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Short-Term Headline-Core Inflation Dynamics

Yash P. Mehra and Devin Reilly

Many analysts contend that the Federal Reserve under Chairmen Alan Greenspan and Ben Bernanke has conducted monetary policy that focuses on core rather than headline inflation. The measure of core inflation used excludes food and energy prices.[1] The main argument in favor of using core inflation to implement monetary policy is that core inflation approximates the permanent or trend component of inflation much better than does headline inflation, the latter being influenced more by transitory movements in food and energy prices. The empirical evidence favorable to the use of core inflation in policy is recently reviewed in Mishkin (2007b). This empirical evidence consists of examining short-term dynamics between headline and core inflation measures, indicating that, in samples that start after the early 1980s, headline inflation has reverted more strongly toward core inflation than core inflation has moved toward headline inflation. However, the research reviewed also shows that the evidence indicating the reversion of headline inflation to core inflation is quite weak in samples that start in the 1960s, suggesting that headline-core inflation dynamics may not be stable over time.[2]

Thomas Lubik, Roy Webb, and Nadezhda Malysheva provided valuable comments on this article. The views expressed in this article do not necessarily reflect those of the Federal Reserve Bank of Richmond or the Federal Reserve System. E-mails: yash.mehra@rich.frb.org; devin.reilly@rich.frb.org.

[1] The evidence suggesting the Federal Reserve under Chairman Greenspan focused on a core measure of inflation appears in Blinder and Reis (2005), Mehra and Minton (2007), and Mishkin (2007b).

[2] See also Clark (2001), Blinder and Reis (2005), Rich and Steindel (2005), and Kiley (2008). These analysts use different empirical methodologies to come to the same conclusion that core inflation is better than headline inflation in gauging the trend in inflation if we focus on the samples that start in the early 1980s. For example, Kiley (2008) uses statistical models to extract directly the trend component of inflation and argues that, in the 1970s and early 1980s, core as well as headline inflation contains information about the trend; however, in the recent data, the trend is best gauged by focusing on core inflation. The evidence in Clark (2001), Blinder and Reis (2005), Rich and Steindel (2005), and Crone et al. (2008) is based on comparing the relative

In this article we re-examine the short-term dynamics between headline and core measures of inflation over a longer sample period of 1959–2007. We offer new evidence that headline-core inflation dynamics have indeed changed during this sample period and that this change in dynamics may be due to a change in the conduct of monetary policy in 1979.[3] In particular, we examine such dynamics over three sub-periods: 1959:1–1979:1, 1979:2–2001:2, and 1985:1–2007:2. We consider the sub-sample 1985:1–2007:2, as it spans a period of relatively low and stable inflation. We consider both the consumer price index (CPI) and the personal consumption expenditure (PCE) deflator. The data used is biannual because the structural vector autoregression (VAR) model employed uses the Livingston survey data on the public's expectations of headline CPI inflation, which is available twice a year. However, the basic results on the change in short-term headline-core inflation dynamics are robust to using quarterly data and to including additional determinants of inflation in bivariable headline-core inflation regressions.

The empirical evidence presented here indicates headline and core measures of inflation are co-integrated, suggesting long-run co-movement. However, the ways these two variables adjust to each other in the short run and generate co-movement have changed across these sub-periods. In the pre-1979 sample period, when a positive gap opens up with headline inflation rising above core inflation, the gap is eliminated mainly as a result of headline inflation not reverting and core inflation moving toward headline inflation. This result suggests headline inflation is better than core inflation in assessing the permanent component of inflation. In post-1979 sample periods, however, the positive gap is eliminated as a result of headline inflation reverting more strongly toward core inflation than core inflation moving toward headline inflation. This suggests core inflation would be better than headline inflation in assessing the permanent component of inflation.

Recent research suggests a monetary policy explanation of this change in short-term headline-core inflation dynamics. We focus on a version of monetary policy explanation suggested by the recent work of Leduc, Sill, and Stark (2007), which attributes the persistently high inflation of the 1970s to a weak monetary policy response to surprise increases in the public's expectations of inflation. In particular, using a structural VAR that includes a direct survey measure of expected (headline CPI) inflation, Leduc, Sill, and Stark show that prior to 1979, the Federal Reserve accommodated exogenous movements in expected inflation seen in the result that the short-term real interest rate did not increase in response to such movements, which then led to persistent increases

forecast performance of core and headline measures; only in recent data is core inflation the better predictor of future headline inflation.

[3] The evidence indicating that inflation dynamics have changed since 1979 appears in Bernanke (2007); Leduc, Sill, and Stark (2007); and Mishkin (2007a).

in actual inflation. Such Federal Reserve behavior, however, is absent post-1979, leading to a decline in the persistence of inflation. We illustrate that such a change in Federal Reserve behavior is also capable of generating the change in headline-core inflation dynamics documented above.

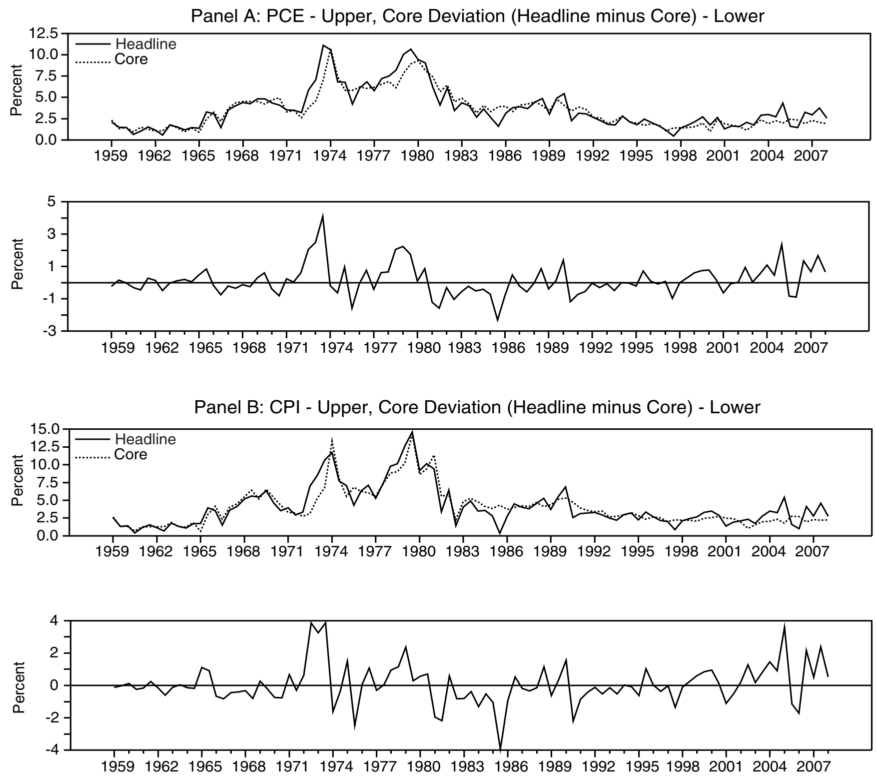
In particular, when we consider a variant of the structural VAR model that includes expected headline inflation, actual headline inflation, actual core inflation, and a short-term nominal interest rate, we find that a change in the interest rate response to exogenous movements in expected headline inflation can explain the change in actual headline-core inflation dynamics. Thus, prior to 1979, when the Federal Reserve accommodated exogenous movements in expected headline inflation, a surprise increase in expected headline inflation (say, due to higher energy and food prices) was not reversed, leading to persistent increases in actual headline inflation with core inflation moving toward headline inflation. A surprise increase in expected headline inflation thus generates co-movement between actual headline and core inflation measures. Since such Federal Reserve accommodation of shocks to expected headline inflation is absent post-1979, surprise increases in expected headline inflation are reversed, with actual headline inflation inverting to core inflation. In the most recent sample period, 1985:1–2007:2, surprise increases in expected headline inflation have no significant effect on core inflation, whereas surprise increases in core inflation do lead to increases in headline inflation, generating co-movement between headline and core CPI inflation measures. Since movements in food and energy prices are likely significant sources of movements in the public's expectations of headline inflation, this empirical work implies that change in headline-core inflation dynamics may be due to the Federal Reserve having convinced the public it would no longer accommodate food and energy inflation.

