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INFLATION DYNAMICS

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Inflation Dynamics
Frederic S. Mishkin
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ABSTRACT

This paper first outlines the key stylized facts about changes in inflation dynamics in recent years: 1) inflation persistence has declined, 2) the Phillips curve has flattened, and 3) inflation has become less responsive to other shocks. These changes in inflation dynamics are interpreted as resulting from an anchoring of inflation expectations as a result of better monetary policy. The paper then goes on to draw implications for monetary policy from this interpretation, as well as implications for inflation forecasts.

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Under its dual mandate, the Federal Reserve seeks to promote both price stability and maximum sustainable employment. For this reason, we at the Federal Reserve are acutely interested in the inflation process, both to better understand the past and--given the inherent lags with which monetary policy affects the economy--to try to forecast the future. We economists have made some important strides in our understanding of inflation dynamics in recent years. To be sure, substantial gaps in our knowledge remain, and forecasting is still a famously imprecise task, but our increased understanding offers the hope that central banks will be able to continue and perhaps even improve upon their successful performance of recent years.

I will outline what I see as the key stylized facts that research has in recent years uncovered about changes in the dynamics of inflation and will present my view of how to interpret these findings. The interpretation has important implications for how we should think about the conduct of monetary policy and what we think might happen to inflation over the next couple of years. I will address these two issues in the final part of this paper.

The Empirical Evidence on Changes in Inflation Dynamics

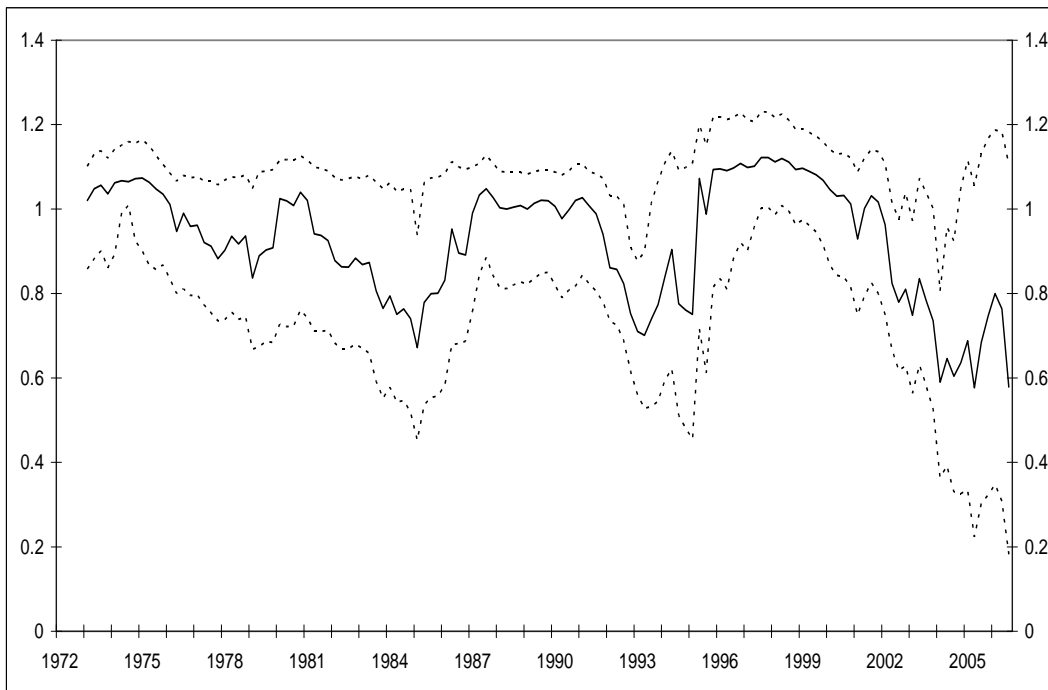
To see what research has discovered about the evolution of inflation dynamics in recent years, let's explore the following questions: (1) What is the available evidence on changes in inflation persistence in recent years? (2) What is the available evidence on changes in the slope of the Phillips curve? (3) What role do other variables play in the inflation process?

