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## **THE RELATIONSHIP BETWEEN INFLATION AND INFLATION EXPECTATIONS**

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### **Executive Summary**

Inflation expectations are widely thought to capture forces important to the determination of inflation. For example, inflation expectations likely affect wage demands, which may in turn affect firms' pricing decisions. In addition, inflation expectations reflect a central bank's credibility and commitment to maintaining price stability. Should that credibility ever come seriously into doubt, long-term inflation expectations would likely increase. Accordingly, many central banks around the world carefully monitor long-term inflation expectations and view keeping these expectations 'anchored' as a crucial factor in achieving their objectives.

This memo summarizes the empirical evidence on the relationship between inflation and inflation expectations. Overall, the evidence shows that expectations are an important force in inflation dynamics, with long-run expectations, which are tantamount to trend inflation, more important than short run expectations. Long-term survey measures of expectations are an excellent proxy for the underlying trend rate of inflation. Shocks to long-term inflation expectations generate persistent increases in inflation. The impacts of shocks to short-term expectations are more transitory. Inflation expectations respond to a range of variables, primarily past inflation, but also to the state of the economy and monetary policy actions.

Importantly, the evidence suggests that inflation and expectations are anchored better today than 25 years ago. The improved anchoring comes in two dimensions. First, the overall volatility of expectations has declined – for example, survey measures of long-term inflation are essentially flat since 1995. Second, shocks to variables such as inflation have a smaller impact on inflation today than 25 years ago. Most explanations for the improved anchoring of long-term expectations point to more systematic behavior in monetary policy in recent decade.

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## *I. Introduction*

Inflation expectations are widely thought to capture forces important to the determination of inflation. For example, inflation expectations likely affect wage demands, which may in turn affect firms' pricing decisions. In addition, inflation expectations reflect a central bank's credibility and commitment to maintaining price stability. Should that credibility ever come seriously into doubt, long-term inflation expectations would likely increase. Accordingly, many central banks around the world carefully monitor long-term inflation expectations and view keeping these expectations 'anchored' as a crucial factor in achieving their objectives.

This memo summarizes the empirical evidence on the relationship between inflation and inflation expectations (additional detail is provided in Clark and Davig 2008, 2009). Section II examines the influence of expectations – short-run and long-run – on inflation. This section also examines various factors that generate movement in inflation expectations. Section III reviews evidence of how the relationship between inflation and inflation expectations has changed over time. Section IV summarizes the evidence and the implications for the current inflation outlook.

Overall, the evidence presented in this memo shows that expectations are an important force in inflation dynamics, with long-run expectations, which are tantamount to trend inflation, more important than short run expectations. Inflation expectations respond to a range of variables, primarily past inflation, but also to the state of the economy and monetary policy actions. Importantly, evidence suggests that inflation and expectations are anchored better today than 25 years ago. The improved anchoring comes in two dimensions. First, the overall volatility of expectations has declined – for example, survey measures of long-term inflation are essentially flat since 1995. Second, shocks to variables such as inflation have a smaller impact on inflation today than 25 years ago. Most explanations for the improved anchoring of long-term expectations point to more systematic behavior in monetary policy in recent decades.

## *II. How Do Expectations Influence Inflation, and What Influences Inflation Expectations?*

In this memo's empirical assessment of the relationship between inflation and inflation expectations, inflation is measured with the CPI (total in some parts of the investigation, core in others), and expectations are measured with CPI projections from the Survey of Professional Forecasters, at the one-year ahead and 10-year ahead horizon.<sup>1</sup> Economic activity is measured with the Chicago Fed's national activity index (the CFNAI). With these data, we estimate a range of models with data from mid-1982 through mid-2008.

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<sup>1</sup> Replacing CPI inflation with PCE inflation yields qualitatively similar results. Note also that, to obtain a reasonably long time series on long-run expectations, we splice long-run forecasts from the Blue Chip Consensus (interpolated from two observations per year to the quarterly frequency) to the SPF data that begin in 1991.

We begin the analysis with an empirical model of inflation and inflation expectations that captures some of the concepts suggested by Bernanke (2007), such as explicitly allowing time variation in long-term inflation expectations.<sup>2</sup> In this model, inflation and expectations depend on an unobserved trend rate of inflation and past inflation. The model is relatively restrictive in that it requires survey expectations to be consistent with the simple model of inflation. The trend rate of inflation is then extracted from actual movements in inflation, deviations of the federal funds rate from a Taylor-type rule and survey measures of long- and short-term inflation expectations. The resulting trend extracted from the model can be thought of as reflecting the public's perception of the central bank's inflation goal.