The rest of the paper is organized as follows. Section 1 presents the main empirical results on the nature of the change in headline-core inflation dynamics across three sub-periods spanning the sample of 1959–2007. Section 2 presents and discusses results from recent research including a structural VAR model, suggesting a monetary policy explanation of the change in headline-core inflation dynamics documented in Section 1. Section 3 contains concluding observations.

1. EMPIRICAL RESULTS ON HEADLINE-CORE INFLATION DYNAMICS

In this section we present the econometric work consistent with change in short-term headline-core inflation dynamics. Figure 1, which charts headline and core measures of PCE and CPI inflation, provides a look at the behavior of these two measures of inflation during the sample period of 1959–2007. Two observations are noteworthy. The first is that headline and core measures

Figure 1 PCE and CPI Inflation Rates Since 1959



of CPI and PCE inflation co-move over the sample period. The lower graph in each panel of Figure 1 charts the "core deviation," measured as the gap between headline and core inflation rates. This series is mean stationary, consistent with co-movement. The second point to note is that, although Figure 1 shows that headline and core measures of inflation co-move in the long run, it is not clear from the figure how this co-movement arises. This co-movement may be a result of one series adjusting to the other, or both series adjusting to each other. We formally investigate such dynamics in this section.

One approach to headline-core inflation dynamics uses the co-integration-error-correction methodology popularized by Granger (1986) and Engle and Granger (1987), among others. Under this approach, one examines short-term inflation dynamics under the premise that headline and core inflation series may be nonstationary but co-integrated, indicating the presence of a long-run relationship between these two measures. Using short-term error-correction equations, one can then estimate how these two series adjust if headline inflation moves above or below its long-run value implied by the co-integrating regression. Another approach treats the inflation series as being mean stationary in levels, especially during shorter sample periods.[4] One infers short-term headline-core dynamics by examining the near-term responses of headline and core inflation measures to a core deviation. We employ both of these approaches.

Unit Roots, Co-integration, and Short-Term Dynamics

To investigate whether there exists a long-run co-integrating relationship between headline and core measures of inflation, we first examine the unit root properties of these two series. Table 1 presents test results for determining whether headline (π_t^H) and core (π_t^C) inflation measures have unit roots. The test used is the t-statistic, implemented by estimating the augmented Dickey-Fuller (1979) regression of the form

$$X_t = m_0 + \rho X_{t-1} + \sum_{s=1}^{k} m_{1s} \Delta X_{t-s} + \varepsilon_t, \tag{1}$$

where X_t is the pertinent variable, ε is the disturbance term, and k is the number of lagged first differences to make ε serially uncorrelated. If $\rho = 1$, X_t has a unit root. The null hypothesis $\rho = 1$ is tested using the t-statistic. As can be seen, the t-statistic reported in Table 1 is small for levels of inflation series but large for first differences of these series, suggesting that inflation is nonstationary in levels but stationary in first differences over 1959:1–2007:2. If headline and core inflation measures are nonstationary in levels, there may exist a long-run co-integrating relationship between them. We use a two-step Engle-Granger (1987) procedure to test for the presence of a long-run relationship. In step one of this procedure, we estimate by ordinary least squares (OLS) the regression of the form

$$\pi_t^H = a_0 + a_1 \pi_t^C + \mu_t, \tag{2}$$

where μ_t is the disturbance term. In step two, we investigate the presence of a unit root in the residuals of regression (2) using the augmented Dickey-Fuller

[4] Many analysts have noted the low power of unit root tests in detecting nonstationarity in series, arguing that inflation may not have a unit root when some more attractive alternative hypotheses are considered. For example, Webb (1995) argues that it is possible to reject the hypothesis of a unit root in inflation when the alternative hypothesis allows for the presence of breaks in monetary policy regimes. As noted in the main text of this article, we also examine short-term headline-core inflation dynamics, treating inflation as being stationary within each subperiod.

Table 1 Unit Root Tests

Augmented Dickey-Fuller Regressions
Biannual Data from 1959:1–2007:2

Levels:

$$\Pi_t^H = m_0 + \rho \Pi_{t-1}^H + \textstyle\sum_{s=1}^k \Delta \Pi_{t-s}^H$$
$$\Pi_t^C = m_0 + \rho \Pi_{t-1}^C + \textstyle\sum_{s=1}^k \Delta \Pi_{t-s}^C$$

First Differences:

$$\Delta\Pi_t^H = m_0 + \rho(\Delta\Pi_{t-1}^H) + \textstyle\sum_{s=1}^k \Delta(\Delta\Pi_{t-s}^H)$$
$$\Delta\Pi_t^C = m_0 + \rho(\Delta\Pi_{t-1}^C) + \textstyle\sum_{s=1}^k \Delta(\Delta\Pi_{t-s}^C)$$

	Levels						First Differences					
	CPI			PCE			CPI			PCE		
	$\hat{\rho}$	$t_{\hat{\rho}}$	k	$\hat{\rho}$	$t_{\hat{\rho}}$	k	$\hat{\rho}$	$t_{\hat{\rho}}$	k	$\hat{\rho}$	$t_{\hat{\rho}}$	k
Headline	0.8362	−2.3982	4	0.8896	−1.9427	4	−0.4085	−6.0378	3	−0.4590	−6.5147	3
Core	0.8510	−2.4537	1	0.9092	−2.1164	0	−0.4239	−8.7399	1	−0.0851	−10.6229	0

Notes: Π^H and Π^C are headline and core inflation, respectively, in levels, while $\Delta\Pi^H$ and $\Delta\Pi^C$ are first differences of headline and core inflation. $\hat{\rho}$ and the t-statistic, $t_{\hat{\rho}}$, for $\rho = 1$ are from the augmented Dickey-Fuller regressions. The series has a unit root if $\rho = 1$. The 5 percent critical value is -2.9. The number of lagged first differences (k) is chosen using the Akaike Information Criterion.

Table 2 Co-integration Tests

			Panel A: Engle-Granger Test		
	$\hat{\alpha}_0$	$\hat{\alpha}_1$	$\hat{\delta}$	$\hat{t}_\delta$	k
CPI	0.1790	0.9714	0.2924	−4.4380	3
PCE	−0.0111	1.0408	0.3101	−4.7694	3
			Panel B: Johansen Test		
	λ_1	λ_2	Co-integrating Vector		LR
CPI	0.2617	0.0852	(−1.3725, 1.4368)		28.8223**
PCE	0.2554	0.0584	(−1.8244, 1.9375)		28.0137**
			Panel C: Fully Modified OLS Estimates		
	α_0	α_1	s_1	s_2	
CPI	0.0837	0.9956	0.9326	0.8841	
PCE	−0.0144	1.0427	0.3521	0.2481	