Inflation Persistence

To answer the first question, we need to measure how long the effects of a shock to inflation will last. Specifically, we need to know whether inflation tends to revert quickly to its initial level, or whether the effects of the shock persist--that is, lead to a changed level of inflation for an extended period. The most obvious way of measuring inflation persistence is to regress inflation on several of its own lags and then calculate the sum of the coefficients on lagged inflation. If the sum of the coefficients is close to 1.0, then shocks to inflation have long-lived effects on inflation. In other words, inflation behaves like a random walk, so that when inflation goes up, it stays up. If the sum of the coefficients drops well below 1.0, then a shock to inflation has only a temporary effect on inflation, and inflation soon reverts back to its trend level.

The evidence from these so-called autoregressions with U.S. data suggests that inflation may have grown less persistent over time. In particular, when autoregressions are run using rolling samples with a fixed width of, say, twelve years, the sum of the lagged coefficients often falls noticeably below unity as the sample advances to include the most recent data. Figure 1 illustrates this tendency, with the core personal consumption expenditures (PCE) price index as the measure of inflation. As you can see, the coefficient sum has declined to about 0.6 or so since the late 1990s, although the dotted lines indicate that the confidence interval for this estimate is wide and still includes 1.0. This result appears robust to the addition of other explanatory variables to the regression, although making such a modification does tend to reduce the extent of the estimated decline.¹ Finally, it's worth noting that this is not just a U.S. phenomenon, as some studies have found similar results for a number of other countries.²

Figure 1
Rolling Coefficient Sums From Univariate Model of Core PCE Price Inflation
(48-quarter window width)



Note: Chart plots median-unbiased estimates of the coefficient sum from univariate AR(5) models (with 90 percent confidence intervals) obtained with the Hansen (1999) grid bootstrap.

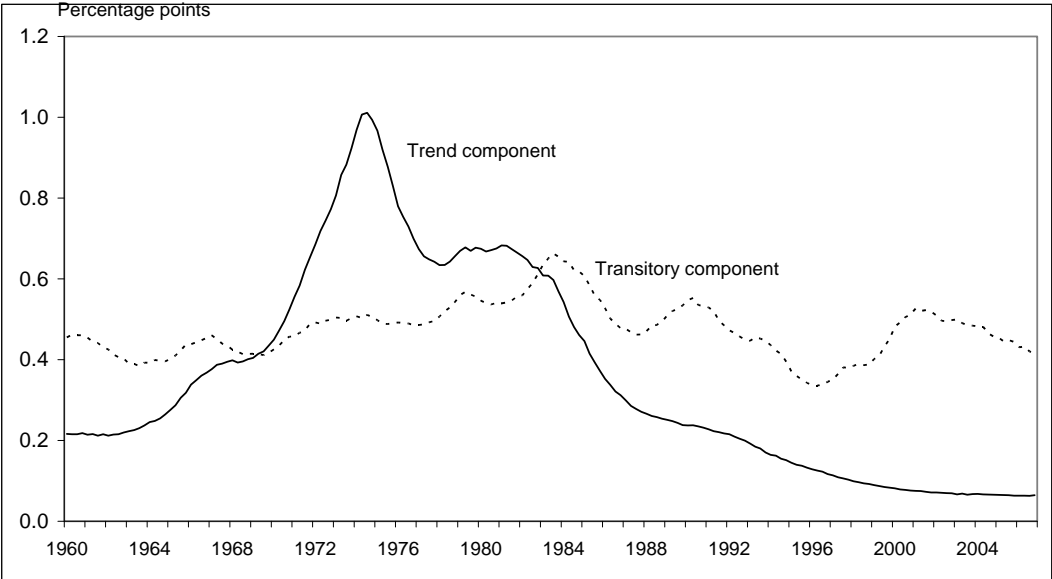
Recent work by Jim Stock and Mark Watson (2007) provides an alternative and, to me, a quite intuitive way of thinking about inflation persistence. They estimate a model that decomposes inflation into two components. The first component, which can be thought of as the underlying trend, follows a random walk, so that shocks to this component persist indefinitely and thus affect the trend inflation rate going forward. The second component is a serially uncorrelated shock, meaning that such shocks are temporary and lead to only transitory fluctuations around the trend. Stock and Watson then allow the volatility of these two kinds of shocks, trend and temporary, to vary over time.

