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Inflation Expectations and the Evolution of U.S. Inflation

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Abstract:
Much recent commentary has centered on the importance of well-anchored inflation expectations serving as the foundation of a well-behaved inflation rate. But the difficulty in relying on this principle is that inflation expectations are not directly observable, and thus it is hard to know whether expectations truly play such an anchoring role in the evolution of inflation. In the current circumstances this question is of much more than academic interest, as widely used measures suggest the coincidence of a large unemployment gap and muted production costs with fairly stable long-run inflation expectations. While a high unemployment rate would tend to depress inflation, lower production costs may serve as a counterweight to downward pressure. Which effect will prevail? This brief examines the role of expectations and anchoring by employing expectations proxies derived from surveys of professional forecasters. The brief concludes that there is some evidence that stable long-run expectations have an indirect anchoring effect on inflation, but that to date the effect on resource slack remains considerable.

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A widely cited nostrum of current monetary policy theory and practice holds that "well-anchored" inflation expectations prevent current inflation from dropping too far or too fast in the presence of subdued production costs and a substantial margin of underutilized resources. The most widely embraced definition of "well-anchored" holds that inflation expectations adhere fairly closely to the explicit or inferred long-term inflation goal of the country's central bank. This adherence reflects confidence on the part of the public that the central bank will guide inflation from wherever it is today to its long-run goal, and return it within a reasonable period of time. If price-setters at individual firms believe that this will occur, they may not allow recent inflation that deviates from the central bank's long-term goal to unduly influence the nominal rate of increase that they build into their own prices, other things equal.

A very simple representation of this story regarding well-anchored expectations suggests that inflation depends only on long-run inflation expectations (a proxy for the central bank's inflation goal) and on current excess capacity, expressed mathematically as

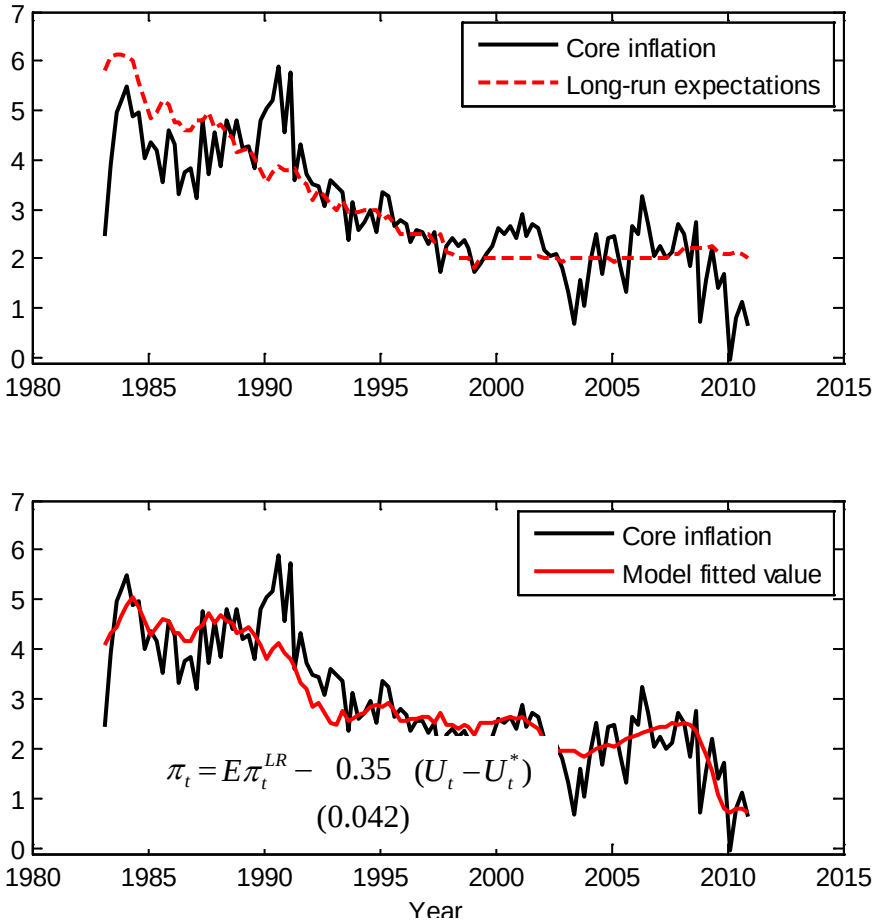
$$\pi_t = E\pi_t^{LR} + a(U_t - U^*),$$

where π_t stands for inflation in period t, E means "the expectation of," π_t^{LR} stands for long-run inflation, and $U_t - U_t^*$, a measure of excess capacity in the economy, represents the deviation of unemployment from its natural rate, or the amount of unemployment that would be present in the economy when all individuals who want to work have a job. The top panel of figure 1 displays a measure of core inflation along with a measure of long-run inflation expectations—the average inflation rate expected over the next six to ten years—derived from the Survey of Professional Forecasters (SPF).[1] As the panel indicates, the long-run expectation captures the overall trend of inflation, but clearly does not follow its short-term fluctuations in recent years.

But one could also interpret figure 1 as suggesting that inflation tends to return toward the long-run trend proxied by the long-run inflation expectations. If so, then one could view this as evidence that inflation is "anchored" to the long-run expectations. Note also that the relationship posited above suggests that unemployment eventually returns to a rate consistent with full employment (U^*), and that inflation will always return to the long-run expectation of inflation.

[1] The measure employed here is derived from the SPF variable, and is taken from the Federal Reserve Board's FRB/US econometric model of the economy. The variable mnemonic is "PTR."