The model indicates, perhaps not surprisingly, that the survey measure of long-term inflation tracks the unobserved rate of trend inflation very closely. As shown in Chart 1, estimates of the unobserved inflation trend correspond nearly exactly to the long-run survey expectation of inflation.<sup>3</sup> An implication is that even small movements in long-term survey measures are likely to reflect more 'signal' than 'noise,' and therefore can represent an important shift in the trend rate of inflation.

Regarding short-run inflation dynamics, estimates of the model imply trend inflation is slightly more important than past rates of inflation (holding trend constant). This finding implies that movements in trend inflation, which can be detected by monitoring long-term inflation expectations, will have a persistent effect on inflation dynamics.

In this setup, expectations don't directly drive inflation – instead, they are supplementary indicators of the unobserved trend rate of inflation. So to assess the relationship between inflation expectations and inflation in a less restrictive setup, we use vector autoregressions (VARs) to estimate the response of inflation to shocks to inflation expectations and the response of inflation expectations to various other shocks. This approach allows us to more directly assess the influence of expectations on inflation and the forces influencing inflation expectations.

The variables in the model consist of (in order) either energy or food inflation, long-run inflation expectations, short-run expectations, core CPI inflation, the CFNAI, and the federal funds rate.<sup>4</sup> We interpret the shocks to inflation expectations in this model as the result of changes in fundamental forces outside the scope of the model, rather than pure shocks to expectations. In other words, movements in expectations – which may importantly affect actual inflation – summarize forces that are not adequately

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<sup>2</sup> Our model also combines elements of the specifications of Kozicki and Tinsley (2006) and Kiley (2008).

<sup>3</sup> The trend estimate shown in Chart 1 is less variable than the trend estimate obtained from the model of Stock and Watson (2007), based on just inflation. One reason may be that the inclusion of inflation expectations in our model provides a stronger signal of trend inflation than does actual inflation by itself.

<sup>4</sup> The impulse responses reported in the memo are obtained from a recursive or Choleski identification, with the variables ordered as listed above. The timing of the Survey of Professional Forecasters rationalizes ordering the expectations variables after measures of food or energy prices (for which high-frequency commodity price information is available) but before the CPI and CFNAI (which typically are not known to SPF respondents at the time of each survey).

captured by the other variables in the model. For example, changes in long-term inflation expectations may be due to shifts in the perceived credibility of monetary policy, which the model cannot effectively measure except through changes in inflation expectations. However, our VAR-based approach does not necessarily permit such strong structural interpretations. In addition, there is some possibility that what appear to be shocks to expectations – particularly to short-run expectations – are in fact systematic responses to news on the inflation outlook not captured by the model.

The estimates of the model indicate that shocks to expectations significantly impact inflation. Chart 2 traces out the response of each variable to selected shocks, from the impact period through the next 15 quarters. As shown in the second column of Chart 2, a shock to long-term expectations generates a persistent rise in both short- and long-term expectations. The impact on short-term expectations is about one-for-one. In turn, the shock passes through to core CPI inflation, causing inflation to eventually increase by more than expectations. For example, a 10 basis point rise in long-term expectations results in a 25 basis point rise in core CPI inflation. The effect of the shock is rather long lasting, with core CPI still 10 basis points above its average four years after the shock. The third column of Chart 2 indicates that a shock to short-term expectations causes long-term expectations to rise – less than one-for-one – and generates some temporary pass-through to inflation. A shock to long-term expectations, however, results in a much more persistent rise in short-term expectations than a direct shock to short-term expectations. The pass-through of expectations shocks to inflation occurs even though, in results not shown, monetary policy tightens in response to the shocks.

As to the determinants of expectations, the model estimates show that both short- and long-term expectations respond to a range of macroeconomic variables. As reported in the first column of Chart 2, shocks to energy price inflation have some impact on both short- and long-term expectations.<sup>5</sup> The effects, however, are quite small and transitory. For example, a 15 percent rise in the energy component of the CPI raises long-term inflation expectations by 4 basis points and short-term expectations by 5 basis points, but the effects only last a few quarters. Also, there is virtually no pass-through of the energy price shock to core CPI inflation. In contrast to the energy price shock, the first column of Chart 3 shows that shocks to food price inflation generate relatively large and persistent responses of both short-term and long-term inflation expectations. Food price changes may have a larger impact than energy price changes because food price inflation is more persistent – that is, takes longer to return to baseline following a shock to food price inflation – and has a larger weight in the CPI basket.

