

December 16, 2009

The Role of Expectations and Output in the Inflation Process

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In current discussions regarding the likely trajectory of inflation, two issues loom large: First, whether “well-anchored” expectations will help to restrain inflation’s decline, and on the flip side whether an “unanchoring” of expectations could lead to an undesirably high rate of inflation; second, whether and to what extent output (or more generally resource utilization) gaps are useful components of empirical models of inflation and, if they are, to what extent current gaps will counter-balance the effects of expectations on inflation.

Page three of your handout provides a skeletal depiction of the most widely used framework for modeling inflation. Some version of this model is in use at virtually all Reserve Banks and the Board; in fact very little exists in the way of strongly competing frameworks. As the top left panel of the chart shows, the framework suggests that inflation depends on the expectation of inflation in the next period, the current value of a driving variable such as marginal cost of production or an output gap, and the inherent inertia in inflation, captured by dependence on the previous period’s inflation rate. Many other factors can influence inflation directly and indirectly, but these key elements sit at the center of the framework and of recent discussion. The extent to which each of these three factors contributes to the evolution of inflation remains under considerable debate.

The top right panel of the chart highlights an implication of this simple framework. If the framework is true in the current period, it holds in the next period as well. If you squint at these

¹ This presentation draws on material from “The Role of Expectations and Output in the Inflation Process,” J. Fuhrer and G. Olivei, “The Relationship Between Inflation and Inflation Expectations,” T. Clark and T. Davig, and “Survey evidence on the perceived relationship between inflation and government debt among consumers and financial experts,” S. Potter, R. Rich, G. Topa and W. van der Klaauw, all of which were prepared for this special presentation.

two panels for a few minutes, you'll see that the model boiled down implies that inflation fundamentally depends on current and expected output, as noted in the bottom left panel. Of course, expectations of output depend in part on expectations of monetary policy. Policy in turn depends on the inflation goal, which in this framework may vary over time. As a consequence, expectations of monetary policy actions and the monetary authority's inflation goal are, not surprisingly, among the determinants of inflation.

The bottom right panel displays the implications that this framework holds concerning which expectations measures should best explain inflation. Taken together, the simplest features of the model in the top left panel and its implications in the next two panels suggest that *short-term* inflation expectations matter directly—or equivalently that the expectations for output on average over the medium term matter directly. Less directly, but importantly for this audience, *long-run* inflation expectations should matter, to the extent that they serve as proxies for the central bank's long-run inflation goal.

What do “anchored expectations” mean in this framework? Your next exhibit (4) suggests that anchored expectations should be interpreted as having two components. First, the public knows the FOMC's numerical inflation goal, and second, the public believes that goal is not likely to change—at least not by much. As indicated in the exhibit, many believe that the Fed's inflation goal has changed quite significantly in postwar history, particularly in the 1970s and 1980s. More recent evidence suggests that public perceptions of the Fed's goal have changed little in recent years. As shown in your next exhibit (5), a carefully constructed econometric estimate of the inflation trend—often interpreted as the public's perception of the FOMC's inflation goal—suggests that it has indeed varied over time, that the variation is well-proxied by the median SPF 10-year CPI inflation forecast, and that this proxy has been remarkably stable

over the past 10–12 years. If this proxy accurately reflects the relevant expectations, then they are currently well-anchored indeed.

We now use a model that incorporates all these features—well-anchored expectations, some effect of output gaps or marginal cost on inflation, and some effect of lagged inflation—to quantify the extent to which, in circumstances such as those we face today, well-anchored expectations may serve to offset downward pressures on inflation from dramatic declines in marginal cost. Your next two exhibits consider such an exercise.

In the first case, shown in exhibit 6, expectations are purely forward-looking. The economy starts at a 2 percent inflation rate, the black line in the top panel, with marginal cost, shown in the bottom panel, well below its historical average—as is the case today for real unit labor costs for the nonfarm business sector, which are about 8-10 percent below their long-run average. Somewhat optimistically, I assume that the output gap is only modestly negative. In these circumstances, the inflation rate, the solid black line, falls to a bit below 1 percent, and rises after two to three years to the Fed’s assumed inflation goal of 2 percent, the red line.

In the second case, shown in your next exhibit (7), inflation depends in roughly equal measure on lagged and expected inflation. The other features of the simulation are identical, but the results in this case are dramatically different. Inflation falls significantly below zero, and the funds rate, the dashed black line, is pinned at the zero lower bound for several quarters. I should emphasize that the coefficient on marginal cost in these simulations is quite small by historical standards. One needs only a very small dependence on marginal cost to develop such results.

Clearly, the implications for inflation in this canonical framework depend critically on the way expectations are formed—purely forward-looking, or with some measure of backward-looking influence. So which is a better description of inflation? Your next exhibit (8) outlines an

empirical approach to answering this question. We estimate a model that allows expectations to be determined by any combination of the following measures: the rational or model-consistent expectations employed in the preceding simulations, lagged inflation, and short- and long-term survey expectations, here using the Survey of Professional Forecasters' measures. We allow the contributions of these four expectations proxies to vary over time.

Your next exhibit (9) presents a simple summary of the results. On average over the past 30 years, the purely forward-looking expectations have played at most a modest role in explaining inflation, and that role has declined in importance in recent years. Lagged inflation has played a somewhat larger role historically, although its role has similarly declined in recent years. Survey expectations have helped to explain inflation, and their influence appears to have risen in recent years. The survey measures are well-approximated by slow-moving averages of recent inflation, which suggests that they too may "anchor" inflation, as they will lend a slow-moving component to it. While this might serve to slow the decline of inflation in the face of significant marginal cost pressure, it will also slow inflation during its ascent to the Fed's inflation goal. The bottom line of this exercise is that the data suggest that the very favorable outcome in the purely forward-looking exercise of exhibit 6 is not our best forecast.

Your next several exhibits consider what would happen if the public's inflation expectations were to become unanchored. Note that the models used in the simulations *require* inflation to rise one-for-one with an increase in long-run inflation expectations. Interestingly, estimates of a less-structured empirical model, shown in exhibit 11, yield the same basic result. A reasonable interpretation is that when long-run expectations move significantly and persistently, they likely reflect a change in the public's perception of our inflation goal. Such a shift, if sustained, would very likely feed into inflation over time.