Figure 1
A long-run expectations model of inflation



Sources: Bureau of Labor Statistics (core inflation), Board of Governors of the Federal Reserve System, FRB/US model (long-run expectations), author's calculations

The bottom panel of figure 1 displays the results from estimating this relationship.[2] The equation's fit, especially over the past 15 years, is quite good. As displayed in the top panel, it is clear from the stability of the long-run expectation over the past decade) that the preponderance of the model's tight fit in recent years comes from the correspondence between current inflation and unemployment fluctuations. In fact, an estimate of this same model over the past 10 years reveals an

[2] The restriction that the long-run expectations enter with a coefficient of one is rejected at the 2 percent level. The estimated coefficient without this constraint is 0.88.

estimated coefficient on the long-run expectation that is statistically indistinguishable from zero, suggesting that *all* of the model's fit derives from the resource utilization measure.[3]

This *Brief* investigates the role of expectations in the evolution of U.S. inflation. First it will review the underlying theory that motivates a role for expectations, both short-run and long-run, and then provide some empirical evidence that attempts to sort out the roles that expectations and resource slack play in determining inflation, both in earlier periods and more recently.

Motivating Theory

Behind this qualitative description of the well-anchored inflation expectations story is a host of empirical economic research and debate, most of which centers on versions of the eponymous Phillips curve that suggests a short-run tradeoff between higher inflation and lower unemployment.[4] The crux of modern versions of this theory lies in the following observations and implications:

1. Prices for many goods and services are adjusted somewhat infrequently;
2. This implies that when setting prices, firms will try to take account of the conditions prevailing over the time they expect the price to be in effect;
3. Thus expectations of future conditions relevant for price-setting should matter;
4. The relevant conditions include the state of excess capacity and a related concept, the marginal cost of producing additional goods;
5. A convenient way of representing these ideas is as follows:

Inflation today = Next period's expected inflation + the effect of excess capacity and/or costs

or in mathematical form

$$\pi_t = E\pi_{t+1} + bx_t, \qquad (1)$$

where x_t stands for excess capacity and/or costs of production. This equation implies that today's inflation depends on the expected values for x in the current and all future periods (think of what the expectation of next period's inflation must depend on—*next* period's excess capacity and the

[3] The estimated equation is $\pi_t = \underset{(0.38)}{0.49}\ E\pi_t^{LR} - \underset{(0.051)}{0.33}\ (U_t - U_t^*)$

[4] For an accessible summary of much of this debate, see Fuhrer, Kodrzycki, Little and Olivei, "The Phillips Curve in Historical Context," in *Understanding Inflation and the Implications for Monetary Policy: A Phillips Curve Retrospective*, ed. Fuhrer, Kodrzycki, Little and Olivei, pp. 3–68, Cambridge, MA: The MIT Press, 2009. This chapter is available online: http://mitpress.mit.edu/books/chapters/0262013630chap1.pdf.

following period's inflation. This recursion can go on indefinitely). This equation and variations of it are used widely by economists who think about, model, and forecast inflation.

An important and more recent modification recognizes that over longer time spans, inflation has risen and fallen quite significantly in ways that may be difficult for this simple model to capture. That is, in addition to being influenced by near-term expectations and the effect of resource slack, inflation has a more slowly moving *trend* component. The long-run inflation expectation displayed by the red line in the top panel of figure 1 may be considered an estimate of trend inflation. The most common interpretation of the slowly moving inflation trend is that it represents gradual changes in the central bank's explicit long-run goal (implicit in the U.S.) for inflation. The model then suggests that price-setters expect inflation eventually to revert to the long-run trend—the Fed's inflation goal—and thus they always think of inflation in terms of its deviation from that trend. Accounting for this trend in inflation gives rise to the following model:

Inflation today relative to trend = Next period's expected inflation relative to trend + the effect of excess capacity and/or costs

In mathematical form, this may be expressed as

$$\pi_t - \bar{\pi}_t = E(\pi_{t+1} - \bar{\pi}_{t+1}) + bx_t, \quad (2)$$

where $\bar{\pi}_t$ is the trend rate of inflation (perhaps the central bank's inflation goal) in period *t*. Thus inflation should depend on both short-run and long-run inflation expectations, although the theory suggests that each one has somewhat different anchoring role.

A key difficulty with this equation is that neither the expectation of next period's inflation nor the trend inflation rate is directly observable. Economists have used several approaches to proxy for these unobserved linchpins in the Phillips curve:

1. Proxy for expected inflation with an average of the recent observations for inflation;
2. Assume that "rational expectations" correspond well to the actual expectations used by price-setting firms;[5] or
3. Employ surveys of people and firms who forecast inflation.

[5] Recall that the concept of "rational expectations" implies the efficient use of all available information in forecasting inflation. In stricter forms, rational expectations becomes "model-consistent" expectations, so that in addition to efficiently using information, price-setters at firms are assumed to use the same model to forecast inflation as the economist writes down.

Option (1) was widely-used by many economists (see especially Gordon 1977) prior to the more widespread use of the rational expectations (RE) hypothesis of John Muth (1961), popularized in macroeconomics by Sargent and Wallace (1975) and many others. Over the past 25 years, the RE assumption has dominated inflation models.