Shocks to core CPI inflation have measurable effects on both short-term and long-term inflation expectations, reported in the fourth column of Chart 2. As is true for most shocks, the response of short-term expectations is initially sharper than the response of long-term expectations. While not reported in the interest of brevity, shocks to economic

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<sup>5</sup> However, the estimated impacts of energy shocks are not robust to alternative orderings of the variables in the model.

activity and monetary policy also have impacts – but relatively small compared to other price shocks – on inflation expectations.<sup>6</sup>

Prior research on inflation and inflation expectations has produced broadly similar conclusions. One line of research assesses the importance of forward-looking expectations versus backward-looking components in inflation dynamics. An array of evidence shows that expectations or trend inflation are a primary source of variation in inflation.<sup>7</sup> In fact, in some work, incorporating survey measures of expectations or trend inflation often substantially weakens or eliminates the importance of past values of inflation in the inflation process. This finding emerges in both statistical models of the inflation process and New Keynesian formulations of the Phillips curve.

Less clear from extant work are distinct roles for short-term versus long-term expectations –most studies use one or the other. As the forecast horizon increases, expectations should become more reflective of the perceived long-run goal of policy (or trend inflation) and less reflective of recent movements in inflation. Therefore, there may be scope (at least in reduced-form models) for short-run and long-run expectations to separately influence inflation dynamics. However, there is little direct evidence of such distinct influences, apart from the estimates presented in this memo and in Clark and Davig (2008).

Other research also indicates that inflation expectations respond to a range of variables: oil prices, commodity prices, past inflation, the state of the economy, and monetary policy actions. For example, some past studies show that long-term inflation expectations are importantly influenced by past inflation.<sup>8</sup> Other evidence shows that changes in oil prices and monetary policy have significant effects on short-term inflation expectations.<sup>9</sup> Other studies find that inflation compensation responds to news on the economy, such as a stronger-than-expected report on job gains.<sup>10</sup> A more limited volume of work indicates that the responses of short-run expectations are normally sharper than the responses of long-run expectations.<sup>11</sup>

Having established the broad importance of inflation expectations in inflation dynamics and the dependence of inflation expectations on past inflation movements and a range of other economic indicators, in the next section we examine the evidence of changes over time in these relationships.

### *III. What's changed over time, and why?*

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<sup>6</sup> Although a formal interpretation is not possible, the shocks to economic activity tend to look like shocks to aggregate demand.

<sup>7</sup> Econometric examples include Stock and Watson (2007) and Cogley, Primiceri, and Sargent (2009). Phillips curve examples include Roberts (1997), Rudebusch (2002), and Brissimis and Magginas (2008).

<sup>8</sup> See, for example, Kozicki and Tinsley (2001) and Cecchetti, et al. (2007).

<sup>9</sup> See, for example, Leduc, Sill, and Stark (2007).

<sup>10</sup> See, for example, Gurkaynak, Levin, and Swanson (2006).

<sup>11</sup> See, for example, Jochmann, Koop, and Potter (2008).

Some important changes in the behavior of inflation and inflation expectations are fairly well known: core inflation and long-term inflation expectations have been much less volatile since at least the mid-1990s than in prior periods (Chart 4). But there is no clear change in the volatility of total inflation.

To assess the sources of this reduced volatility, we use a VAR in inflation and short- and long-term inflation expectations that allows for continuous, smooth changes over time in the coefficients of the model and the sizes of the shocks of the model.<sup>12</sup> The estimates reveal sharp changes in the typical sizes of shocks to expectations and core inflation, but only small changes in the coefficients of the model. Chart 5 shows that the estimated shocks to expectations, both long-run and short-run, and core inflation, are significantly smaller today than 25 years ago. In the case of long-run expectations and core inflation, current shocks are about  $\frac{1}{4}$  of their size of 25 years ago. For the most part, the reduction in volatility seems to have occurred gradually from the early 1980s through the late 1990s, rather than in a single, sharp break. This reduced volatility indicates that, in a broad sense, both expectations and inflation are better anchored today than 25 years ago. In particular, long-run expectations today move very little.<sup>13</sup>

While the primary factor in the improved stability of long-run expectations is the reduced size of shocks to expectations, another factor seems to be some reduced sensitivity of expectations to other shocks in the economy. For example, as indicated in Chart 6, a shock to short-run expectations has a slightly smaller impact on long-run expectations today than it did in 1982. In 1982, a 50 basis point shock to short-run expectations caused long-run expectations to rise about 10 basis points. As of 2008:Q2, though, a shock of the same size causes long-run expectations to rise only about 5 basis points, but, statistically speaking, the response does not differ significantly from zero. This change in responsiveness from 1982 to 2008 further implies long-term expectations are slightly better anchored today than in 1982.

Other research also suggests inflation has been better anchored in the past 25 years than in the '60s and '70s. For example, Leduc, Sill, and Stark (2007) show that shocks to expectations elicit a stronger monetary response today than in earlier decades and as a result, these shocks have less impact on inflation today than in the past. Other studies report a greater influence of expectations on inflation, so more stable expectations result in more stable inflation dynamics.<sup>14</sup> Some studies, however, emphasize the stability in trend inflation, so movements in actual inflation are driven primarily by transitory factors. This logic suggests trend inflation plays less of a role in current inflation volatility, but is consistent with better anchored inflation expectations.