Notes: Biannual data from 1959:1–2007:2. *10 percent significance, **5 percent significance. For the Engle-Granger (1987) test, $\hat{\alpha}_0$, $\hat{\alpha}_1$, $\hat{\delta}$, and the t-statistic for $\delta = 1$ in Panel A are from two regressions of the form $\Pi_t^H = \alpha_0 + \alpha_1 \Pi_t^C + u_t$ and $\tilde{u}_t = \delta \tilde{u}_{t-1} + \sum_{s=1}^{k} b_s \Delta \tilde{u}_{t-s}$. Headline and core measures are not co-integrated if the residual series, $\tilde{u}_t$, has a unit root, i.e., if $\delta = 1$. For the Johansen (1988) test, the table shows the two eigenvalues, λ_1 and λ_2, used in evaluating Johansen's likelihood function, the estimated co-integrating vectors, and the likelihood ratio statistic, LR, for testing the null hypothesis of no co-integration. The LR is calculated as $-T \cdot \ln(1-\lambda_1)$, where T is the number of total observations. Critical values for LR are reported under the heading Case 1 in Hamilton (1994, 768, Table B.11). Panel C shows results from a fully modified OLS regression of the form $\Pi_t^H = \alpha_0 + \alpha_1 \Pi_t^C + u_t$. The statistic s_1 is the significance level of the test hypothesis $\alpha_1 = 1$, while s_2 is the significance level of the test of the hypothesis $\alpha_0 = 0$ and $\alpha_1 = 1$. See notes from Table 1 for variable definitions.

test implemented by estimating regression of the form

$$\widetilde{u}_t = \delta \widetilde{u}_{t-1} + \sum_{s=1}^{k} b_{1s} \Delta \widetilde{u}_{t-s}, \tag{3}$$

where $\widetilde{u}$ is the residual. If $\delta = 1$, then there does not exist a long-run relationship between headline and core measures of inflation. The null hypothesis, $\delta = 1$, is tested using the t-statistic. Table 2, Panel A presents the pertinent t-statistic, which is large for both PCE and CPI inflation measures, leading to the rejection of the null hypothesis. These test results suggest headline and core measures of inflation are indeed co-integrated.

The Engle-Granger test is implemented above by assuming a particular normalization, regressing headline inflation on core inflation, and examining the presence of a unit root in the residuals of (2). For robustness with respect to normalization, we also implement the likelihood test of co-integration as in Johansen (1988). Table 2, Panel B reports the likelihood test results and estimated co-integrating vectors. The likelihood ratio statistic that tests the null hypothesis of no co-integrating vector against the alternative of one co-integrating vector is large, leading to the rejection of the null hypothesis.

In order to be able to carry out tests of hypotheses on parameters of the estimated co-integrating vectors, we re-estimate the co-integrating relationship (2) using a fully modified OLS estimator as in Phillips and Hansen (1990) because standard OLS estimates, though consistent, do not have the asymptotic normal distribution. The estimates are reported in Table 2, Panel C. As can be seen, the estimated long-run coefficient, $\widetilde{a}_1$, is positive and statistically different from zero, suggesting the presence of a positive relationship between headline and core inflation measures. The estimated long-run coefficient, $\widetilde{a}_1$, is not different from unity, suggesting the headline measure of inflation moves one-for-one with the core measure in the long run. The significance level of the statistic that tests the null hypothesis $a_0 = 0$, $a_1 = 1$ is .88 using CPI and .25 using PCE. These significance levels are large, leading to an acceptance of the null hypothesis.

Having established above that headline and core measures of inflation co-move in the long run, we now investigate the sources of this co-movement by estimating short-term error-correction equations of the form given in (4) and (5):

$$\Delta\pi_t^H = b_0 + \lambda_h \mu_{t-1} + \sum_{s=1}^{k} \Delta\pi_{t-s}^H + \upsilon_t, \text{ and} \tag{4.1}$$

$$\Delta\pi_t^C = b_0 + \lambda_c \mu_{t-1} + \sum_{s=1}^{k} \Delta\pi_{t-s}^C + \upsilon_t. \tag{4.2}$$

Under the assumptions $a_0 = 0$, $a_1 = 1$, we can re-write (4) as (5):

$$\Delta\pi_t^H = b_0 + \lambda_h (\pi^H - \pi^C)_{t-1} + \sum_{s=1}^{k} \Delta\pi_{t-s}^H + \upsilon_t, \text{ and} \tag{5.1}$$

$$\Delta\pi_t^C = b_0 + \lambda_c (\pi^H - \pi^C)_{t-1} + \sum_{s=1}^{k} \Delta\pi_{t-s}^C + \upsilon_t. \tag{5.2}$$

Regressions (4) and (5) capture short-term dynamics between headline and core inflation measures, and the coefficients λ_h and λ_c indicate how headline inflation and core inflation adjust if a gap emerges between headline and core inflation rates. If $\lambda_h = 0$ and $\lambda_c > 0$, headline and core inflation stay together mainly by core inflation moving toward headline inflation. If $\lambda_h < 0$ and $\lambda_c = 0$, headline and core inflation stay together mainly by headline inflation moving toward core inflation. If $\lambda_h < 0$ and $\lambda_c > 0$, both series adjust, with headline inflation moving toward core inflation and core inflation moving toward headline inflation. The relative magnitudes of these adjustment coefficients convey information about which series adjusts more in response to a core deviation.

Table 3, Panel A, presents estimates of short-term error-correction (adjustment) coefficients, providing information about the ways these two series adjust over three sub-samples considered. Focusing first on the adjustment coefficient, $\widehat{\lambda}_h$, that appears in headline inflation regressions, this estimated coefficient is positive and not statistically different from zero in the pre-1979 sample period, but is negative and statistically different from zero in the recent sample period, 1985:1–2007:2. This result holds for headline CPI as well as for headline PCE inflation. These estimates of the adjustment coefficient, $\widehat{\lambda}_h$, suggest that if headline inflation is above core inflation, headline inflation inverts toward core inflation in the recent sample period but not in the pre-1979 sample period. Focusing now on the adjustment coefficient, $\widehat{\lambda}_c$, that appears in core inflation equations, we see that results differ for CPI and PCE inflation measures. In core PCE inflation equations, the estimated coefficient is positive, large, and statistically significant in the pre-1979 sample period but it becomes small and not statistically different from zero in the recent sample period, 1985:1–2007:2, suggesting that if headline inflation is above core inflation, core inflation moves toward headline inflation in the pre-1979 sample period but not in the recent sample period, 1985:1–2007:2. For CPI inflation, the adjustment coefficient, $\widehat{\lambda}_c$, that appears in the core inflation equation does decline significantly from .91 in the pre-1979 sample period to .19 in the recent sample period. However, it remains statistically significant in the recent sample period, suggesting the CPI measure of core inflation has also moved somewhat toward headline inflation. Together, these short-term adjustment coefficients suggest that, whereas in the pre-1979 sample period headline and core measures of inflation stayed together as a result of core inflation moving toward headline inflation, in the recent sample period they have stayed together more as a result of headline inflation moving toward core inflation than core inflation moving toward headline inflation. In order to check robustness, discussed in detail later in this article, we re-estimate short-term adjustment equations (5) augmented to include two additional lags of other economic determinants of inflation such as changes in a short-term nominal interest rate and changes in the unemployment rate. Table 3, Panel B, presents the short-term adjustment coefficients from these short-term augmented regressions. We can see estimates of short-term adjustment coefficients yield qualitatively similar results about change in headline-core inflation dynamics.[5]

[5] The adjusted R-squared statistics provided in Table 3 appear reasonable given that short-term adjustment equations are estimated using first-differences of inflation measures.