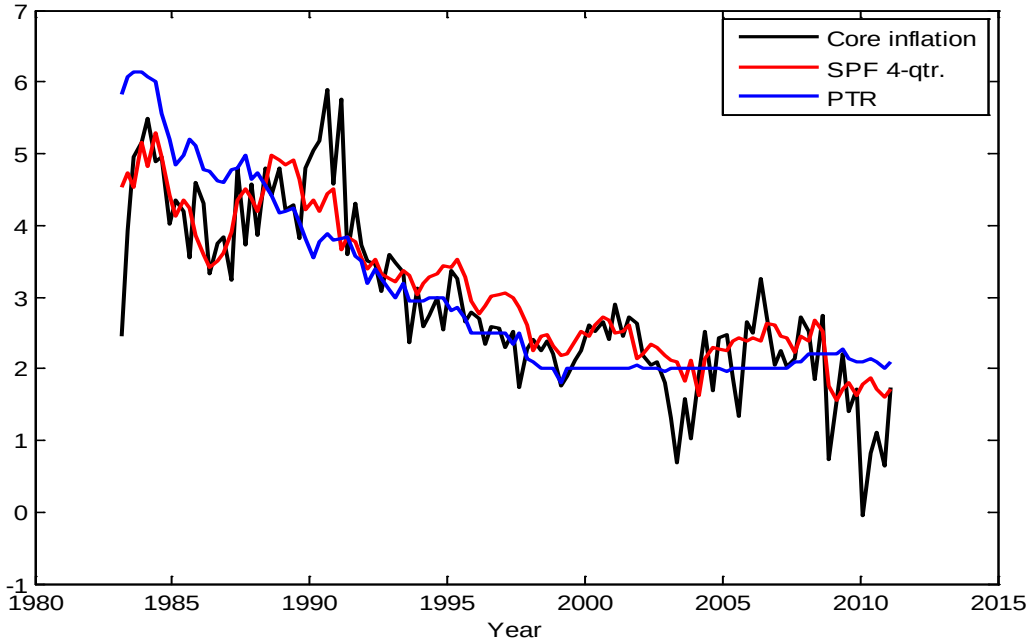
In part because of the extreme information assumptions required by the RE hypothesis (see Friedman 1979), and in part because the RE versions of Phillips curves met with only partial empirical success (see Rudd and Whelan (2006); Roberts (1997)), recent work has begun to consider whether survey expectations might constitute a reasonable middle ground between the loose proxies afforded by lagged inflation and the more theoretically rigorous assumptions of the RE hypothesis (see Adam and Padula (2011); Roberts (1997); and Nunes (2010); Fuhrer(forthcoming)).

Empirical Evidence on Expectations and Inflation Using Survey Measures

Figure 2, on the following page, displays core CPI inflation along with a short (one-year) and a longer-term measure (the FRB/US model variable with mnemonic "PTR" displayed above and defined in footnote 1) of inflation expectations. The figure suggests that there may well be a role for both expectations measures in explaining inflation. The long-run expectation captures the long-run or trend movements in inflation, while the shorter-run expectation appears to capture higher-frequency movements in inflation.

Figure 2 also suggests that there has been an important change in the behavior of U.S. inflation over the past 30 years. In the first half of this period, inflation exhibited a fairly pronounced downward trend, and the long-run expectation traced out that slower movement. In the second half, inflation appears to have fluctuated around a relatively flat trend of about 2 percent, perhaps reflecting a widely held perception that the Fed's unofficial inflation goal is about 2 percent.

Figure 2
Short- and long-run inflation expectations



Sources: Bureau of Labor Statistics (core inflation), Survey of Professional Forecasters (four-quarter inflation expectations), Board of Governors of the Federal Reserve System, FRB/US model (long-run expectations).

Of key interest at present is the movement of inflation below the 2 percent trend in the wake of the Great Recession. If the long-run expectations serve as an "anchor" for inflation, then this may put some upward pressure on inflation that partly offsets the downward pressure implied by the large amount of excess capacity in the economy at present. If not, then one would expect this "slack" to exert downward pressure on inflation, thus implying a continued decline in inflation going forward.

In assessing the role of the anchoring of longer-run expectations, an important difficulty lies in the behavior of expectations over the past dozen years. As figures 1 and 2 illustrate, long-run expectations have remained remarkably stable over this recent period—these expectations have almost literally "flat-lined." As a consequence, a model that suggests that current inflation equals the long-run inflation expectation adjusted for the influence of the unemployment gap behaves essentially the same as a model that suggests inflation equals a constant rate—its average over the past dozen years—adjusted for the unemployment gap. Table 1 and figure 3 display the fit of these two alternatives. One would be hard-pressed to declare one or the other the winner in this contest.

Table 1
Estimates of simple inflation equations

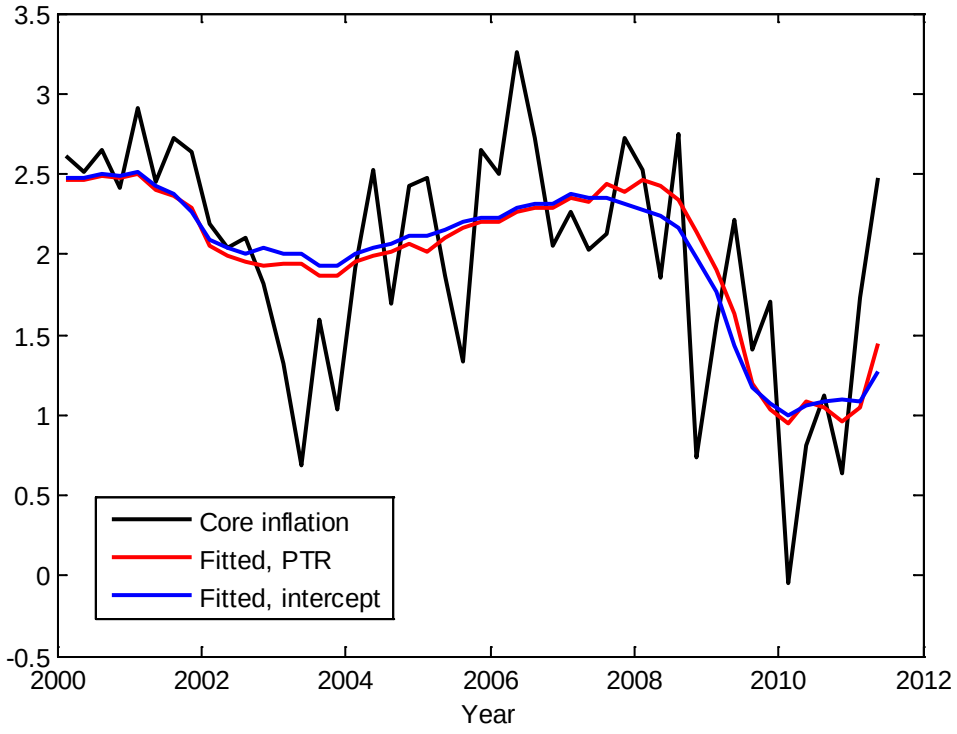
$$\pi_t = a\pi_t^{LR} - b(U_t - U_t^*)$$