Stock and Watson find that the importance of the trend shocks relative to that of the temporary shocks started to rise at the end of the 1960s in the United States, peaked in the mid-1970s, stayed elevated over the next ten years, and then declined to a historical low (upper panel of figure 2). When the relative importance of the trend shocks became high, as it did in the 1970s and early 1980s, inflation became highly persistent. Under such conditions, if inflation went up, the trend component typically rose in tandem so that inflation stayed up. In contrast, when the temporary shocks were relatively more important, as was true before the 1970s and after the mid-1980s, a change in inflation tended to reflect a change in the temporary component, not the trend. As a result, fluctuations in inflation tended to fade away, implying that inflation persistence was much lower. In the context of the Stock-Watson model, then, when inflation rose to double-digit levels during the “Great Inflation” period of the 1970s and early 1980s, persistence became very high because the trend rate of inflation moved around a lot--that is, trend inflation became unanchored.

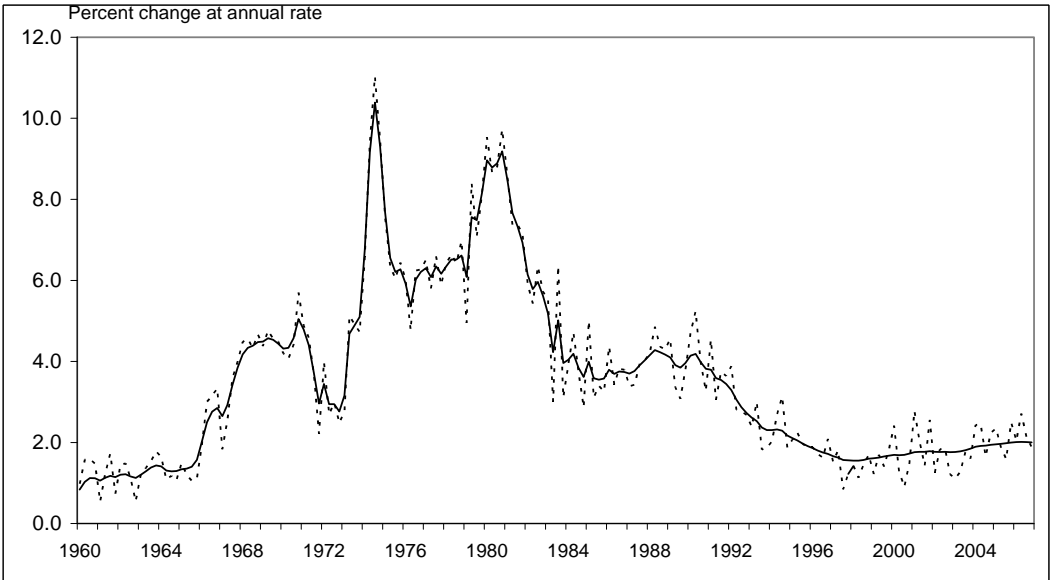
Although the importance of the trend component has fallen markedly since the 1970s, the estimates produced by Stock and Watson suggest that it is still large enough to be economically meaningful. The bottom panel of figure 2 illustrates this point; as you can see, the estimated trend (the solid line) has drifted up a bit since the mid-1990s. Of course, such estimates are inevitably imprecise to some degree. For example, Cecchetti *et al* (2007) employ a slightly modified version of the Stock-Watson procedure in a recent paper and find that inflation

Figure 2
Core PCE Inflation: Estimates from the Stock-Watson UC/SV Model

A. Standard deviation of innovations



B. Estimated trend component (solid line) and actual inflation (dashed line)



persistence has fallen so low that their estimated trend for gross domestic product (GDP) price inflation has been almost perfectly flat at about 2.2 percent over the past few years. In contrast, Cogley and Sargent (2005), using a different modification of the procedure, obtain results more in line with the original Stock and Watson paper. Finally, follow-up work by staff members at the Federal Reserve Board suggests that the degree of persistence found with these techniques varies across different measures of inflation. Thus, the empirical evidence on this question can vary. Nonetheless, I think it fair to say that inflation has become less persistent over the past two decades but that the underlying trend may not yet be perfectly stable.

When Cecchetti and his co-authors apply this type of analysis to other countries, the results are remarkably similar. In particular, in Canada, Italy, and the United Kingdom, the importance of the trend shocks began to rise in the late 1960s and early 1970s and then declined only in the mid-1980s. France followed a similar pattern, although there the rise began a bit earlier, in 1963. In short, all these countries experienced a similar “Great Inflation,” when trend inflation became unanchored. Germany and Japan had shorter periods of high persistence of inflation, with persistence beginning to decline around 1969 in Germany and around 1979 in Japan. Cecchetti and his co-authors conclude that the rise and subsequent decline of inflation persistence has thus been a worldwide phenomenon.³

Slope of the Phillips Curve

In traditional Phillips-curve equations, inflation depends on past values of inflation, an unemployment gap (the difference between the unemployment rate and an estimate of its natural rate), and variables such as the relative price of energy and import prices. When researchers estimate these equations, they typically find that the coefficient on the unemployment gap has

declined (in absolute value) since the 1980s, often by a marked amount.⁴ In other words, the evidence suggests that the Phillips curve has flattened.