Table 3 Short-Term Headline-Core Inflation Dynamics

Panel A: Bivariable Adjustment Regressions

$$\Delta\Pi_t^H = \beta_0 + \lambda_h\left(\Pi_{t-1}^H - \Pi_{t-1}^C\right) + \sum_{s=1}^2 \Delta\Pi_{t-s}^H + v_t$$

$$\Delta\Pi_t^C = \beta_0 + \lambda_c\left(\Pi_{t-1}^H - \Pi_{t-1}^C\right) + \sum_{s=1}^2 \Delta\Pi_{t-s}^C + v_t$$

	CPI				PCE			
	λ_h	$\bar{R}^2$	λ_c	$\bar{R}^2$	λ_h	$\bar{R}^2$	λ_c	$\bar{R}^2$
1959:1–1979:1	0.3551	−0.027	0.9141**	0.433	0.4011	−0.042	0.7734**	0.406
1979:2–2001:2	−0.2208	0.144	0.2917	0.136	−0.8139**	0.200	−0.0483	0.107
1985:1–2007:2	−0.7319**	0.365	0.1943**	0.264	−0.6168**	0.328	0.0763	0.203

Panel B: Multivariable Adjustment Regressions

$$\Delta\Pi_t^H = \beta_0 + \lambda_h\left(\Pi_{t-1}^H - \Pi_{t-1}^C\right) + \sum_{s=1}^2 (\Delta\Pi_{t-s}^H + \Delta\Pi_{t-s}^C + \Delta sr_{t-s} + \Delta ur_{t-s}) + v_t$$

$$\Delta\Pi_t^C = \beta_0 + \lambda_c\left(\Pi_{t-1}^H - \Pi_{t-1}^C\right) + \sum_{s=1}^2 (\Delta\Pi_{t-s}^C + \Delta\Pi_{t-s}^H + \Delta sr_{t-s} + \Delta ur_{t-s}) + v_t$$

	CPI				PCE			
	λ_h	$\bar{R}^2$	λ_c	$\bar{R}^2$	λ_h	$\bar{R}^2$	λ_c	$\bar{R}^2$
1959:1–1979:1	0.4745	0.251	1.0793**	0.520	0.2213	0.147	0.6770*	0.354
1979:2–2001:2	−0.0881	0.322	0.6665**	0.601	−0.2972	0.260	0.4519*	0.335
1985:1–2007:2	−0.6471*	0.351	0.2701**	0.465	−0.5400	0.261	0.4158**	0.280

Notes: *10 percent significance, **5 percent significance. The coefficients λ_h and λ_c are estimated using OLS; Δsr_t is the first difference in the short-term nominal rate, defined as the three-month Treasury-bill rate; Δur is the first difference in the unemployment rate. See notes from Table 1 for the definitions of other variables.

Stationarity and Mean Reversion

We also examine short-term headline-core dynamics by focusing on the influence of core deviation on the longer-horizon behavior of inflation, assuming headline and core inflation measures are likely mean stationary in shorter sample periods. If headline inflation is above core inflation and if adjustment occurs mainly as a result of headline inflation moving toward core inflation, we should expect headline inflation to decline in the near term. With that in mind, we examine the behavior of inflation over various forecast horizons as in (6.1) and (6.2):[6]

$$\pi^H_{t+f} - \pi^H_t = b_{0f} + \lambda_{hf}(\pi^H - \pi^C)_t + \sum_{s=1}^{k} b_{1f}\pi^H_{t-s} + \mu_{t+f}, \text{ and} \quad (6.1)$$

$$\pi^C_{t+f} - \pi^C_t = c_{0f} + \lambda_{cf}(\pi^H - \pi^C)_t + \sum_{s=1}^{k} c_{1f}\pi^C_{t-s} + \mu_{t+f}, \quad (6.2)$$

where π^H_{t+f} is the f-periods-ahead headline inflation rate, π^H_t is the current-period headline inflation rate, π^C_t is the current-period core inflation rate, $\pi^H - \pi^C$ is the contemporaneous core deviation, f is the forecast horizon, and μ_{t+f} is a mean-zero random disturbance term. Regressions (6.1) and (6.2) relate the change in inflation over the next f (six-month) periods to the contemporaneous gap between headline and core inflation rates. If the coefficients, λ_{hf}, in (6.1) are generally negative and the coefficients, λ_{cf}, in (6.2) are zero, then core deviation is eliminated primarily as a result of headline inflation inverting to core inflation. In contrast, if the coefficients, λ_{hf}, in (6.1) are zero and the coefficients, λ_{cf}, in (6.2) are positive, core deviation is eliminated mainly as a result of core inflation moving toward headline inflation.

Table 4 presents estimates of the coefficients from regressions given in (6.1) and (6.2). The estimates are presented for forecast horizons of one to four periods in the future. Panel A presents estimates using CPI and Panel B uses PCE. Since results derived using CPI are broadly similar to those derived using PCE inflation, we focus on estimates derived using CPI. As can be seen in the pre-1979 sample period, estimated coefficients $\widehat{\lambda}_{hf}$, $f = 1, 2, ..., 4$ are zero and $\widehat{\lambda}_{cf}$, $f = 1, 2, ..., 4$ are positive, confirming that the series have stayed together mainly as a result of core inflation moving toward headline inflation. In the most recent sample period, 1985:1–2007:2, however, estimated coefficients $\widehat{\lambda}_{hf}$, $f = 1, 2, ..., 4$ are negative and $\widehat{\lambda}_{cf}$, $f = 1, 2, ..., 4$ are positive, suggesting that both series are adjusting to each other. However,

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[6] In previous research, analysts have focused only on equation (4.1), examining inversion in headline inflation. See, for example, Clark (2001), Cogley (2002), and Rich and Steindel (2005).

Table 4 Short-Term Headline-Core Inflation Dynamics

Long-Horizon Behavior of Inflation

$$\Pi^H_{t+f} - \Pi^H_t = b_{0,f} + \lambda_{hf}\left(\Pi^H_t - \Pi^C_t\right) + \sum_{s=1}^{2} \Pi^H_{t-s} + \mu_{t+f}$$
$$\Pi^C_{t+f} - \Pi^C_t = b_{0,f} + \lambda_{cf}\left(\Pi^H_t - \Pi^C_t\right) + \sum_{s=1}^{2} \Pi^C_{t-s} + \mu_{t+f}$$

Panel A: CPI

	1959:1–1979:1		**1979:2–2001:2**		**1985:1–2007:2**	
	$\hat{\lambda}_{hf}$ (t-value)	$\hat{\lambda}_{cf}$ (t-value)	$\hat{\lambda}_{hf}$ (t-value)	$\hat{\lambda}_{cf}$ (t-value)	$\hat{\lambda}_{hf}$ (t-value)	$\hat{\lambda}_{cf}$ (t-value)
$f = 1$	0.2922 (1.4712)	0.9476 (5.1898)	−0.7230 (−2.3898)	0.1660 (0.6635)	−0.7101 (−4.9165)	0.1858 (3.7078)
$f = 2$	0.1799 (0.6308)	1.0523 (4.0652)	−0.8962 (−3.5360)	0.2796 (1.1604)	−0.9658 (−5.9644)	0.1906 (2.5528)
$f = 3$	0.2708 (0.8540)	0.9571 (3.2132)	−0.6554 (−2.4870)	0.1431 (0.5892)	−0.8059 (−4.9527)	0.1478 (1.7234)
$f = 4$	−0.4165 (−1.1036)	0.5683 (1.5071)	−1.2379 (−3.9101)	−0.1730 (−0.6615)	−1.0563 (−6.2716)	0.0934 (3.6687)