$$\pi_t = c - d(U_t - U_t^*)$$

Core CPI inflation, 2000:Q1-2011:Q2

Variable	Coefficient	Significance	Coefficient	Significance
Long-run expectation (*a*)	1.1	strong	-	-
Intercept (*c*)	-	-	2.2	strong
Unemployment gap (*b*,*d*)	-0.28	strong	-0.26	strong

Figure 3
Comparison of PTR and Intercept model of inflation, 2000-2011:Q2



Sources: Bureau of Labor Statistics (core inflation), Board of Governors of the Federal Reserve System, FRB/US model (long-run expectations), author's calculations

These inconclusive results make it difficult to interpret the role that long-run expectations have had in influencing short-term inflation in recent years. Are the expectations irrelevant—flat at 2 percent and unrelated to recent fluctuations in inflation? Or are the long-run expectations the anchor that pulls inflation back, implying that inflation *must* average about 2 percent over this period?

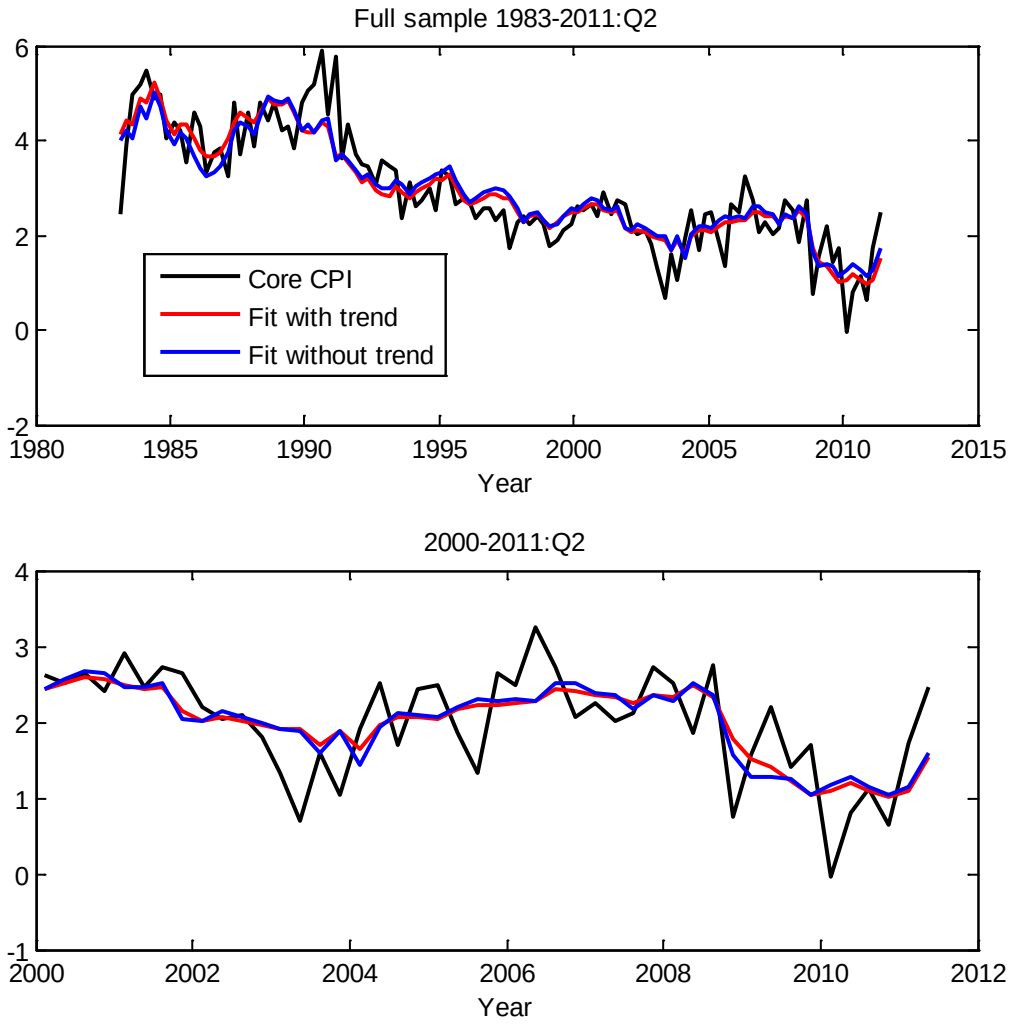
A Phillips Curve Perspective on the Role of Expectations

Recall from the discussion above that received theory suggests a role for both short- and long-run inflation expectations in determining inflation. Using the Phillips curve, which imposes a bit more economic structure on inflation and related data, may help us to sort out the relative roles played by long- and short-run expectations. In particular, if we cast the Phillips curve in its "deviation from trend" form as in equation (2) above, how much predictive power do we gain relative to a Phillips curve that excludes the long-run trend over the past 30 years? How much do we gain in explaining inflation during recent years?