The finding that inflation is less responsive to the unemployment gap, if taken at face value, suggests that fluctuations in resource utilization will have smaller implications for inflation than used to be the case. From the point of view of policymakers, this development is a two-edged sword: On the plus side, it implies that an overheating economy will tend to generate a smaller increase in inflation. On the negative side, however, a flatter Phillips curve also implies that a given increase in inflation will be more costly to wring out of the system. We can quantify this latter consideration using the so-called sacrifice ratio--the number of years that unemployment has to be 1.0 percentage point greater than its natural rate to reduce the inflation rate 1.0 percentage point. Averaging estimates obtained from a comprehensive battery of equation specifications suggests that the sacrifice ratio may be 40 percent larger--that is, it may be 40 percent more costly to reduce inflation than it was two decades ago. Is this really bad news? I will return to this question later.

Role of Other Variables in the Inflation Process

Empirical evidence suggests that inflation has also become less responsive to other shocks. The two oil price shocks in the 1970s were associated with large jumps in core inflation, whereas recent surges in energy prices have not had a similar effect. This reduced sensitivity manifests itself in traditional Phillips-curve models as a substantial decline in the estimated coefficient on the energy price term in these equations. Because this term equals the change in relative energy prices multiplied by the share of energy in aggregate output, energy price effects

on inflation appear to have fallen by more than can be accounted for by the greater energy efficiency of the economy.⁵

In contrast, unpublished empirical work by the staff at the Federal Reserve Board suggests that, once we take the rising share of imports into account, the influence of import prices on core inflation in the United States has not changed much in the context of reduced-form forecasting models.⁶ At the same time, the influence of exchange rate movements on import prices--the so-called pass-through effect--may have fallen substantially, at least according to some studies.⁷ If so, then the influence of exchange rate fluctuations on domestic inflation may now be less than it once was, when one controls for changes in the volume of our foreign trade.

What Interpretation Can We Give to Changes in Inflation Dynamics?

In interpreting these stylized facts about changes in inflation dynamics, we must first recognize that all of them are based on *reduced-form relationships*, and thus they are about correlations and not necessarily about true structural relationships. Because the explanatory variables in inflation regressions are themselves influenced by changes in economic conditions, changes in the underlying monetary policy regime are likely to be a source of changes in reduced-form inflation dynamics. This problem is especially acute for structural relationships involving expectations or other factors that are not directly observable and so cannot be included in reduced-form regressions. In such cases, we cannot use the reduced-form equations to disentangle the effects of such unobserved factors--which themselves may be driven by changes in monetary policy--from that of other influences.

The most important development in monetary economics that I have witnessed over my now-long career has been the recognition that expectations are central to our understanding of the behavior of the aggregate economy. Theory tells us that inflation expectations must be a key driving force behind inflation. This dependence has long been implicit in traditional Phillips-curve analysis, but expectations--now in explicit form--are also a central feature of the increasingly popular New Keynesian Phillips curves, in which current-period inflation is a function of expectations of next period's inflation and resource utilization. Therefore, a natural first place to look for explanations of changing inflation dynamics is a possible change in the expectations-formation process.

The first stylized fact discussed earlier is that inflation persistence, which rose in the 1970s during the Great Inflation, has since declined to a much lower level. An intuitive way of thinking about this rise and fall in inflation persistence is that it resulted from an un-anchoring of trend inflation during the period of the Great Inflation, and a re-anchoring in recent years, as the work of Stock and Watson suggests. When we think about what drives trend inflation, inflation expectations--particularly long-run expectations--come to mind. A de-anchoring of inflation expectations would surely lead to trend inflation becoming unanchored, whereas an anchoring of inflation expectations at a particular level would necessarily lead to a stabilization of trend inflation and hence a decline in inflation persistence.