Panel B: PCE

	1959:1–1979:1		**1979:2–2001:2**		**1985:1–2007:2**	
	$\hat{\lambda}_{hf}$ (t-value)	$\hat{\lambda}_{cf}$ (t-value)	$\hat{\lambda}_{hf}$ (t-value)	$\hat{\lambda}_{cf}$ (t-value)	$\hat{\lambda}_{hf}$ (t-value)	$\hat{\lambda}_{cf}$ (t-value)
$f = 1$	0.1621 (0.6311)	0.7294 (4.3905)	−0.9177 (−3.9444)	−0.1905 (−1.1215)	−0.7550 (−4.5498)	0.0684 (0.6118)
$f = 2$	−0.0373 (−0.1061)	0.7377 (2.7125)	−1.2218 (−5.5721)	−0.0874 (−0.5304)	−0.9640 (−4.9353)	0.2006 (1.6302)
$f = 3$	−0.1051 (−0.2686)	0.5343 (1.6707)	−0.8718 (−4.0458)	−0.0183 (−0.0981)	−0.8452 (−4.4408)	0.1519 (1.2177)
$f = 4$	−0.9059 (−2.1481)	0.2232 (0.6207)	−1.5878 (−7.2154)	−0.6071 (−3.1880)	−1.1517 (−5.4391)	−0.0300 (−0.1976)

Notes: f is the number of periods in the forecasting horizon. Regressions are estimated including levels of lagged inflation. All regressions are estimated using OLS. See notes from Table 1 for variable definitions.

relative magnitudes of the estimated adjustment coefficients suggest headline inflation has moved more toward core inflation than core inflation has moved toward headline inflation.

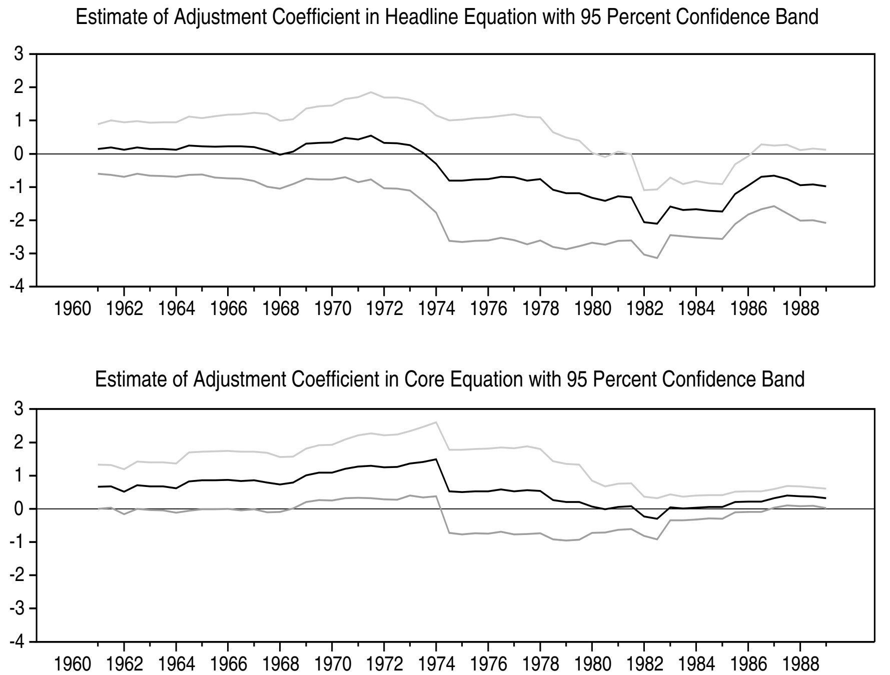
Robustness: Multivariate System, Data Frequency, and Sample Breaks

The change in short-term headline-core inflation dynamics summarized above are derived using a bivariable framework, biannual data, and three sub-periods generated by breaking the sample in 1979 and 1984. Here, we present some additional evidence indicating inference that the nature of change in headline-core inflation dynamics remains robust to several changes in specification. The first change in specification expands the regressions given in (5.1) and (5.2) to include other possible determinants of inflation such as changes in a short-term nominal interest (capturing the possible influence of monetary policy actions) and changes in the unemployment rate (as a proxy for the influence of the state of the economy). We focus on the sign and statistical significance of the short-term adjustment coefficients in these expanded regressions. As already noted, estimates from these multivariate regressions (Table 3, Panel B) yield qualitatively similar inferences about the nature of the change in short-term headline-core inflation dynamics to those derived using bivariable regressions.

Rather than focus on three sub-periods, we estimate the short-term adjustment coefficients from the multivariate versions of regressions given in (5.1) and (5.2) using rolling regressions over a 19-year window.[7] We estimate those regressions using biannual as well as quarterly data. Since the results using biannual data are qualitatively similar to those derived using quarterly data and, since the results also appear robust to the use of CPI or PCE inflation, we focus on estimates derived using biannual data and CPI inflation. Panel A in Figure 2 charts estimates of the short-term adjustment coefficient, λ_h, from headline inflation regressions, and Panel B charts estimates of the short-term adjustment coefficient, λ_c, from core inflation regressions, with 95 percent confidence bands. In samples that begin in the 1960s or early 1970s, the short-term adjustment coefficient, λ_h, is usually positive but statistically indifferent from zero whereas the short-term adjustment coefficient, λ_c, is positive and statistically different from zero, suggesting headline inflation does not revert, but rather core inflation moves toward headline inflation. In contrast, in samples that begin in the early 1980s, the short-term adjustment coefficient, λ_h, is instead negative and statistically significant whereas the short-term adjustment coefficient, λ_c, is positive but not always statistically

[7] In the multivariable versions of (5.1) and (5.2), we include changes in a short-term nominal interest rate and changes in the unemployment rate, besides including lags of headline and core inflation rates.

Figure 2 Rolling Window Regression: 19-Year Window, Biannual Data, CPI Inflation



Notes: Entries on the x-axis represent the start of the sample window for the coefficient estimate.

different from zero. This suggests that the gap between headline and core CPI inflation is eliminated as a result of headline inflation inverting toward core inflation rather than core inflation moving toward headline inflation. These results are qualitatively similar to those derived using bivariable regressions estimated across three chosen sample periods.

2. DISCUSSION OF RESULTS

What explains the change in the short-term headline-core inflation dynamics documented above? Recent research suggests a monetary policy explanation. Mishkin (2007a) provides evidence that in recent years inflation persistence has declined and inflation has become less responsive to changes in unemployment and other shocks. He attributes this change in inflation dynamics to the anchoring of inflation expectations as a result of better conduct of monetary policy. In a recent paper, Leduc, Sill, and Stark (2007) attribute the persistently high inflation of the 1970s to a weak monetary policy response to surprise increases in the public's expectations of inflation. In particular, using a structural VAR that includes a direct survey measure of expected (headline CPI) inflation, Leduc, Sill, and Stark show that, prior to 1979, the Federal Reserve accommodated exogenous movements in expected inflation, seen in the result that the short-term real interest rate did not increase in response to such movements, which then led to persistent increases in actual inflation. Such behavior, however, is absent post-1979. We argue below that such change in the Federal Reserve's accommodation of expected headline inflation is also capable of generating the change in actual headline-core inflation dynamics documented above. We demonstrate this by using a variant of the structural VAR model that includes actual headline and core inflation measures.[8]

To explain further, consider a four-variable VAR that contains a direct survey measure of the public's expectations of headline inflation, represented by the median Livingston survey forecast of the eight-month-ahead headline CPI inflation rate (π_t^{eH}). The other variables included in the VAR are actual headline CPI inflation (π_t^H), actual core CPI inflation (π_t^C), and a short-term nominal interest rate (sr_t). Following Leduc, Sill, and Stark (2007), we define and measure variables in such a way that survey participants making forecasts do not observe contemporaneous values of other VAR variables, thereby helping to identify exogenous movements in expected headline inflation.[9] Using a recursive identification scheme $\{\pi_t^{eH}, \pi_t^H, \pi_t^C, sr_t\}$ in which expected inflation is ordered first and the short nominal interest rate is last, we examine and compare the impulse responses of actual headline and core inflation measures to surprise increases in expected headline inflation (and core inflation itself).