Your next exhibit (12) considers a potential cause of such a shift in longer-run expectations. Based on the same empirical model, the exhibit examines the response of long-run expectations to a decline in core inflation. The figure suggests that, over the past 25 years, persistent deviations of core inflation from the Fed's inflation goal have engendered significant movements in long-run expectations. This exhibit highlights the risk that, in the wake of declines in core inflation over the past year, long-run expectations could also decline. Together with persistently large output gaps and cost pressures, this could yield large declines in inflation. Of course, the risk could play out in the opposite direction if expectations moved persistently higher.

A candidate for spurring such a dynamic is the potential link between inflation expectations and the expected path of federal deficits. The NY Fed conducted a set of surveys to elicit perceptions among consumers and financial experts about the association between future changes in government debt and inflation. Survey responses shown in exhibit 13(a) indicate that a majority of consumers perceive unexpected increases in government debt to be inflationary, irrespective of whether unexpectedly high debt is due to a shortfall in tax revenues or higher-than-expected government spending. In a follow-up survey, the scenarios described in the exhibit were expanded by adding specific hypothetical causes for the increase in government spending and shortfall in tax revenues. These additions had no effect on the response patterns. Moreover, they are robust across education, income, and financial literacy categories of consumers.

In contrast to consumers, financial experts view the scenario in which higher-than-expected debt is due to a shortfall in tax revenues—a recession being the leading cause for such a scenario—as *not* inflationary, with 6 out of 11 financial experts associating such conditions with a decline in inflation. However, 10 out of 11 financial experts perceive the scenario in which there is higher than expected government spending to be inflationary.

Having discussed some ways in which expectations could become unanchored, we now attempt to quantify how unanchored expectations might affect our outlook for inflation. Exhibit 14 displays a simulation of the model we discussed earlier in exhibit 7, except in this case the public mistakenly believes the central bank's inflation goal has risen to 3 percent. The upward pressure that this places on inflation, the black line, is noticeable—inflation does not decline as deeply as in the simulation with anchored expectations. The funds rate, the black dashed line, is pinned at the ZLB for a shorter time. But the Fed's actions and the course of inflation gradually persuade the public that the Fed's goal is *not* 3 percent, so the economy returns to its desired state of full employment with price stability. Even with un-anchored expectations, very low costs and sizable slack at the onset of the simulation still imply a protracted period of low inflation.

All of the Phillips-curve models, structural or reduced-form, old-fashioned or new, hinge on the influence of an activity or cost variable. Without the influence of such a variable, these relationships are vacuous and inflation is indeterminate—there is no channel for monetary policy to control inflation, and as suggested in exhibit 3, the relevant expectations have nothing to anchor them. Exhibits 15 and 16 examine the issue of whether activity gaps have been reliable inflation predictors. Much ink has been spilled over this issue, so we are unlikely to provide a definitive answer. But our empirical work corroborates the common-sense findings of Stock and Watson: Gaps matter when they are large, but less noticeably when they are small.

The figure in exhibit 16 summarizes the evidence simply. Using historical data from 1961 to 2009, the figure compares the absolute value of unemployment gaps on the vertical axis to the difference between forecast errors from a Phillips curve and a naïve statistical model of inflation that does not include the activity gap. The reduction in forecast error provided by incorporating an unemployment gap measure is insignificant when the unemployment gap is near zero, toward

the bottom of the chart. But as the magnitude of the gap increases, the forecast error made by the gap-augmented model falls relative to the error from the naïve model, as indicated by the prevalence of blue diamonds to the left of the vertical axis in the upper half of the chart. This finding is consistent with the small estimated coefficients on output gaps in Phillips curves for the 1990s and early 2000s, and explains the finding in some prior research that during those relatively calm times, a naïve model predicts inflation as well as or better than a gap-dependent forecasting model. This is less likely to be the case in current circumstances.

What does this empirical finding imply for the current inflation forecast? Your next exhibit (17) shows that a model that incorporates this nonlinearity explains the past several years' inflation data quite well. However, the surge in unemployment over the past year implies a significant decline in inflation to near zero over the next year or so. Thus, the next several quarters will provide an important test of this model.

Finally, we would be remiss if we altogether ignored money in a discussion of inflation dynamics. Your final exhibit, courtesy of the Minneapolis Fed, displays the correlations between money growth and inflation at progressively longer horizons from left to right. While these correlations do not show causality, many would agree that over long periods of time, high growth in money is likely to be accompanied by high inflation. Because such correlations are essentially contemporaneous, they also do not imply that money can be used to *predict* future inflation. As the exhibit suggests, Milton Friedman may now rest in peace.

*Material for Briefing on
The Role of Expectations and Output in the
Inflation Process*

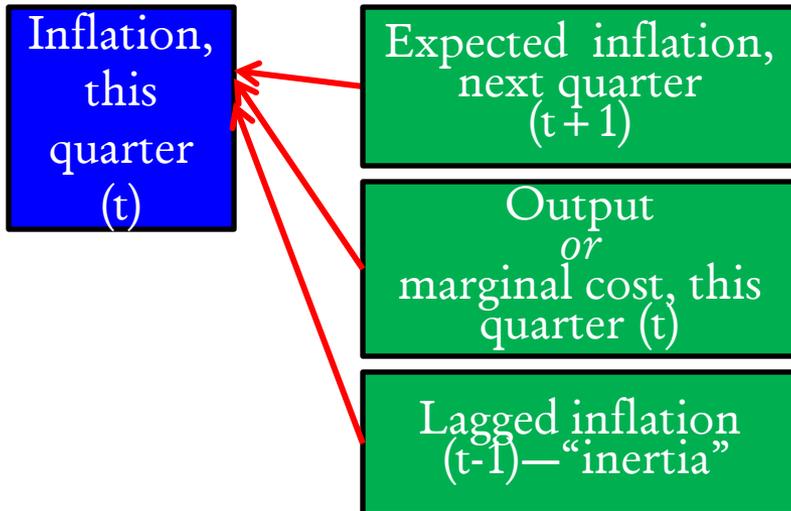
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Overview