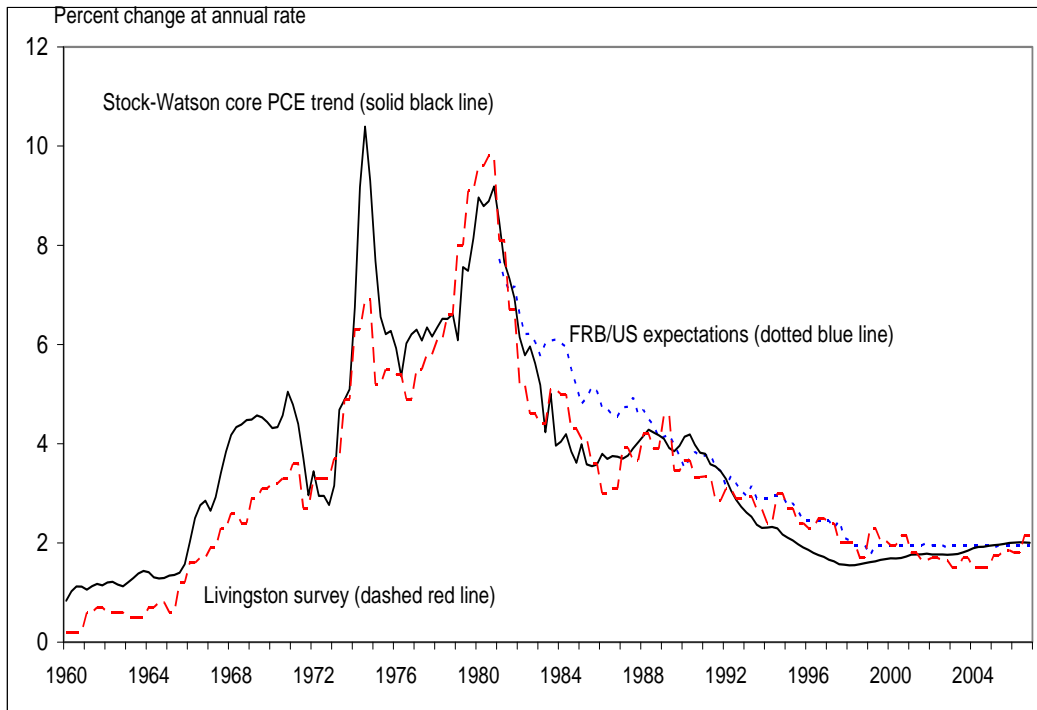
Do indicators of inflation expectations support this story? They certainly do. Consider the measure of expected inflation for the coming twelve months reported by the Livingston survey. As illustrated by the dashed line in figure 3, this measure of expected short-run inflation--adjusted by a constant factor to convert it from a CPI basis to a PCE basis--soared

during the 1970s and then fell back markedly during the 1980s and early 1990s. Over the past few years, the short-run series has fluctuated around 2 percent, with its month-to-month movements correlated with swings in energy prices, as one might expect. An even more striking story is told by the survey-based measure of expected long-run inflation used in the FRB/US model, the dotted blue line in figure 3.⁸ When we look at this long-run series (which should be more closely related to expectations about policy objectives than the short-run measure), we see that the public's expectations stood at a high level of 7-3/4 percent at the start of the 1980s, when this information first began to be collected. From that point on, however, expectations fell steadily over the 1980s and most of the 1990s as the process of re-anchoring continued. By 1998, this process was apparently completed, and since that time the public's expectations--at least according to this particular measure--have been steady as a rock. Estimates of inflation compensation derived from indexed Treasury yields have also been remarkably stable in recent years. Figure 3 also reproduces the estimate of trend inflation produced by the Stock-Watson procedure (the solid line). As you can see, this series more or less tracks the survey-based measures of long-run expectations, suggesting that the anchoring of long-run inflation expectations in recent years may explain the finding of a marked decline in inflation persistence.