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<sup>12</sup> More specifically, the model is a VAR with time-varying parameters and stochastic volatility, as in Primiceri (2005), estimated with Bayesian methods. For computational tractability, the model's variables are limited to the long-run expectation, short-run expectation, and core CPI inflation.

<sup>13</sup> Clark and Davig (2009) conduct a more detailed assessment of the sources of the increased stability of long-run inflation expectations – primarily using variance decompositions – and document a reduction in the importance of shocks to expectations and an increase in the importance of shocks to inflation.

<sup>14</sup> See, for example, Clark and Nakata (2008).

While evidence on the sources of these changes is limited, most studies explain the changes in the dynamics of inflation with changes in the behavior of monetary policy. For example, some studies have found that the reduced volatility and persistence of inflation is mostly due to a falloff in the volatility of an implicit inflation target.<sup>15</sup> Others attribute changes in the behavior of inflation to changes in the systematic behavior of monetary policy, such as a stronger response of the federal funds rate target to movements in inflation.<sup>16</sup> Still other studies highlight the importance of learning by the public or the central bank in inflation dynamics and changes over time in dynamics.<sup>17</sup>

#### *IV. Summary and Implications for the U.S. Inflation Outlook*

Overall, the empirical evidence presented in this memo points to the following conclusions:

- i) Long-term survey measures are an excellent proxy for the underlying trend rate of inflation. Further, the underlying trend rate of inflation exerts slightly more influence on short-run inflation dynamics than past inflation.
- ii) Shocks to long-term inflation expectations result in pass-through to both short-term inflation expectations and core inflation.
- iii) Shocks to long-term inflation expectations generate a persistent rise in short-term expectations. In contrast – and not surprisingly – shocks to short-term expectations are more transitory, but still have a measurable impact on long-term expectations.
- iv) Shocks to consumer energy prices have minor implications for expectations, whereas shocks to food prices have a measurable and persistent impact on both short- and long-term expectations.
- v) The volatility of shocks to short- and long-term expectations has declined markedly over the past 25 years.
- vi) The sensitivity of long-term expectations in response to movements in short-term expectations has declined over the past 25 years.

What, then, do recent movements in inflation expectations imply for the inflation outlook? The most recent SPF short- and long-term (CPI) inflation expectations are given in Chart 7. Long-term inflation expectations have posted a recent decline of 24 basis points and short-term expectations have demonstrated a sharper decline. These observations raise two more specific questions. First, do falling short-term expectations pose a threat in terms of eventually ‘spilling over’ to long-term expectations and, in turn, inflation? Second, to what extent is the shift in long-term expectations indicative of a more fundamental shift in the underlying trend rate of inflation?

Based on the evidence presented above, in response to the first question we suggest that falling short-term expectations may be of concern if there is evidence that such movements would eventually lower long-term expectations. Specifically, concern may

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<sup>15</sup> See, for example, Cogley, Primiceri, and Sargent (2009).

<sup>16</sup> See, for example, Benati and Surico (2009).

<sup>17</sup> See, for example, Erceg and Levin (2003) and Roberts (2007).

arise if short-term expectations are falling faster than what is typical following a recession, even after adjusting for the severity of the current recession. Based on the empirical estimates in this memo, such movements in short-term expectations, even if surprisingly low, pose minimal risk for movements in long-term expectations.