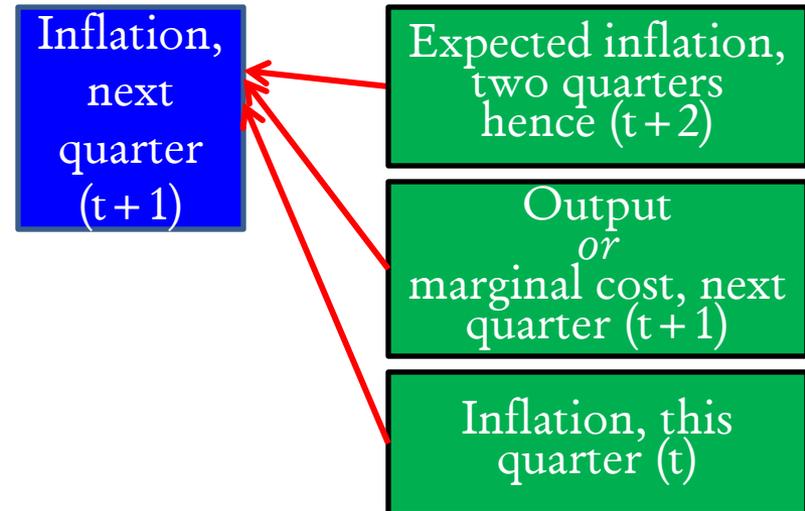
- Two key determinants of inflation in current economic thinking
 - Marginal cost or output gap
 - Expectations (of inflation and, implicitly, of costs and monetary policy)
- Both are the subject of considerable discussion
 - Can we measure gaps well? How reliable are gaps as forecasters of inflation?
 - Are expectations well-anchored? What do we mean by that? If so, will they offset downward pressure from costs or output? How are they connected to monetary policy?
- Goals of presentation
 - Add some economic structure to the discussion
 - Examine some empirical evidence on the role of gaps and expectations in determining inflation

Inflation, expectations, and monetary policy

1. A standard inflation framework



2. This relationship also holds in “t + 1”



3. Implications for expectations, I

- Inflation depends on current and expected costs/output
- These depend (in part) on monetary policy
- Monetary policy depends (in part) on the inflation goal, which may vary over time
- Expectations of policy actions and the inflation goal matter

4. Implications for expectations, II

- In practical terms, the expectations that should matter are:
 - Short-run inflation expectations
 - Long-run inflation expectations, as a proxy for the Fed’s long-run inflation goal
 - Longer-run cost or output expectations

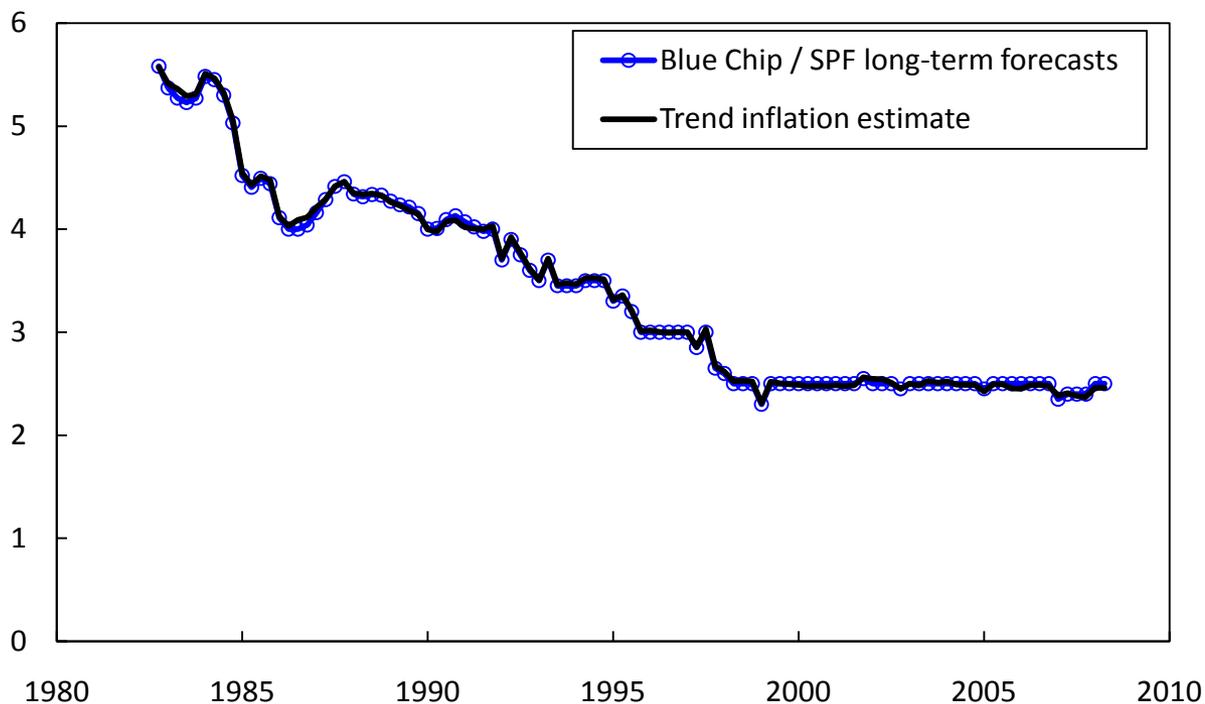
“Anchored” expectations in this framework

- People know the Fed’s inflation goal, whether it’s subject to change, and how vigorously the Fed will pursue its inflation goal
- People expect the goal to remain reasonably stable
 - Note: Historically, some of the longer-term movements in inflation may well have been caused by fluctuations in the Fed’s inflation goal
 - For that reason, and because the goal *could* (in principle) change over time, we allow for this effect of the Fed’s goal on inflation in our framework
 - We expect (and empirical evidence confirms) that this source of variation is smaller today than it was several decades ago

“Anchored” expectations and the Fed’s long-run inflation goal

- Clark and Davig estimate a reduced-form model which shows that long-term expectations (the 10-year SPF forecast) are an excellent proxy for “trend inflation”
- Trend inflation may be thought of as an indicator of the public’s perception of the Federal Reserve’s inflation goal