These questions are addressed in figure 4, shown on the following page. Whether we consider the full sample since 1983 (during which inflation exhibited a pronounced downward trend), or the most recent dozen years (during which inflation exhibited no trend), the answer is "nothing at all." The fitted values for the two models lie nearly on top of one another, and this suggests that adding the trend inflation proxy to the model has little effect. The relative goodness-of-fit (R-squared) measures for the two models are displayed in table 2 below. There is literally no evidence suggesting that one needs to include the long-run expectation once short-run expectations are accounted for.

Figure 4

How important is the trend inflation?



Sources: Bureau of Labor Statistics (core CPI inflation), author's calculations

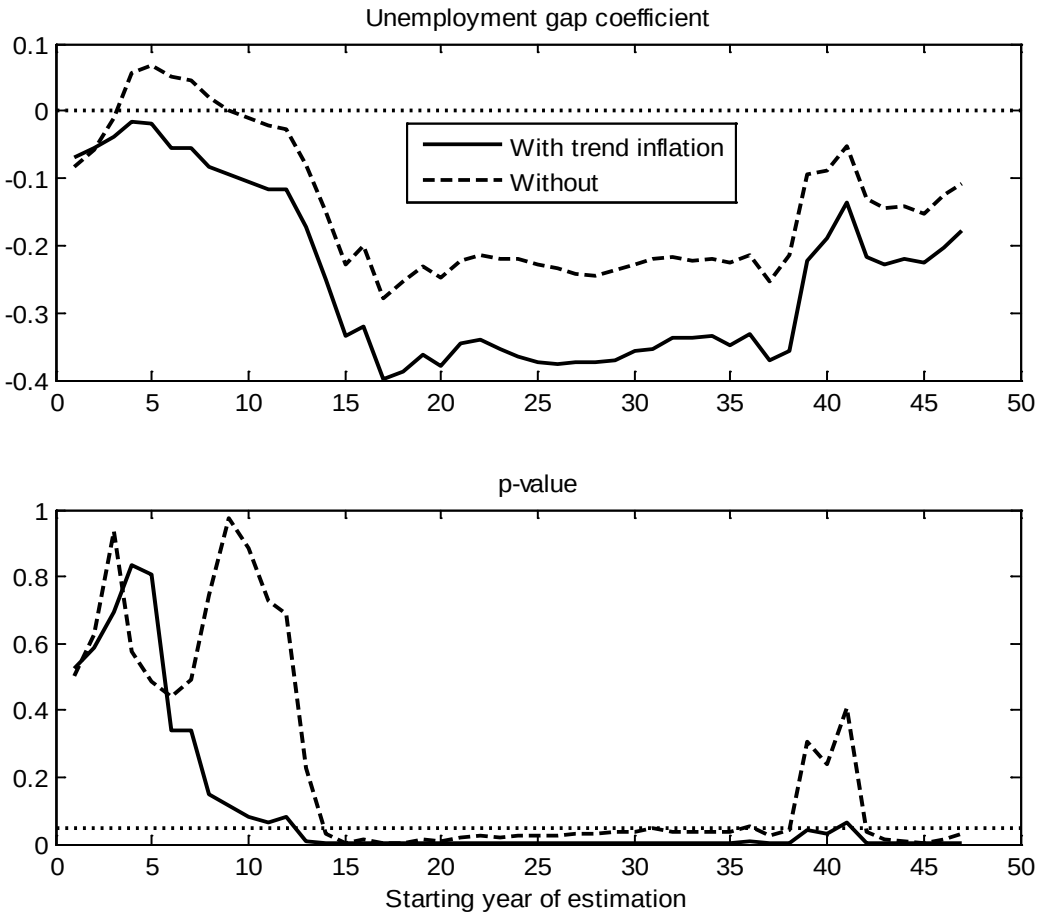
Table 2 goodness of fit measures for inflation models including and excluding "trend inflation"		
Sample	With trend	Without
1983-2011:Q2	0.97	0.97
2000:Q1-2011:Q2	0.94	0.94

In these estimates, note the role that resource slack plays. Table 3 displays estimates of the unemployment coefficient for selected subsamples, while figure 5 shows the estimates from rolling 10-year quarterly regressions from 1990 to the present. In most all cases, the coefficient on resource slack is sizable and significantly estimated. It may be that using survey expectations as the inflation expectations proxy helps us to better identify the role of resource slack, particularly in recent years.

Table 3
Unemployment gap coefficients in Phillips curves

	Coefficient	Significance
Deviations, 83-2011	-0.18	High
Deviations, 2000-2011	-0.18	High
No trend, 83-2011	-0.11	High
No trend, 2000-2011	-0.10	High

Figure 5
The role of resource utilization in inflation, 1990-present



Sources: Author's calculations

Do Long-Run Expectations Play *Any* Role in Determining Inflation?

So far, one might conclude from this brief that we can happily ignore long-run or trend inflation measures in explaining U.S. inflation behavior over the past 30 years. Not so fast.

The results of the preceding section suggest that a combination of short-run expectations and a measure of resource utilization do quite well at explaining inflation fluctuations. However, this does not entirely preclude a role for long-run expectations. In fact, it appears that long-run expectations may serve as an anchor for short-run expectations.

To illustrate this, we examine a simple depiction of the relationship between short- and long-run inflation expectations. In particular, we examine an "error-correction" model of inflation expectations, which answers the question: when short- and long-run expectations diverge, which path is more likely to revert to the other measure?