Figure 3 shows the responses of VAR variables to a one-time surprise increase in expected headline inflation for three sample periods: 1959:1–1979:1 (Panel A), 1979:2–2001:2 (Panel B), and 1985:1–2007:2 (Panel C). Figure 4 shows the responses to a one-time increase in core inflation. In these figures, and those that follow, the solid line indicates the point estimate, while the darker and lighter shaded regions represent 68 percent and 90 percent confidence bands, respectively.

Focusing on Figure 3, we highlight two observations. First, the effects of a surprise increase in expected headline inflation on actual headline and core measures of inflation have changed over time. In the pre-1979 sample period, a surprise increase in expected headline inflation is not reversed and leads to a persistent increase in actual headline and core inflation measures. However, in post-1979 sample periods, such effects have become weaker. In fact, in the

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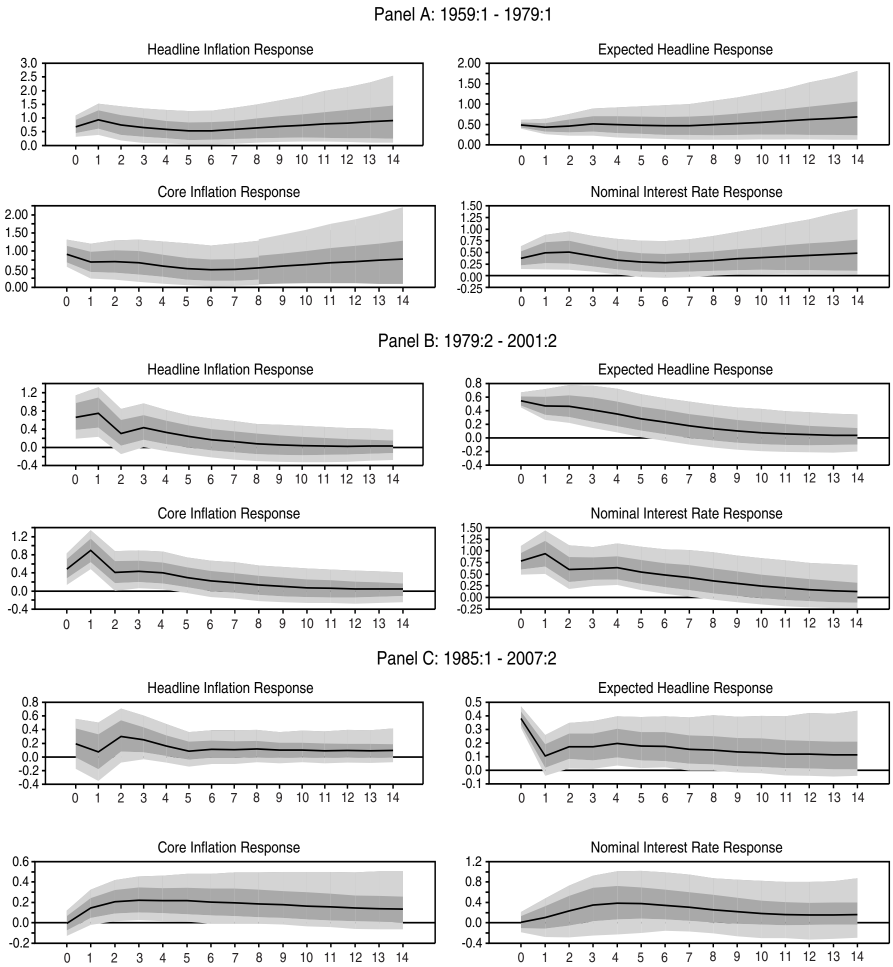
[8] For an empirical demonstration of the impact of change in policy on the stability of empirical models (the so-called Lucas critique), see Lubik and Surico (2006).

[9] For further details see Leduc, Sill, and Stark (2007) and Mehra and Herrington (2008).

Figure 3 Shock to Expected Headline Inflation



Notes: Responses to a one standard deviation shock to expected headline CPI inflation. The responses are generated from a VAR with expected headline CPI inflation, actual headline CPI inflation, actual core CPI inflation, and the three-month Treasury bill rate. All responses are in percentage terms. In each chart, the darker area represents the 68 percent confidence interval and the lighter area represents the 90 percent confidence interval. The x-axis denotes six-month periods.

most recent sample period, 1985:1–2007:2, a surprise increase in expected headline inflation is reversed and has no significant effect on actual headline and core inflation measures (compare responses in Panels A and C). These results suggest that, in the pre-1979 sample period, shocks to expected headline inflation can generate co-movement between headline and core measures of inflation and that this co-movement arises as a result of headline inflation not reverting to core inflation and core inflation moving toward headline inflation. In contrast, in the recent sample period, 1985:1–2007:2, a surprise increase in expected headline inflation does not generate co-movement between actual headline and core inflation measures because they are not affected by movements in expected headline inflation. As discussed below, a surprise increase in core inflation, however, can generate co-movement between headline and core measures of inflation in the most recent sample period.

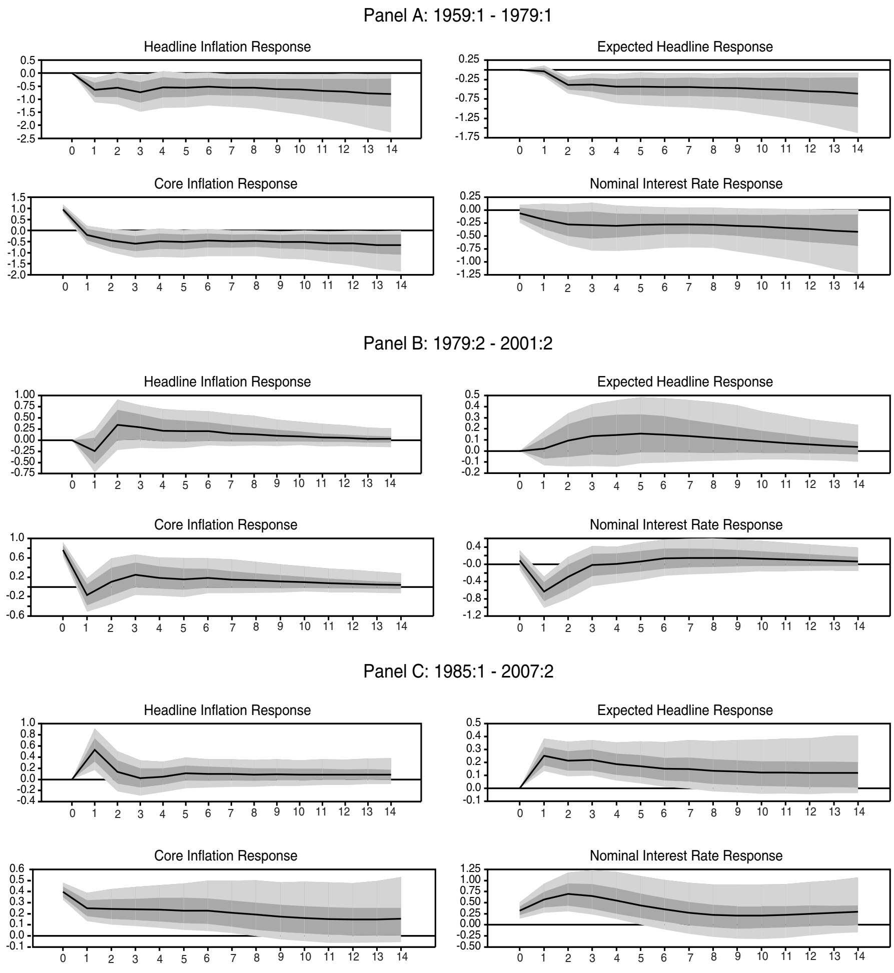
Second, the interest rate responses shown in Figure 3 suggest monetary policy may be at the source of the above-noted change in the response of actual headline inflation to expected headline inflation shocks. If we focus on the nominal interest rate response shown in Panel A, we see that the nominal interest rate does increase in response to a surprise increase in expected headline inflation, but that this increase in the nominal interest rate approximates the increase in expected headline inflation leaving the real interest essentially unchanged.[10] The behavior of the real interest rate in response to surprise increases in expected headline inflation suggests that the Federal Reserve followed an accommodative monetary policy. However, in the sample period 1979:2–2001:2, the real interest rate rises sharply in response to a surprise increase in expected headline inflation, suggesting that the Federal Reserve did not accommodate shocks to expected headline inflation. In the most recent sample period, 1985:1–2007:2, there is no significant response of the real interest rate to an expected inflation shock, because a surprise increase in expected headline inflation is reversed, having no significant effect on actual headline and core inflation measures.