CPI inflation



Model: Inflation depends on

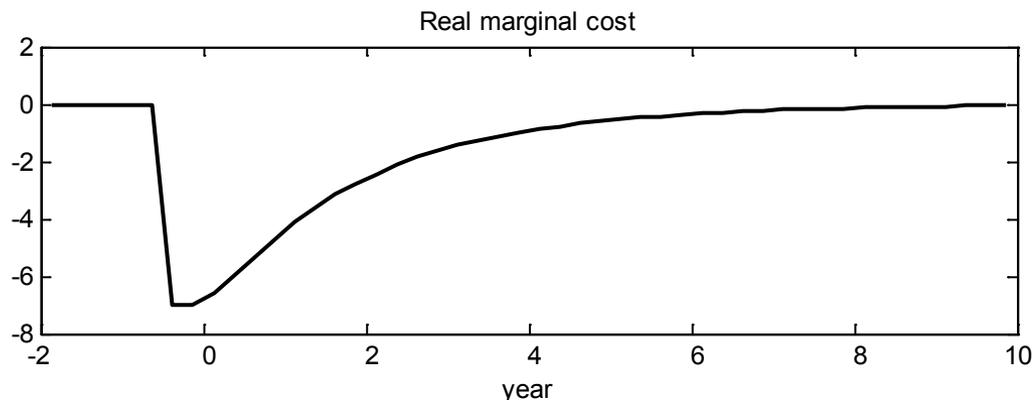
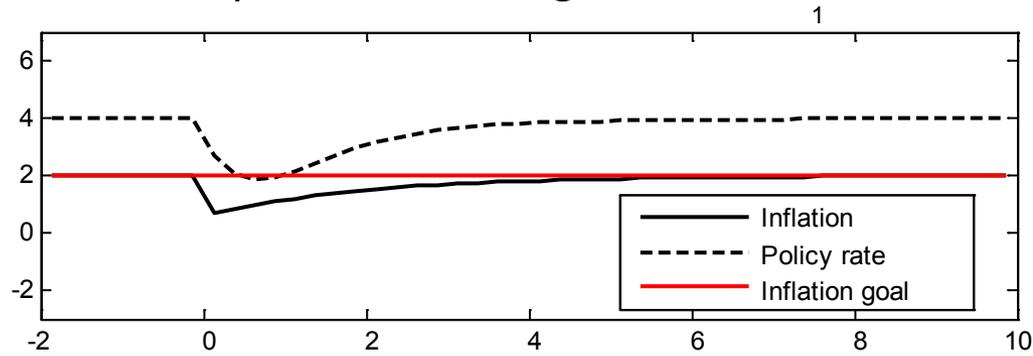
- Past inflation
- Inflation trend (unobserved)
- Monetary policy

- Long-run expectations/perception of the Fed’s goal “well-anchored” of late

How much could anchored expectations offset downward cost and output pressures?

- Answer: depends on how “forward-looking” price-setters are
- Consider two options:
 1. Purely forward-looking/model-consistent
 2. Combination of above and backward-looking

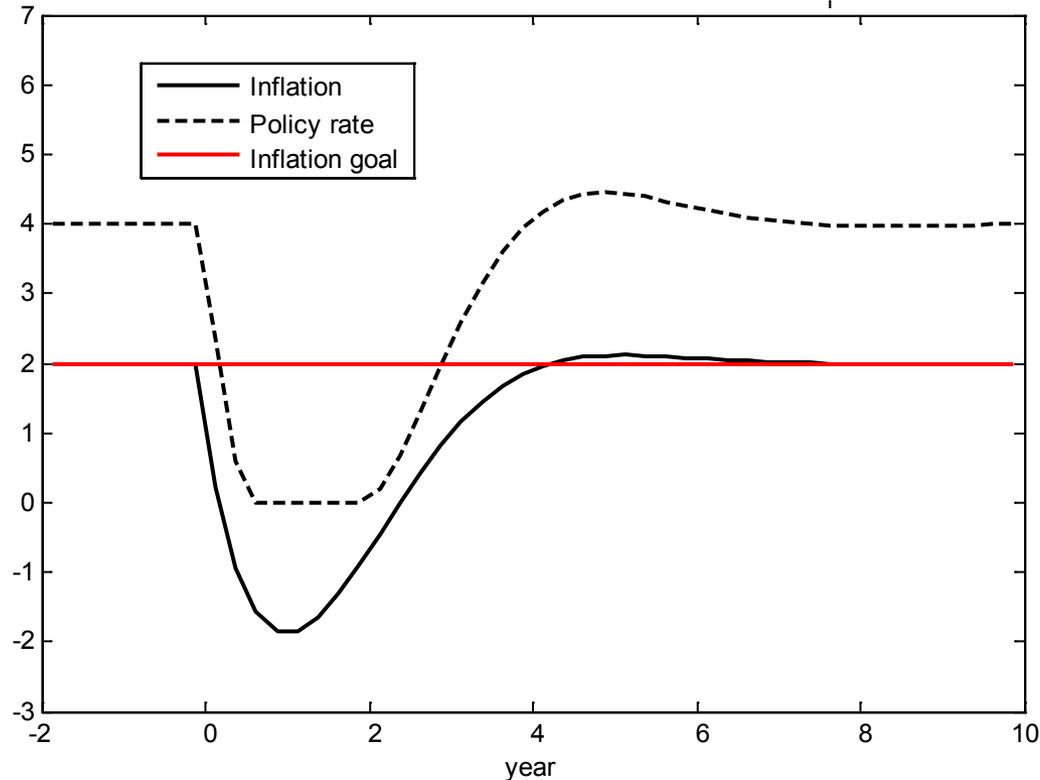
1. Purely forward-looking/model-consistent



Purely forward-looking: relatively small and short-lived decline in inflation

Anchored expectations versus declining marginal cost: an intermediate case

2. Mixed model-consistent/backward-looking (50-50)



Mixed model: Very different results. Significant disinflation, with a period during which funds rate is stuck at zero lower bound

So which model is more realistic?

- A somewhat structural approach: modified New Keynesian Phillips Curve, in which expectations may be any combination of
 - “Model-consistent” or “rational” expectations
 - Backward-looking behavior (average of past four quarters)
 - Survey-based inflation expectations
 - SPF one-year-ahead (median of forecasts)
 - SPF 10-year average (median of forecasts)

$$\pi_t = \mu_1 \pi_{t-1}^{avg} + \mu_2 E_{t-1} \pi_{t+1} + \mu_3 \pi_t^{S1} + (1 - \mu_1 - \mu_2 - \mu_3) \pi_t^{S10} + \gamma \tilde{y}_t + d \Delta \frac{p_{t-1}^o}{p_{t-1}} + \varepsilon_t$$

- See how these have changed over time, and what is important today

Results

Which expectations proxies best explain inflation?		
Proxy	Weight in model over past 30 years	Past 10 years: larger or smaller influence?
Model-consistent expectations	Small to moderate	Smaller
Lagged inflation	Moderate	Smaller
1- year SPF survey	Small to moderate in some cases	Mixed
10-year SPF survey	Small to moderate in some cases	Larger in some cases

- **Bottom line:**
 - Model-consistent expectations matter relatively little
 - The extreme model with purely forward-looking expectations is not well-supported in the data
 - Modest role for inertial survey expectations in explaining short-run fluctuations in inflation