Figure 6 displays the results from simple error-correction regressions that take the form

$$\Delta E\pi_t^{SR} = ec_S(E\pi_t^{SR} - E\pi_t^{LR}) + \sum_{i=1}^{2} a_i \Delta E\pi_{t-i}^{SR} + \sum_{j=1}^{2} b_j \Delta E\pi_{t-i}^{LR}$$

$$\Delta E\pi_t^{LR} = ec_L(E\pi_t^{SR} - E\pi_t^{LR}) + \sum_{i=1}^{2} a_i \Delta E\pi_{t-i}^{SR} + \sum_{j=1}^{2} b_j \Delta E\pi_{t-i}^{LR} \quad .$$

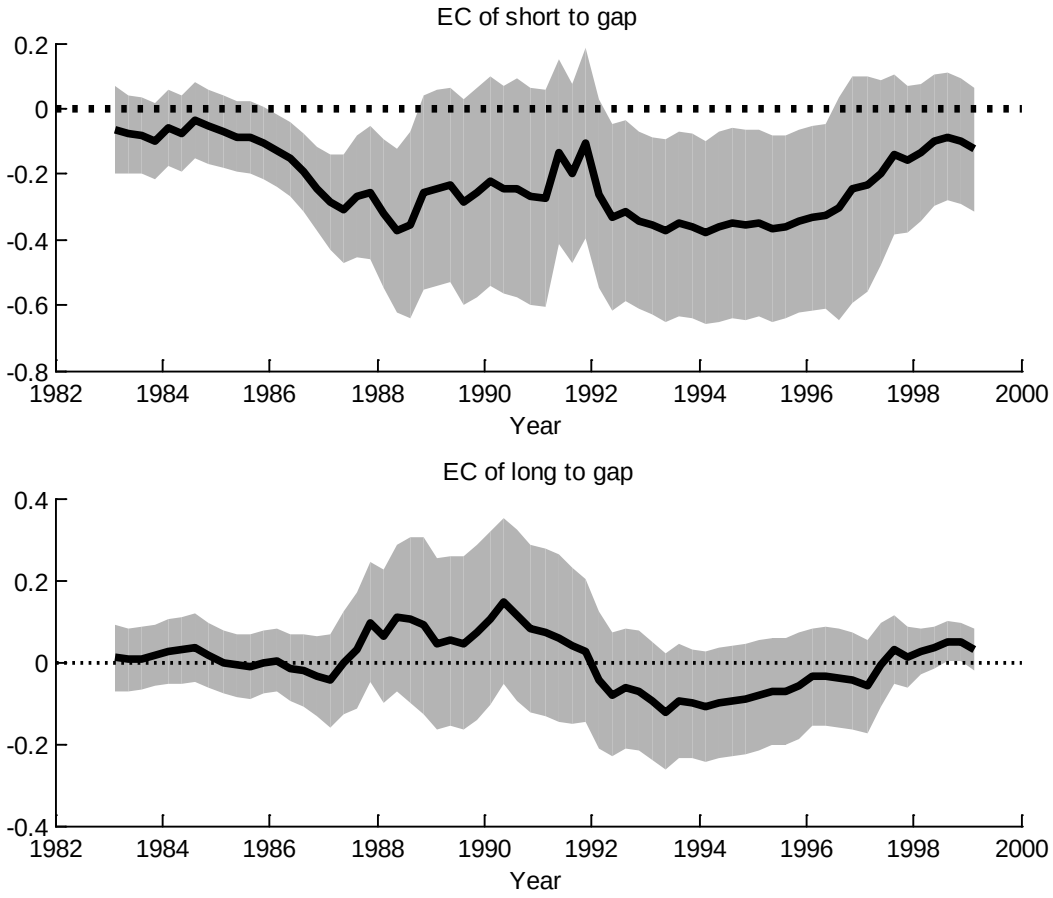
The coefficient of interest is *ec*, which determines whether the expectation measure (short- or long-run) moves consistently to close the gap between the short-run and long-run expectations. If the long-run expectation serves as an anchor for the short-run expectation, then the coefficient ec_S should be negative—because this implies that when the short-run expectation is above (below) the long-run, the short-run expectation will fall (rise). The figure displays the results of rolling regressions that employ a 50-quarter sample with the first start date in 1983:Q1. The solid line is the estimated error-correction coefficient, and the shaded area depicts the two-standard-error deviation band around the estimate.

The results in figure 6 show a fairly strong tendency for the short-run expectation to move toward the long-run expectation when the two diverge, but the opposite movement does not occur. In fact, over the past 30 years the error-correction coefficient for the long-run expectation is almost never significant at the 5 percent level. This simple test suggests that by and large, the long-run inflation expectation serves as an anchor for the short-run inflation expectation.

Figure 6

Error-correction of short- and long-run expectations

2-standard error band in gray shading



Sources: Author's calculations

But it is clear from figure 2 that while short-run expectations tend to revert toward long-run expectations, other factors influence how the short-run expectations are formed. The logic of the Phillips curve, which posits a relationship between inflation and resource utilization, might suggest that short-run expectations of inflation would depend on short-run expectations of resource utilization. We can use the SPF forecasts of unemployment to proxy for these expectations. Thus a simple model for short-run expectations that employs survey data and is consistent with the theory behind the Phillips curve would be