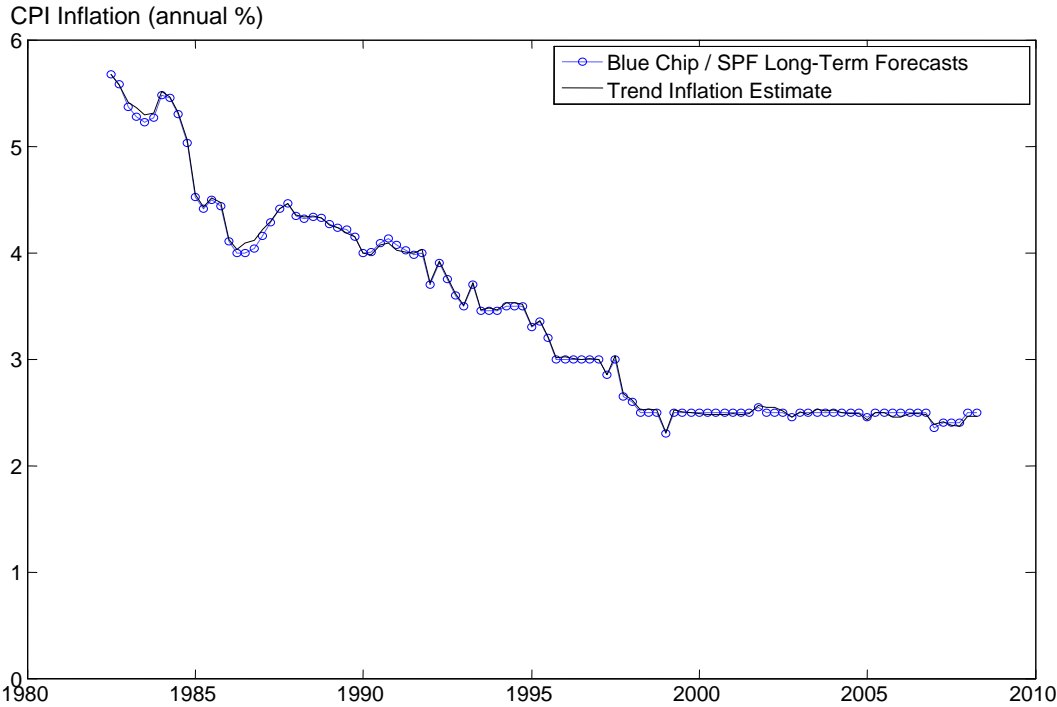
As to the second question, unexpected movements in long-term expectations could signal a shift in the trend rate of inflation, which based on evidence in this memo, has a measurable impact on inflation. As previously discussed, long-term expectations provide a strong signal regarding the underlying trend in inflation. Until the most recent long-term observation in Q4, long-term expectations had essentially not moved during the current recession. Therefore, up to this point, the decline in actual inflation that occurred during the recession was likely due to temporary forces. The recent one-quarter decline in long-term expectations should not be literally taken as meaning trend inflation has begun to move down, but suggests future movements should be closely monitored.