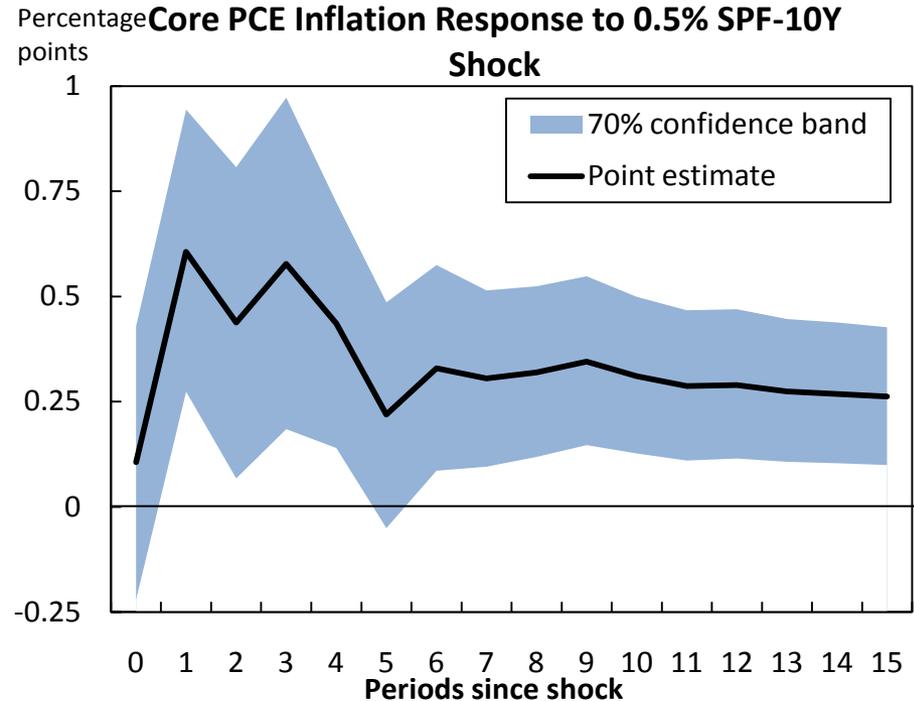
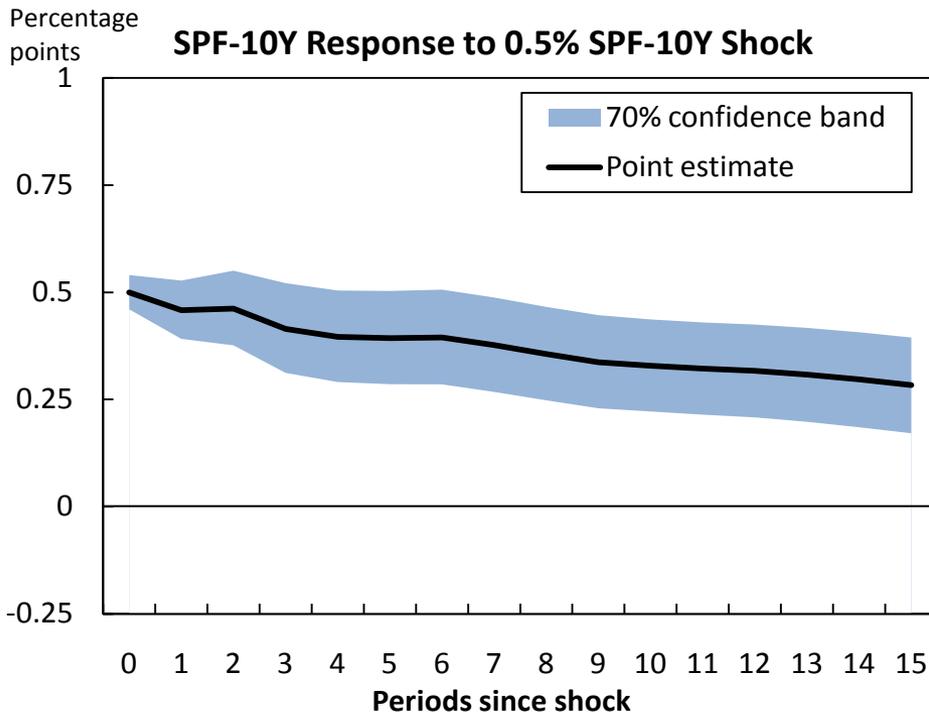
What if expectations are not fully anchored?

How would a change in long-term inflation expectations affect inflation?

- The inflation scenarios just presented treat long-term expectations as anchored at the Fed's inflation goal
- But expectations have moved historically, perhaps because the Fed's inflation goal has changed significantly over time
 - From the early 1980s to the early 2000s, long-run expectations dropped from just below 6% to 2.5%
- The models used in the scenarios imply that inflation eventually moves one-for-one with a sustained change in expectations
- An empirical model that does not impose the one-for-one pass-through of expectations into actual inflation validates this assumption