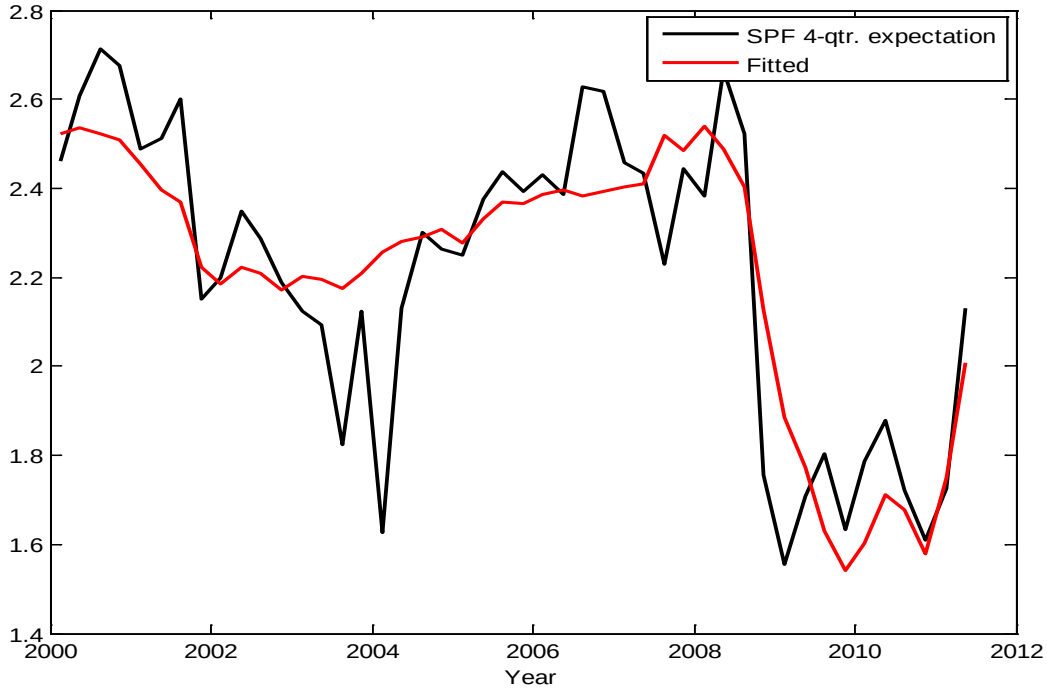
$$E\pi_t^{SPF} = E\pi_{LR}^{SPF} - bE(U_{t+1}^{SPF} - U_{t+1}^{*}).$$

An estimate of this equation yields the coefficients displayed in table 4, and the fitted values for the regression are shown in figure 7. The coefficient on the unemployment forecast gap is sizable and significant, and the fit for the past 10 years appears quite reasonable. The constraint that the long-

run expectation enters with a coefficient of one is not rejected in the later sample covering the 2000–2011 period, but it is rejected for the full sample.[6]

Table 4 Estimates of simple model for short-run inflation expectations		
	Estimate (significance)	
Coefficient	**1983-2011**	**2000-2011**
$E\pi_{LR}^{SPF}$	1 (imposed)	1 (imposed)
b	-0.19 (<1%)	-0.26 (<1%)

Figure 7
Simple model for short-run expectations
Anchored by long-run expectations



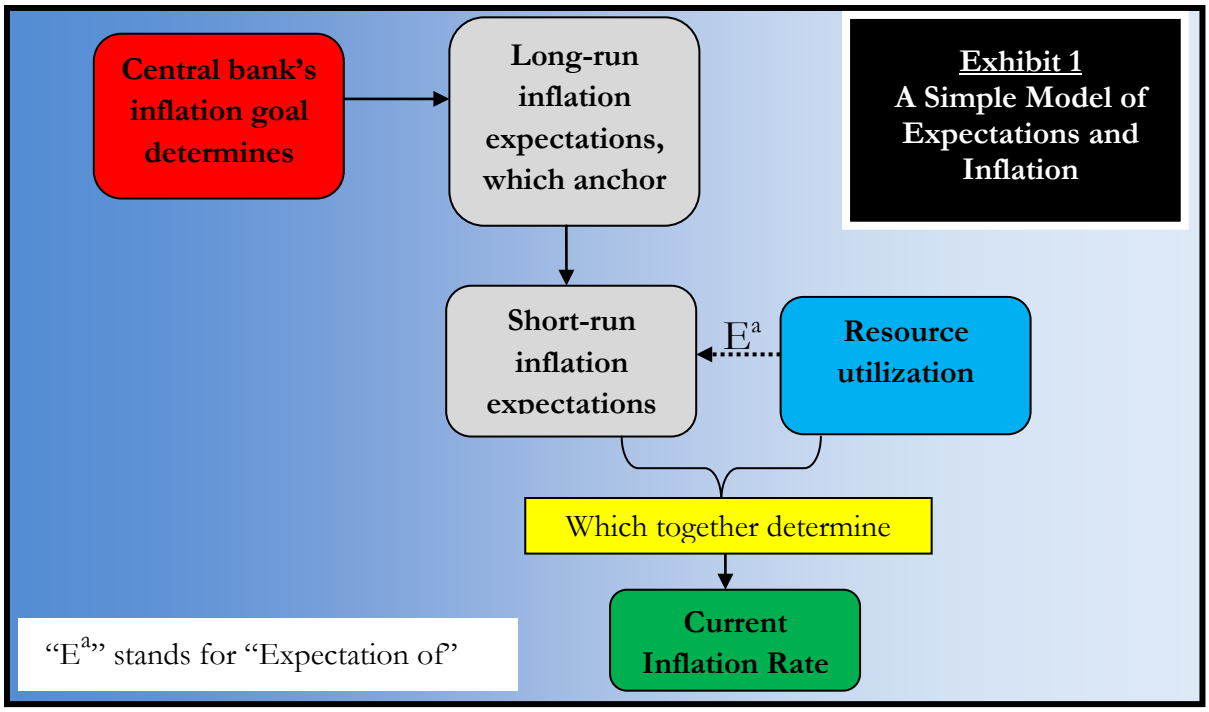
Sources: Survey of Professional Forecasters (4-quarter expectation), Author's calculations

Overall, this simple survey-based model explains the fluctuations in inflation and short-run economic fluctuations quite well, and helps to sort out the role that expectations play in determining inflation in the United States.