Focusing on Figure 4, we see that it is only in the most recent sample period, 1985:1–2007:2, in which a surprise increase in core inflation leads to an increase in expected and actual headline inflation, generating co-movement between headline and core measures of inflation. This co-movement is generated as a result of headline inflation moving toward core inflation. Furthermore, the real interest rate does rise significantly in response to a surprise increase in core inflation, suggesting that in conducting monetary policy the Federal Reserve appears to be focused on the core measure of inflation. In contrast, in the pre-1979 sample period, a surprise increase in core inflation does not lead to an increase in headline inflation and there is no significant response of the nominal interest rate.[11]

[10] We infer the response of the real interest rate to a shock by comparing the responses of the nominal interest rate and expected headline inflation. Thus, the expected real interest rate response is simply the short-term nominal interest rate response minus the expected headline inflation response.

[11] However, in the pre-1979 sample period, a surprise increase in core inflation is reversed and leads to a decline (not increase) in expected and actual headline inflation. Even though the

Figure 4 Shock to Core Inflation



Notes: Responses to one standard deviation shock to core CPI inflation. The responses are generated from a VAR with expected headline CPI inflation, actual headline CPI inflation, actual core CPI inflation, and the three-month Treasury bill rate. All responses are in percentage terms. In each chart, the darker area represents the 68 percent confidence interval and the lighter area represents the 90 percent confidence interval. The x-axis denotes six-month periods.

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nominal interest rate does not increase in response to a positive shock to core inflation, the expected real interest rate does increase because of a decline in expected headline inflation. These responses

Together, the responses depicted in Figures 3 and 4 imply that, before 1979, headline and core inflation measures co-move mainly as a result of core inflation moving toward headline inflation, because the Federal Reserve accommodated surprise increases in the public's expectations of headline inflation. A surprise increase in core inflation is simply reversed and does not lead to higher expected or actual headline inflation. Since 1979, however, the Federal Reserve has not accommodated increases in the public's expectations of headline inflation, and hence co-movement has mainly arisen as a result of headline inflation moving toward core inflation.

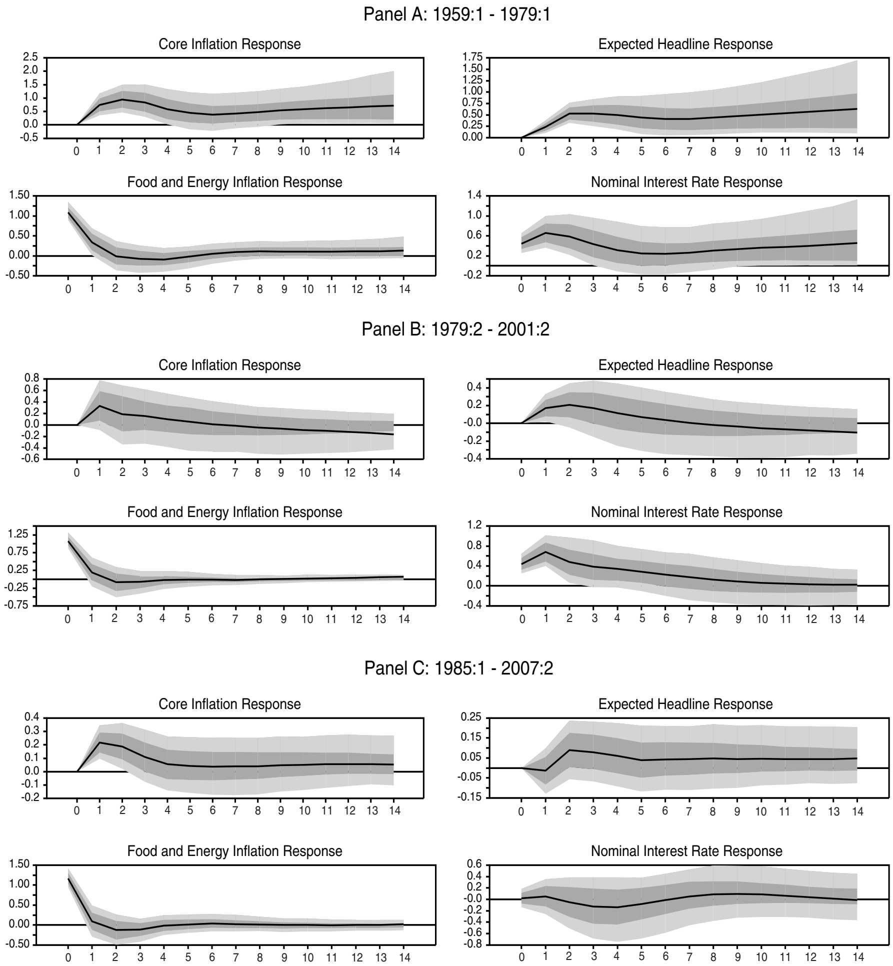
Food and Energy Inflation

Since the measure of core inflation used here is derived excluding food and energy inflation from headline inflation, and since food and energy prices are likely to be a significant source of movements in expected headline inflation, the results discussed above imply that change in monetary policy response to expected headline inflation may reflect change in monetary policy response to movements in expected food and energy prices. Since we do not have any direct survey data on the public's expectations of food and energy price inflation, we provide some preliminary evidence on this issue by examining responses to movements in actual food and energy inflation. With that in mind, we consider another variant of the structural VAR model that includes expected headline inflation, actual core inflation, the food and energy component of headline CPI inflation, and the short-term nominal interest rate. We continue to assume the baseline identification ordering $\{\pi_t^{eH}, \pi_t^C, (\pi_t^H - \pi_t^C), sr_t\}$ in which expected headline inflation is exogenous but food and energy price inflation is not. Food and energy inflation is measured as the gap between headline and core inflation rates.

Figure 5 shows responses to a surprise increase in the food and energy component of headline inflation over three sample periods: 1959:1–1979:1 (Panel A), 1979:2–2001:2 (Panel B), and 1985:1–2007:2 (Panel C). In the pre-1979 sample period a surprise temporary increase in food and energy prices has a significant effect on expected headline inflation, leading to a persistent increase in expected (and hence actual) headline inflation. Core inflation is also persistently higher in response to a surprise increase in food and energy inflation. These responses suggest that a surprise increase in food and energy inflation can generate co-movement between headline and core measures of inflation, with core inflation moving toward headline inflation. However, in

suggest that the Federal Reserve was not as accommodative to shocks to core inflation as it was to shocks to expected headline inflation. As noted by several analysts, the Federal Reserve may have believed that shocks to food and energy prices are likely temporary and would not lead to persistent increases in headline inflation.