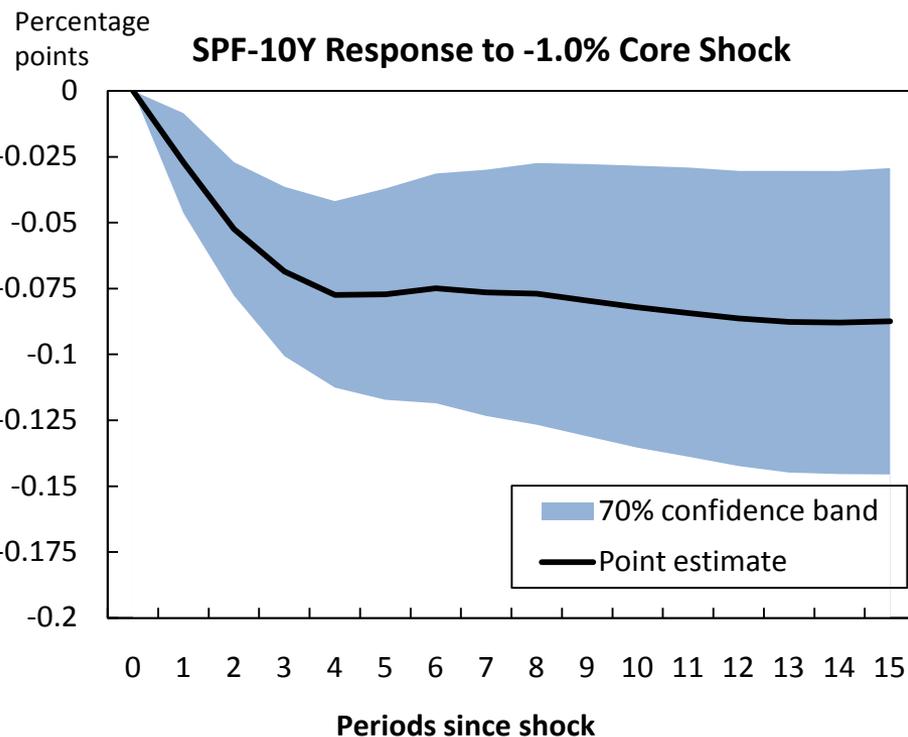
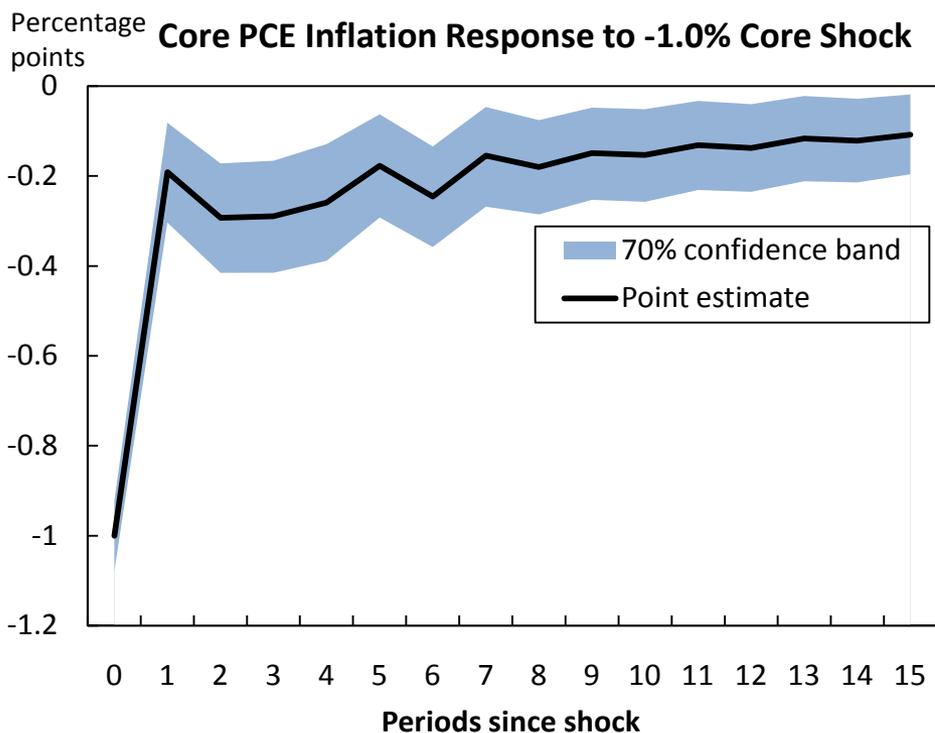
Estimate of the effect on inflation of a change in long-term inflation expectations

- Model: vector autoregression including the SPF-10 year expectation, core PCE inflation, economic activity, and the federal funds rate (estimated 1983-2009)
- Consider response to a 50 basis point one-time shock to the SPF 10-year expectation
 - The shock results in a persistent increase in the SPF expectation
 - The shock also generates a persistent rise in inflation, which roughly matches the rise in expectations
- Change in long-run expectations—inflation goal?—reflected one-for-one in inflation



What factors could un-anchor inflation expectations?

- Vector autoregressive models indicate survey-based expectations generally respond more to price variables than to economic activity or monetary policy
- The scenario: a -1%, one period shock to core PCE inflation
 - The shock results in a sustained reduction in core inflation of about -0.25%
 - The federal funds rate (not shown) falls in response
- Long-run expectations gradually decline, but by a small amount—about 0.08%
- Expectations should remain anchored as long as policy responds appropriately to inflation developments



Survey Results: Government Debt and Inflation Expectations

Exhibit 13a: Perceptions of Consumers and Financial Experts

A. Consider the following scenario: over the next 12 months, the government debt ends up growing substantially more than the administration has predicted BECAUSE tax revenues are lower than expected while the level of government spending remains on target. Under this scenario, how would this change your forecast for the rate of inflation over the next 12 months?

B. Now consider this alternative scenario: over the next 12 months, the government debt ends up growing substantially more than the administration has predicted BECAUSE the level of government spending is much higher than expected while tax revenues remain on target. Under this alternative scenario, how would this change your forecast for the rate of inflation over the next 12 months?

Number (percentage) responding:	Question A		Question B	
	Consumers	Experts	Consumers	Experts
I would expect much lower inflation	8 (2%)	1	12 (3%)	0
I would expect somewhat lower inflation	41 (10%)	5	37 (9%)	0
I don't believe that it would have an effect on inflation	74 (18%)	4	94 (23%)	1
I would expect somewhat higher inflation	245 (60%)	1	196 (48%)	10
I would expect much higher inflation	37 (9%)	0	69 (17%)	0
Total responses	409	11	408	11

Exhibit 13b: Consumer Expectations

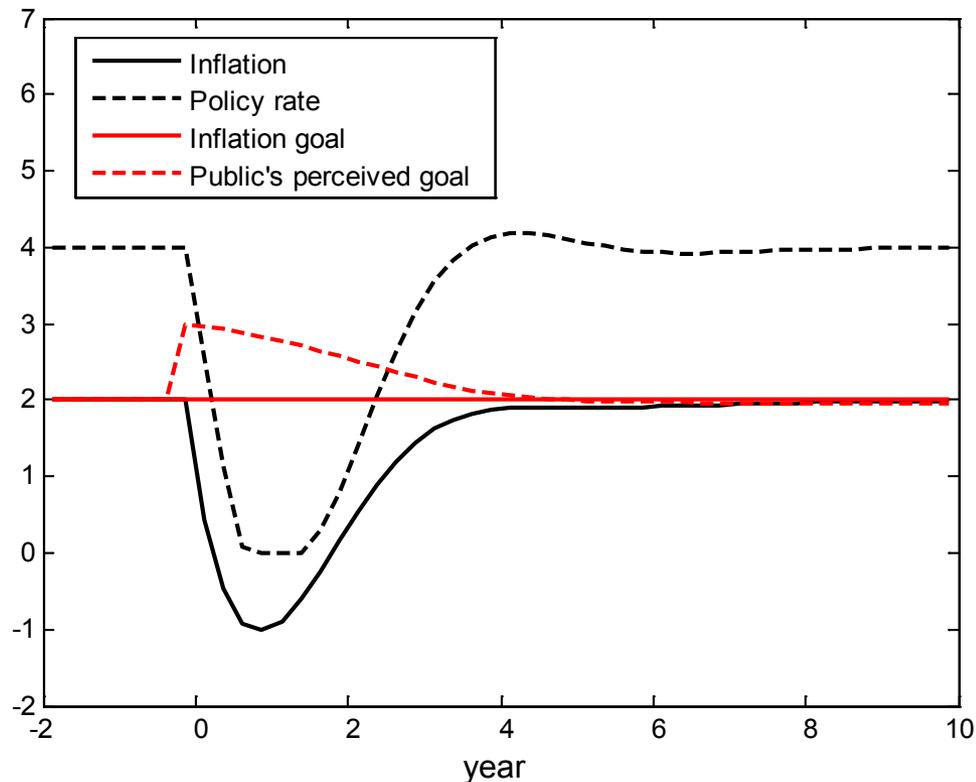
In percentage terms, by how much do you expect the level of government debt to be [higher/lower] twelve months from now?