[6] The unconstrained estimate for the coefficient on the long-run expectation over the full sample is 0.74.

Conclusions

The diagram below provides a schematic illustration of the linkages among the current inflation rate, short- and long-run expectations, and monetary policy that are consistent with the results in this *Brief*. The central bank's implicit or explicit goal for inflation determines long-run inflation expectations. These in turn act as an anchor for short-run expectations. The combination of short-run expectations and resource utilization determine the current rate of inflation.



What does this model imply for the current trajectory of inflation? Will the anchoring of short-run expectations help to anchor inflation expectations, even in the presence of a large unemployment gap? A full answer to this question lies outside the scope of this brief, but it surely depends on the following:

1. Do long-run inflation expectations remain anchored at about 2 percent? This may depend on the Federal Reserve's perceived commitment to such an inflation goal but it may depend on other factors as well, such as the extent of resource slack and the rate of increase of production costs.

2. Will the unemployment gap remain elevated for an extended period? If so, this will exert continued downward pressure on inflation, partly or completely offsetting the upward pull of long-run expectations.

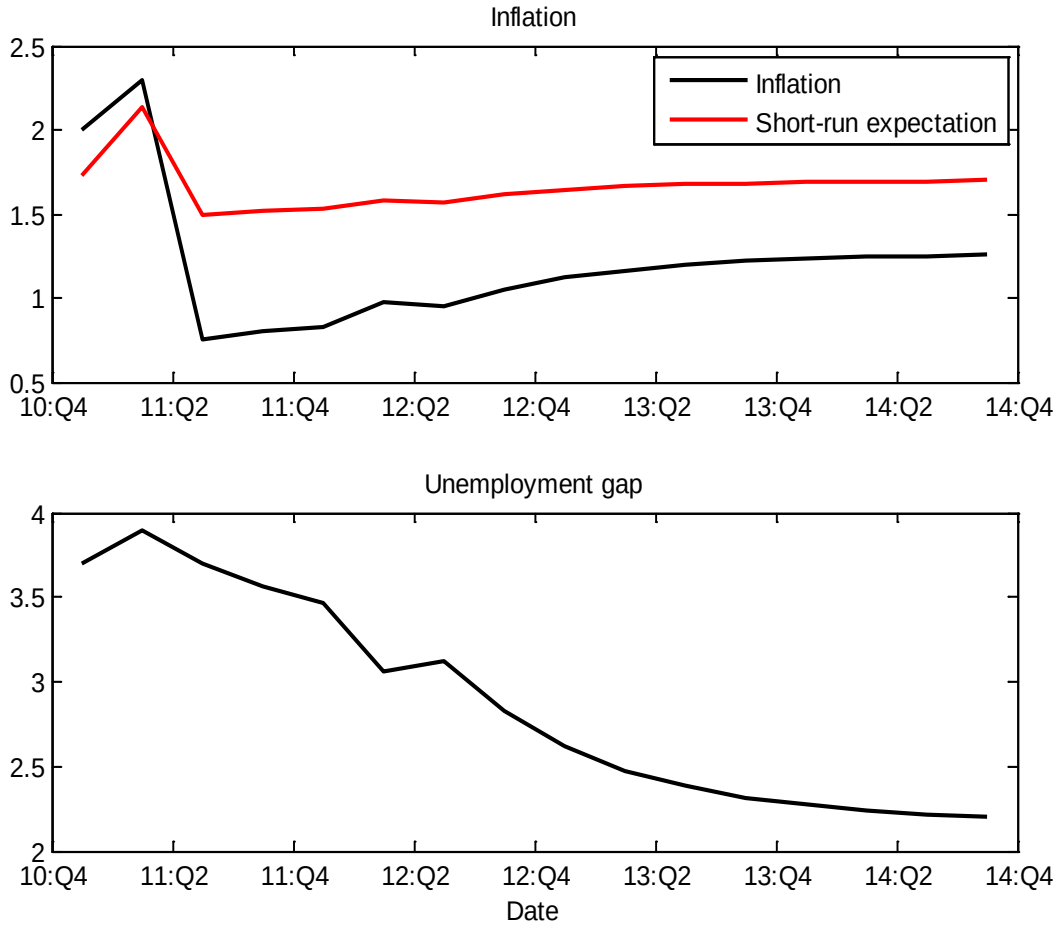
The final exercise conducts a simulation in which

- We impose that long-run expectations remain anchored at 2 percent;
- The unemployment gap gradually declines from its current level (where the current gap is computed using the CBO estimate of the natural rate of unemployment), and
- We use the estimated relationship among the current inflation rate, the short-run inflation expectation, and the unemployment gap; and the relationship among the short-run inflation expectation, the long-run expectation, and the expected (survey) unemployment gap.

The simulation yields the results depicted in figure 7, which appears on the following page. The simulated values begin in 2011:Q3 and the model views recent elevated inflation rates as transitory. The simulation suggests an inflation rate that rises quite gradually from below 1.0 to a bit below 1.5 percent in late 2014. Long-run inflation expectations anchor short-run expectations, which keep the current inflation rate from declining much below 1.0 percent, but the U.S. economy experiences a sustained period of quite low inflation.

Figure 7

Implications of simple survey-expectations inflation model for near-term inflation



Sources: Author's calculations

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