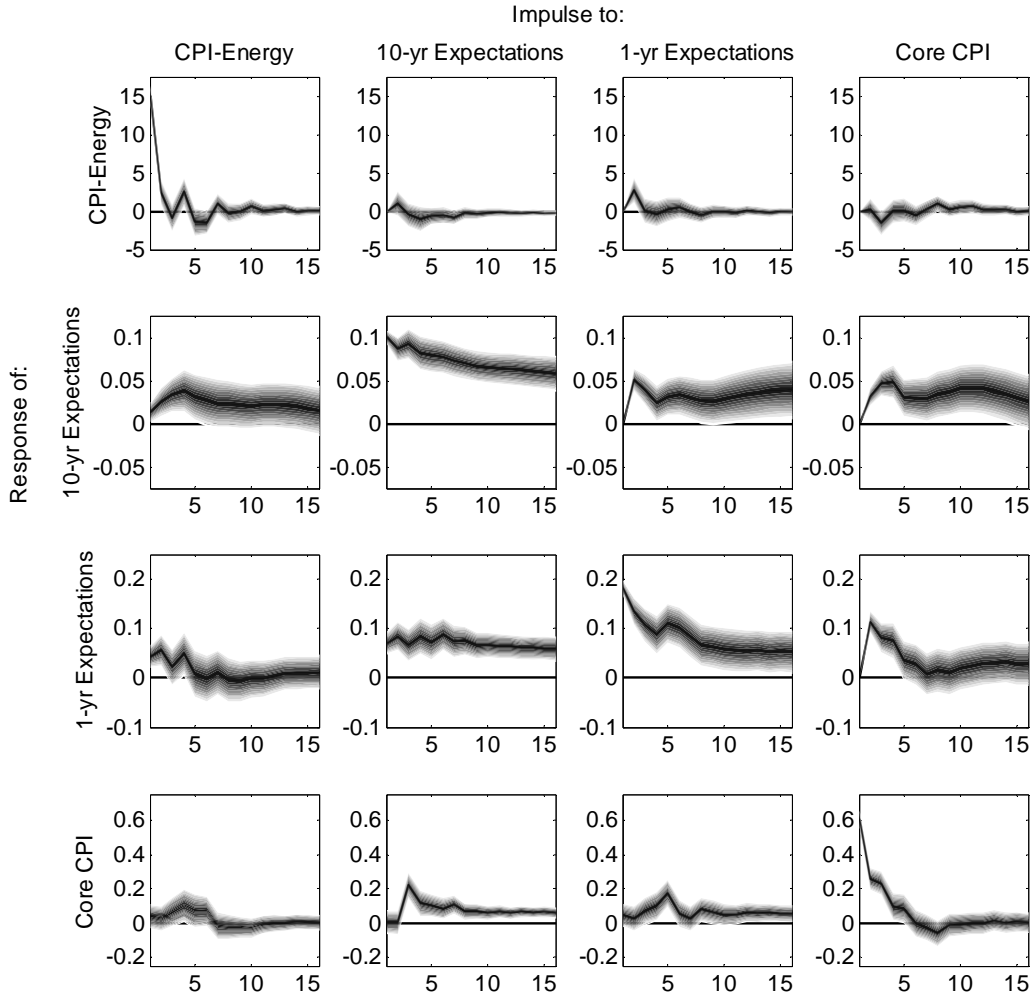
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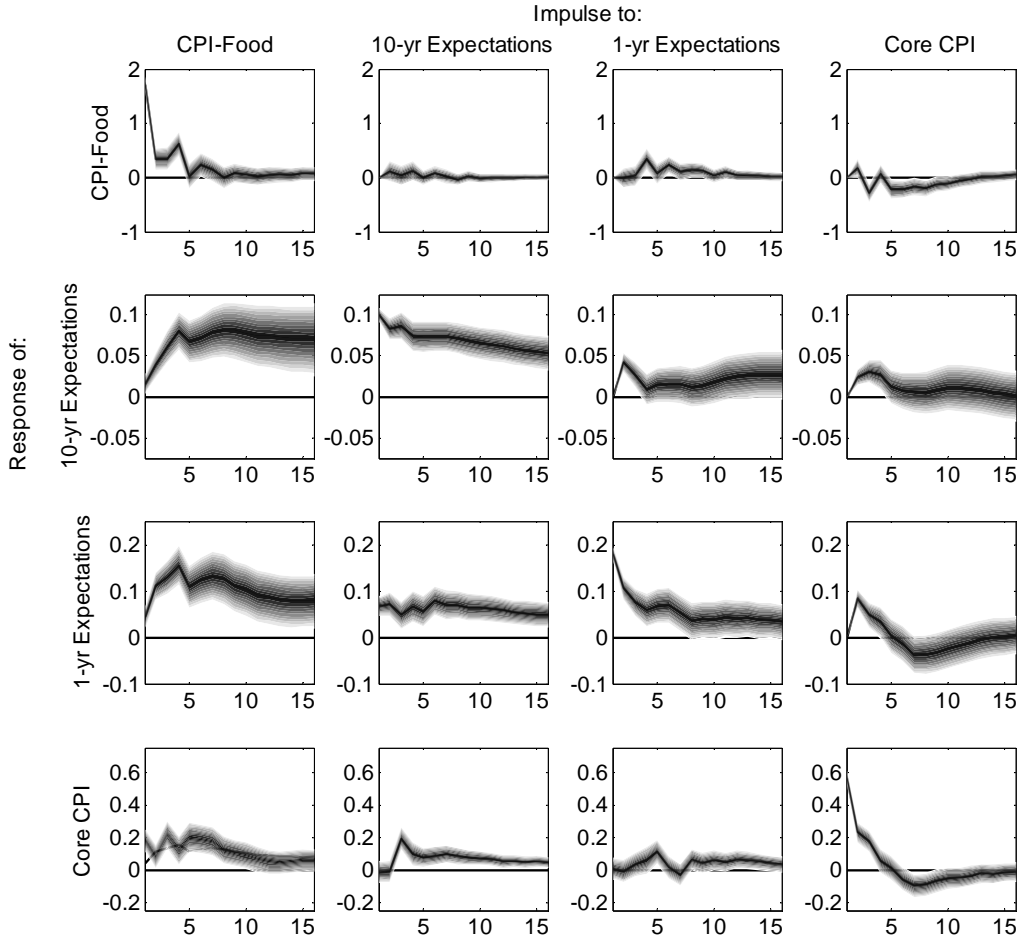
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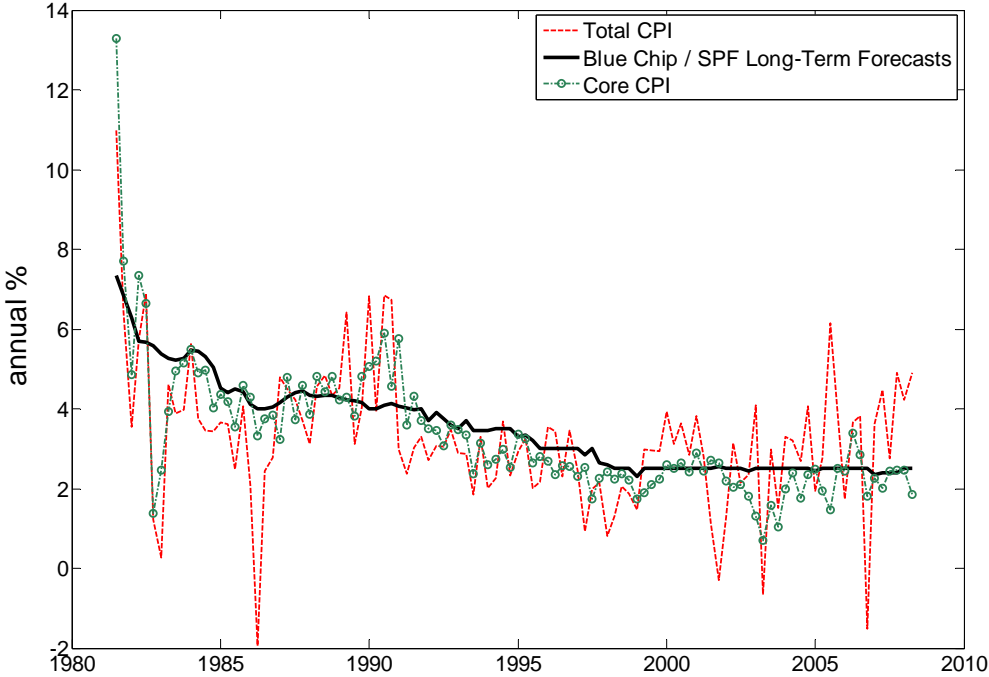
**Chart 1:** Long-Term Inflation Expectations and Trend Inflation Estimate