Quartiles of distribution of expected percentage change in government debt	All	College	Less than College
25 th percentile	+5%	+5%	+5%
Median	+10%	+10%	+12%
75 th percentile	+20%	+20%	+25%
Total responses	1,198	615	583

An unanchored expectations scenario

- Public believes inflation target has risen to 3% (deficit fears?)
- Other economic conditions the same as previous simulations

Mixed model-consistent/backward-looking (50-50)



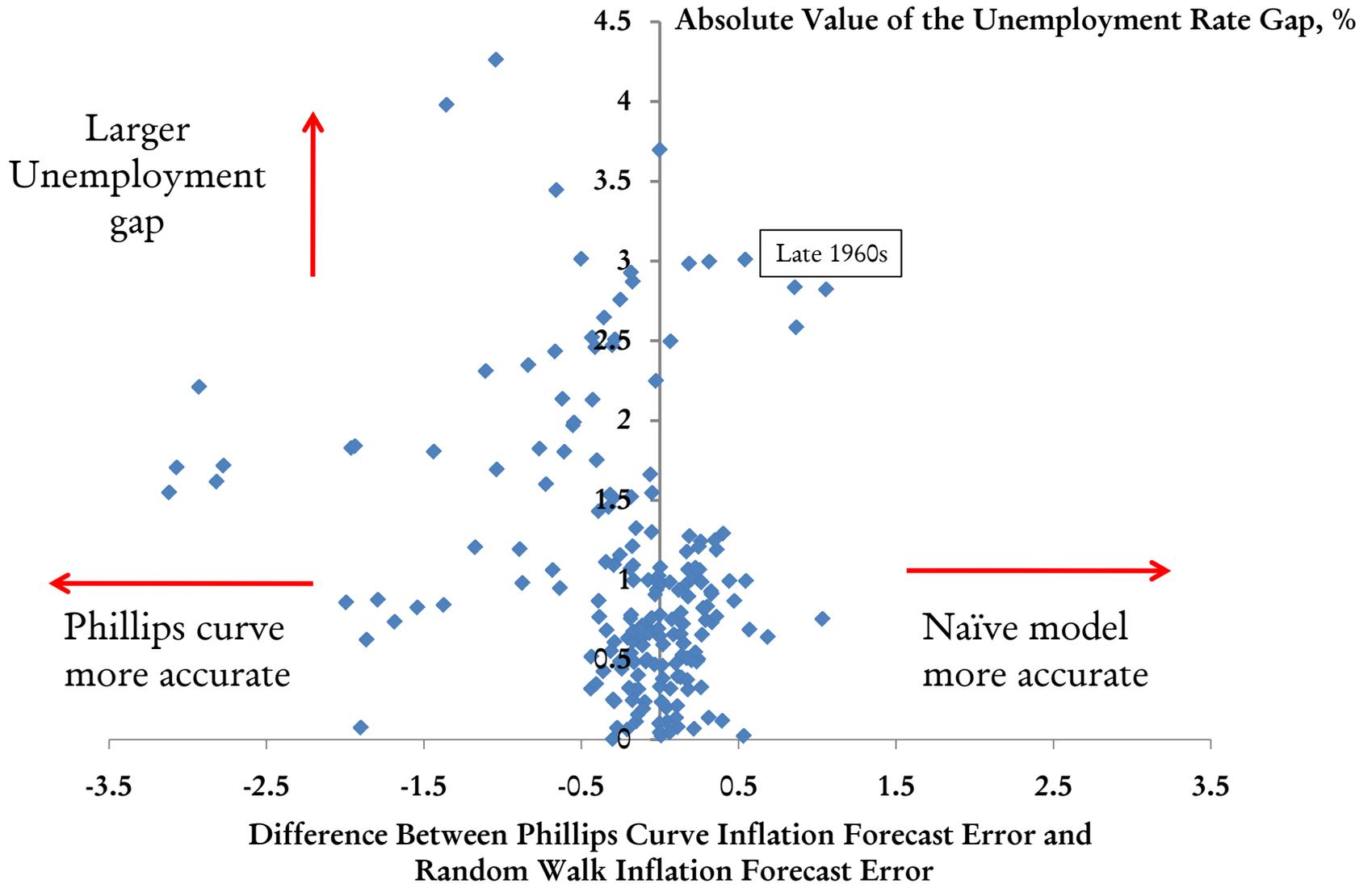
- Still implies a significant drop in inflation and policy rate

Do output gaps matter?

- Much appropriate discussion about difficulty of measurement, small coefficients in estimated equations, etc.
- We allow for a “nonlinearity”—*viz* that output or unemployment gaps matter when they’re large, not much when they’re smaller
- How large is large?
 - Stock and Watson (2009) and Fuhrer and Olivei (2009) find threshold for output gap at approximately 3 percentage points (1.5 percentage points away from estimated NAIRU for unemployment)