Figure 5 Shock to Food and Energy Component of Headline Inflation



Notes: Responses to one standard deviation shock to the food and energy component of headline CPI inflation. The responses are generated from a VAR with expected headline CPI inflation, core CPI inflation, food and energy inflation, and the three-month Treasury bill rate. All responses are in percentage terms. In each chart, the darker area represents the 68 percent confidence interval and the lighter area represents the 90 percent confidence interval. The x-axis denotes six-month periods.

post-1979 sample periods the positive response of expected headline inflation to a surprise increase in food and energy inflation weakens considerably. More interestingly, in the most recent sample period, 1985:1–2007:2, a surprise increase in food and energy inflation has no significant effect on expected headline inflation, suggesting that the public believes increases in food and energy prices are unlikely to lead to a persistent increase in headline inflation (compare responses across Panels A through C).[12]

The response of the real interest rate to a surprise increase in food and energy prices implicit in Panels A through C suggests a monetary policy explanation of the decline in the influence of food and energy prices on expected headline inflation. In the pre-1979 period, the real interest rate does not change much because the rise in nominal interest rate matches the rise in expected headline inflation, suggesting an accommodative stance of monetary policy. However, in the sample period 1979:2–2001:2, the real interest rate rises significantly in response to a surprise increase in food and energy prices, suggesting that the Federal Reserve did not accommodate increases in food and energy prices. Hence, the decline in the influence of food and energy inflation on expected headline inflation since 1979 may be due to the Federal Reserve no longer accommodating shocks to food and energy prices.

In the most recent sample period, 1985:1–2007:2, however, there is no significant response of the nominal (or real) interest rate to a surprise increase in food and energy prices, because a surprise increase in food and energy inflation has no significant effect on expected headline inflation. One plausible explanation of the absence of any significant effect of movements in food and energy inflation on expected headline inflation is that past Federal Reserve behavior has convinced the public that it would not accommodate food and energy inflation. As a result, surprise increases in food and energy inflation have no significant effect on expected headline inflation, suggesting the Federal Reserve has become credible.

But do shocks to food and energy inflation matter for expected headline inflation? The results of the variance decomposition of expected headline inflation presented in Table 5 are consistent with the decline in the influence of food and energy inflation on expected headline inflation since 1979. In the pre-1979 sample period, shocks to the food and energy component of inflation account for about 35 percent of the variability of expected headline inflation at a two-year horizon, whereas in the recent sample period, 1985:1–2007:2, they account for less than 4 percent of the variability of expected headline inflation at the same two-year horizon.

3. CONCLUDING OBSERVATIONS

This article investigates empirically short-term dynamics between headline and core measures of CPI and PCE inflation over three sample periods: 1959:1–1979:1, 1979:2–2001:2, and 1985:1–2007:2. Headline and core inflation

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[12] In the recent sample period, 1985:1–2007:2, a surprise increase in food and energy prices does feed into core inflation.

Table 5 Variance Decomposition of Expected Headline CPI Inflation

		Panel A: 1959:1–1979:1		
Ordering: Π^{eH}, Π^{C}, $\Pi^{H}-\Pi^{C}$, SR				
Steps	Π^{eH}	Π^{C}	$\Pi^{H}-\Pi^{C}$	SR
1	100.000	0.000	0.000	0.000
2	83.939	0.979	11.621	3.461
3	56.768	3.739	32.307	7.186
4	49.345	4.427	35.859	10.370
6	45.326	7.700	36.358	10.616
8	44.895	10.508	35.244	9.353
		Panel B: 1979:2–2001:2		
Ordering: Π^{eH}, Π^{C}, $\Pi^{H}-\Pi^{C}$, SR				
Steps	Π^{eH}	Π^{C}	$\Pi^{H}-\Pi^{C}$	SR
1	100.000	0.000	0.000	0.000
2	75.964	12.141	7.771	4.125
3	62.899	22.970	10.382	3.749
4	55.940	29.473	10.809	3.777
6	49.066	35.928	10.363	4.644
8	45.673	39.126	9.858	5.343
		Panel C: 1985:1–2007:2		
Ordering: Π^{eH}, Π^{C}, $\Pi^{H}-\Pi^{C}$, SR				
Steps	Π^{eH}	Π^{C}	$\Pi^{H}-\Pi^{C}$	SR
1	100.000	0.000	0.000	0.000
2	66.457	27.758	0.081	5.704
3	55.816	35.223	2.653	6.309
4	50.830	39.187	3.676	6.307
6	49.452	41.004	3.676	5.867
8	49.412	41.533	3.659	5.394

Notes: Entries are in percentage terms, with the exception of those under the column labeled "Steps." Those entries refer to n-step-ahead forecasts for which decomposition is done. Π^{eH} is expected headline inflation, as measured by the Livingston Survey. See notes from Tables 1 and 3 for the definitions of the other variables.

measures are co-integrated, suggesting long-run co-movement. However, the ways in which these two variables adjust to each other in the short run and generate co-movement have changed across these sample periods. In the pre-1979 sample period, when a positive gap opens up with headline inflation rising above core inflation, the gap is eliminated mainly as a result of headline inflation not reverting and core inflation moving toward headline inflation. These dynamics suggest headline inflation would be better than core inflation in assessing the permanent component of inflation. In post-1979 sample periods, however, the positive gap is eliminated as a result of headline inflation reverting more strongly toward core inflation than core inflation moving toward headline inflation, suggesting core inflation would be better than headline inflation in assessing the permanent component of inflation. Although short-term headline-core inflation dynamics are investigated using biannual data, the basic result on change in inflation dynamics is robust to the use of quarterly data and includes additional economic determinants of inflation in the bivariable headline-core inflation regressions. The results are also not sensitive to the precise breakup of the sample in 1979 and 1984.

Recent research suggests a monetary policy explanation of change in inflation dynamics. We focus on a version suggested in Leduc, Sill, and Stark (2007) that attributes the decline in the persistence of actual headline inflation to a change in the accommodative stance of monetary policy in 1979. We illustrate that such a change in monetary policy response to exogenous shocks to the public's expectations of headline inflation can generate the change in headline-core inflation dynamics documented above. Before 1979, the Federal Reserve accommodated shocks to expected headline inflation: A surprise increase in expected headline inflation is not reversed, leading to a persistent increase in actual headline inflation and co-movement arising as a result of core inflation moving toward headline inflation. Since 1979 that has not been the case: A surprise increase in expected headline inflation is reversed and co-movement arises mainly as a result of headline inflation moving toward core inflation.

Since food and energy prices are likely a significant determinant of expected headline inflation, the results imply that the change in headline-core inflation dynamics may simply be due to the Federal Reserve no longer accommodating food and energy inflation. In the most recent sample period, a surprise increase in food and energy inflation has no significant effect on the public's expectations of headline inflation. This result suggests that past Federal Reserve behavior has convinced the public that it would no longer accommodate food and energy inflation.

In previous research, analysts have often found that the empirical evidence indicating that core inflation is better than headline inflation at gauging the trend component of inflation is not robust across sample periods. The empirical work in this article explains this lack of robustness; namely, headline-core inflation dynamics changed with a change in the conduct of monetary policy in 1979. Hence, in sample periods beginning in the 1960s and ending in the 1980s or 1990s, the hypothesis that the trend component of inflation is best gauged by focusing only on core inflation may or may not be found consistent with the data.

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