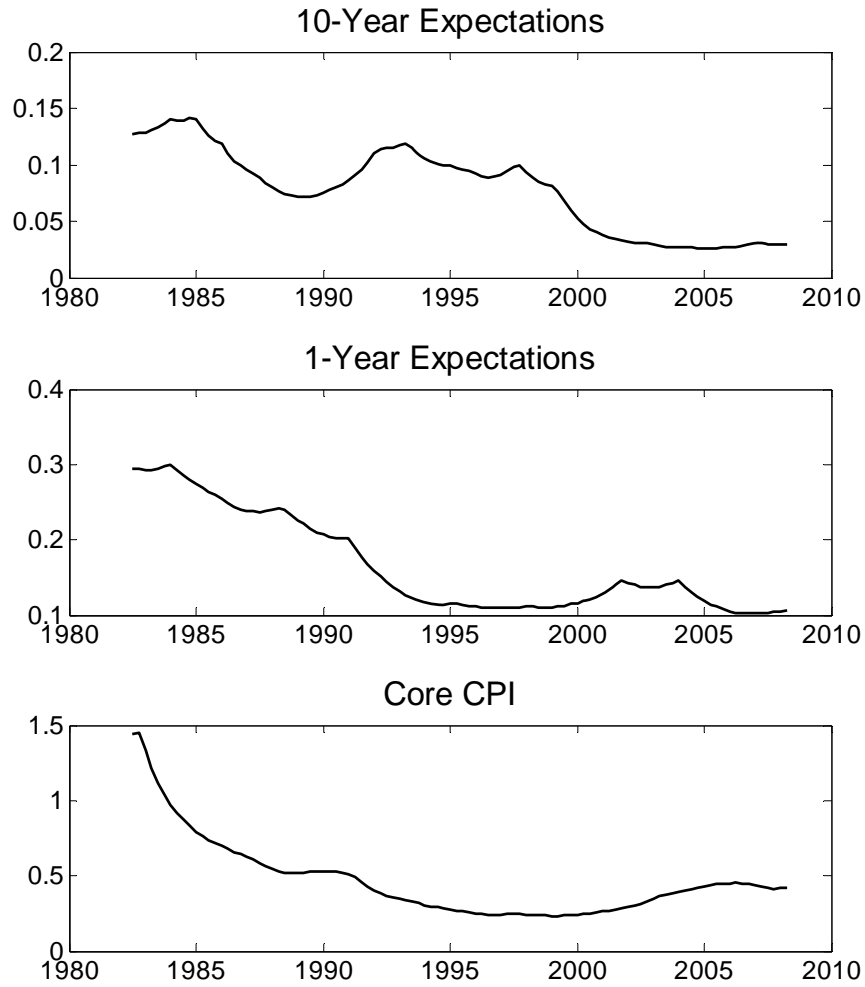
**Chart 2: Impulse Responses from VAR with Energy Prices**  
(Note: Not all responses are shown. Outer edge of shaded area represents 1-standard deviation bands)