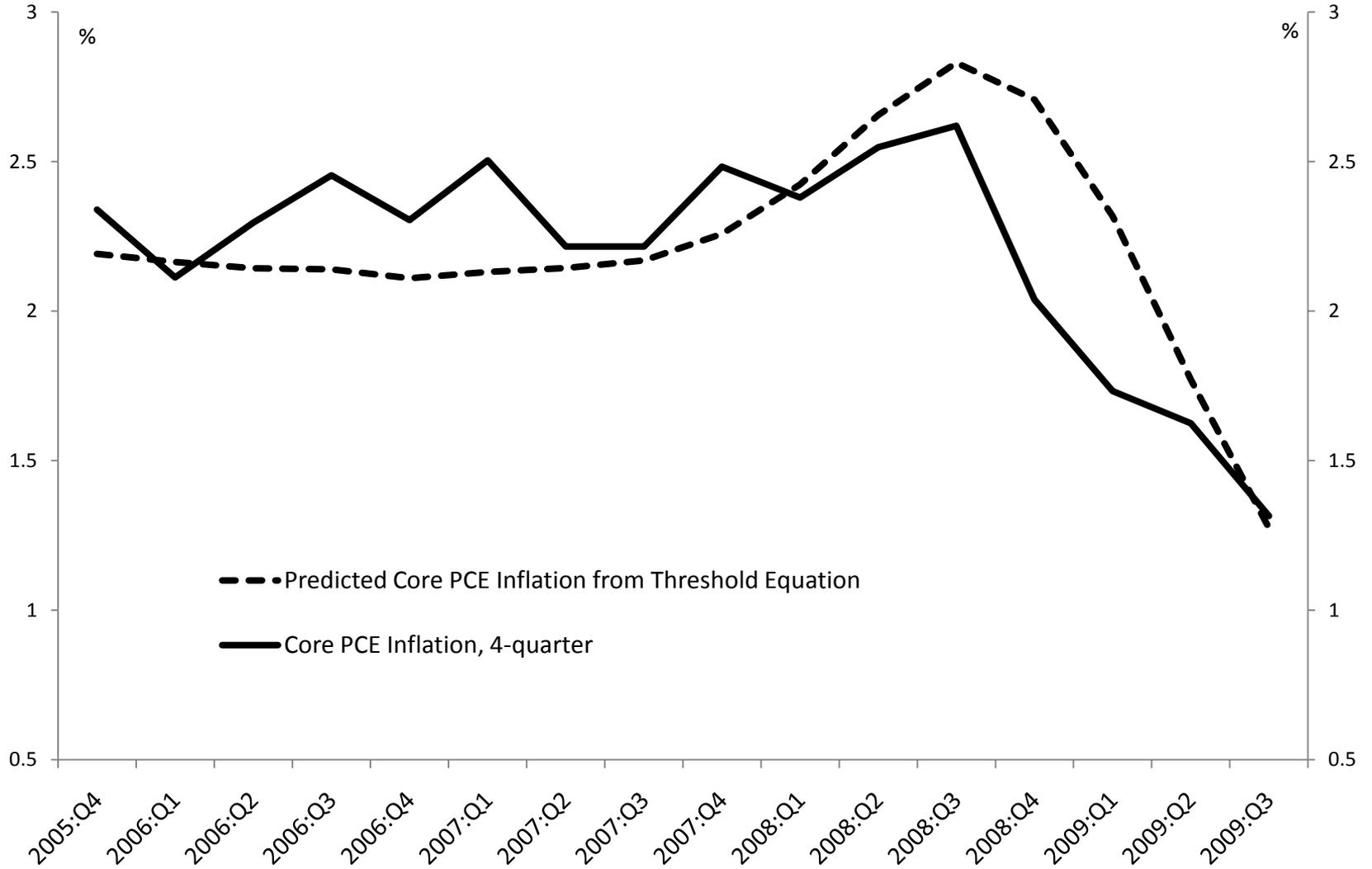
Gaps matter when they're large

Improvement in forecast error from including gap variables



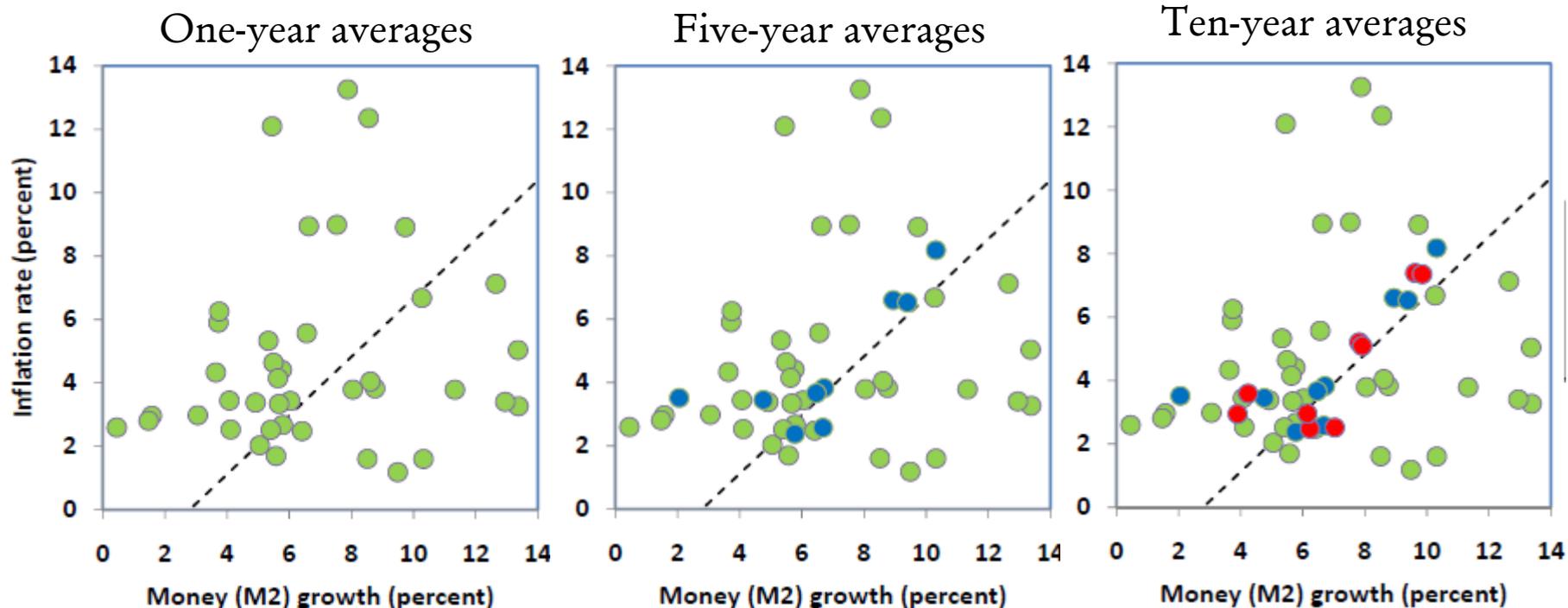
What does this model imply for the current outlook?

Out-of-sample fit of threshold model



Money and Inflation

We had to say something, or Milton Friedman would have been very angry



- The correlation improves as the horizon lengthens
- Correlation does not imply causality
 - But many would expect a money-to-inflation causality, in the long run
- Contemporaneous correlations: Prediction not implied
 - High money growth now does not necessarily imply high inflation later