The price term is given by $A_1(p_{t+1} - x_t'\delta)$ in equation (10).
[3]The futures term is given by $A_2(f_t - x_t'\beta)$ in equation (10).
[4]The surprise term is given by $A_3(s_{t+1} - f_t - x_t'\kappa)$.

Table 4 Actual and Expected Inflation: 1980 to 1983

	One period ahead		Two periods ahead		One year ahead	
Period Ending	Actual	Expected	Actual	Expected	Actual	Expected
1980:I	14.19	11.88				
1980:II	13.89	11.88	14.04	12.87		
1980:III	7.98	12.66	10.94	12.80	12.02	13.78
1981:I	11.58	10.17	9.78	13.10	11.15	13.31
1981:II	8.49	8.19	10.02	10.17	9.34	13.91
1981:III	11.16	9.18	9.83	8.88	10.40	10.67
1982:I	4.17	7.83	7.67	8.81	7.93	8.90
1982:II	4.74	6.51	4.44	8.84	6.68	9.10
1982:III	5.58	4.47	5.16	6.03	4.82	9.29
1983:I	0.60	4.59	3.09	4.17	3.64	5.93
1983:II	3.96	2.76	2.28	5.03	3.38	4.23
1983:III	3.60	3.06	3.78	2.11	2.73	5.27

Note: Roman numerals denote four-month intervals.

expected 1.03 percent and 2.23 percent more inflation than actually occurred over the eight-month and one-year forecast horizons, respectively. The one-period-ahead forecast errors do not, however, give as clear a signal. Expected inflation exceeds actual inflation by only 27 basis points on average for the entire period. The combination of these two results implies that the four-month forecasts of inflation four months out and eight months out are drastically overpredicting inflation.[9] That is, even though inflation is declining, agents do not seem to believe that the disinflationary path will continue. Essentially, longer-run expectations appear to be much too static over the period. In this sense, the econometric model indicates that much of the disinflationary path was unanticipated.

5. CONCLUSION

The disinflation that occurred in the early 1980s was a dramatic event in post-World War II monetary policy. Inflation had reached unprecedented heights and was brought down fairly rapidly. It is likely that this disinflation was partially responsible for the two recessions that occurred in rapid succession. The disinflationary policy was announced and underscored by a change in Federal Reserve operating procedures. The policy was carried out over a prolonged period. These two factors could easily lead to the interpretation that

[9] We checked the unbiasedness of the forecasts by regressing Δp_{t+1} on a constant and $E_t \Delta p_{t+1}$. For the four-month and eight-month regressions, we could not reject a zero constant and a unitary slope coefficient. However, the hypothesis that $p_{t+1} = E_t p_{t+1}$ plus a white noise error was rejected at the annual frequency. Therefore, we conclude that greater weight should be placed on the eight-month forecast.

the disinflation was anticipated and, therefore, that this episode is consistent with theories emphasizing the impact of anticipated monetary policy on real economic activity.

Although the policy was announced, evidence documented by Goodfriend (1992) suggests that it may not have been entirely credible. Hence the actual disinflation could still have been unanticipated. Determining the extent to which the disinflation was unanticipated can help ascertain the degree to which Fed credibility was lacking.

In an attempt to resolve whether the disinflation was anticipated, we performed a statistical analysis of the public's expectations of inflation using the methodology developed in Hamilton (1992). Our conclusion is that much of the disinflation was unanticipated and that the Fed suffered from a credibility problem. The fact that much of the disinflation was unanticipated, however, does not allow us to discriminate among the competing models outlined in the introduction. Such discrimination would necessarily involve a more subtle hypothesis test.

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