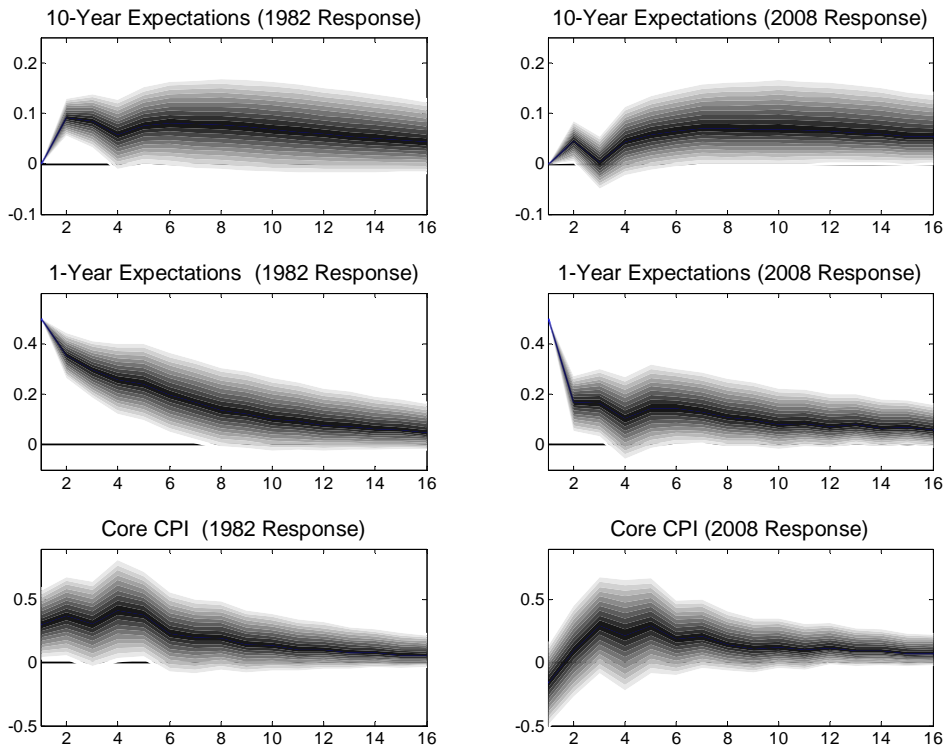
**Chart 3: Impulse Responses from VAR with Food Prices**  
(Note: Not all responses are shown. Outer edge of shaded area represents 1-standard deviation bands)



**Chart 4:** Long-Term Inflation Expectations and CPI Inflation

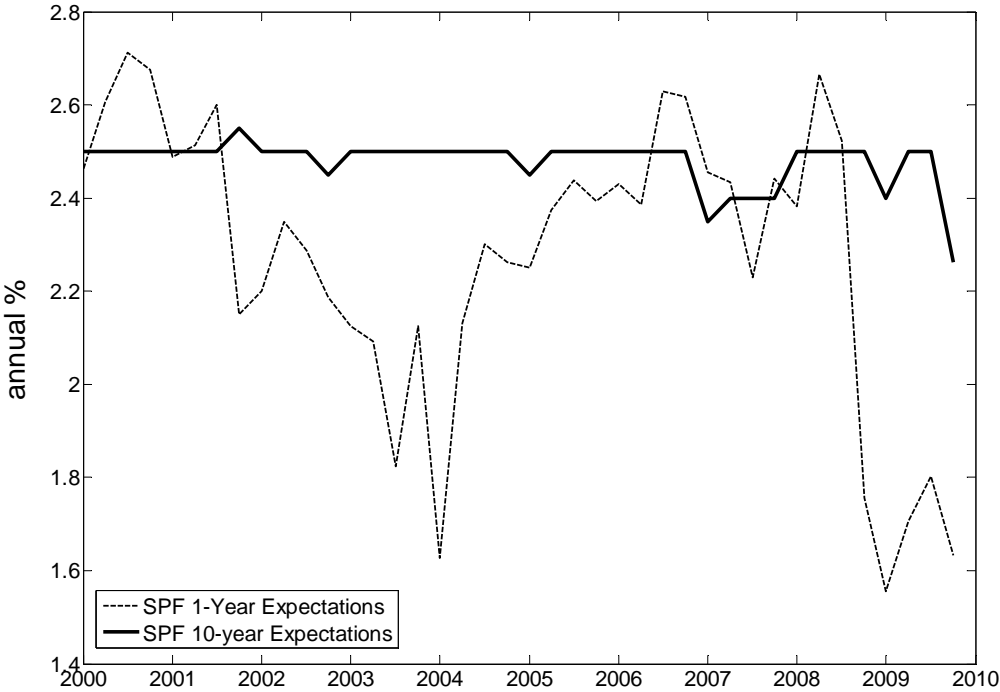


**Chart 5:** Volatility Estimates of Shocks to Core Inflation and Inflation Expectations (Values represent residual standard deviations from a time-varying parameter VAR with stochastic volatility)



**Chart 6: Shock to Short-Term Inflation Expectations**  
(Note: Outer edge of shaded area represents 1-standard deviation bands)





**Chart 7:** Survey of Professional Forecasters Short- and Long-Term Inflation Expectations