Anchoring of inflation expectations is not a *deus ex machina*. It must come from somewhere, and since Milton Friedman's adage that "[i]nflation is always and everywhere a monetary phenomenon" is still true, monetary policy must be the source of the change in the evolution of long-run inflation expectations. During the 1960s and 1970s, the Federal Reserve and a number of other central banks maintained a policy stance that, inadvertently or not, was too easy on average and that allowed both actual and expected inflation to drift up markedly over

many years. Since the late 1970s, however, the Federal Reserve and many other central banks have increased their commitment to price stability, in both words and actions. The Fed pursued

Figure 3
Trend and Expected Inflation



Note: The FRB/US expectations series splices readings on expected long-run inflation from the Hoey survey (1981-1990) and the Survey of Professional Forecasters (1991-present). A constant adjustment factor of 1/2 percentage point is subtracted from both the Livingston survey and the FRB/US measure to control for the average historical difference between CPI and PCE inflation.

preemptive strikes against rises in inflation in 1994-95, in 1999-2000, and in 2004-06, as well as preemptive strikes against potentially deflationary forces in the fall of 1998 and in 2001-04. The result has been not only low and stable inflation but also, as we have seen, a strong anchoring of long-run inflation expectations.

The pursuit of more-aggressive monetary policy to control inflation and the achievement of anchored inflation expectations can also help explain the other stylized facts about inflation dynamics. With expectations of inflation anchored, any given shock to inflation--whether it is from aggregate demand, energy prices, or the foreign exchange rate--will have a smaller effect on expected inflation and hence on trend inflation. These shocks will then have a much less persistent effect on actual inflation. The recent experience with surging oil prices seems consistent with this story. The price of West Texas intermediate crude oil rose from about \$30 per barrel in late 2003 to a peak of almost \$75 per barrel in July of last year. During this episode, inflation appears to have been boosted only temporarily and by a strikingly small amount, in contrast to the 1970s when oil price shocks led to large, persistent increases in inflation.

Interestingly, monetary policy could have worked to flatten the estimated Phillips curve even without these favorable expectational effects, simply by moving more aggressively to stabilize both inflation and output. A theorem from the literature on optimal control states that implementing a policy of adjusting some instrument to stabilize a particular variable has the effect, in the limit, of driving the correlation between the instrument and the targeted variable to zero. Thus, a monetary policy that more successfully stabilizes inflation and resource utilization could well lead to a smaller estimated coefficient on unemployment gaps in a traditional Phillips-curve equation.

Research carried out with quite different models of the macroeconomy by my former colleagues at Columbia, Jean Boivin and Marc Giannoni (2006), and by John Roberts (2006) at the Federal Reserve Board, supports these conclusions. In particular, their analyses suggest that

changes in the way the Federal Reserve conducts monetary policy--including changes in both the parameters of monetary policy reaction functions and the volatility of shocks to those functions--may account for most of the reduction in the coefficients on resource utilization in traditional Phillips curves.⁹

What is particularly attractive about highlighting a better anchoring of inflation expectations as probably the primary factor driving the changes in inflation dynamics is that this one explanation covers so many of the stylized facts--an application of Occam's razor. Indeed, I have always become more confident in a theory if it can explain a number of very different facts.¹⁰ This is why I am so attracted to the view that inflation expectations are a key driving factor in the inflation process.

Of course, many other factors also influence inflation, and some of these provide other possible explanations for the recent changes in inflation dynamics. For example, smaller coefficients on unemployment gaps and energy prices in traditional Phillips curve equations may reflect the influence of lower and less-variable inflation on the frequency with which firms change their prices. In the context of a low-inflation environment, firms may have concluded that they can leave their prices fixed for longer periods at little cost, causing inflation to be less responsive to shocks, particularly if they are transitory. In this way, monetary policy may have affected the slope of the Phillips curve without having affected the manner in which expectations are formed. Also, from the mid-1980s through the first years of this decade, energy price movements were smaller and more transitory. We see this in futures markets, in which oil prices in far-dated futures contracts moved much less than spot prices over this period, suggesting that people expected a quick reversal in any rise in oil prices. Such transitory shocks to energy price

would presumably have a smaller effect on inflation than the more-persistent oil price shocks of the 1970s and early 1980s. Increased globalization and other sources of increased competition may also have lowered the sensitivity of domestic inflation to aggregate demand, thereby flattening the Phillips curve. However, the evidence on this last point is limited and inconclusive.¹¹

Policy Implications

These stylized facts--that inflation has become less persistent and now responds less to aggregate demand and supply shocks--can lead to inappropriate policy advice. If we take these facts to be structural and attributable to factors other than monetary policy, we might interpret them as suggesting that the Federal Reserve could respond less to shocks and yet be confident that inflation would remain at a low level. In addition, the smaller coefficient on unemployment gaps in traditional Phillips-curve models, which seems to imply that the sacrifice ratio has gone up, might lead us to think that reducing inflation is very costly because it requires long periods of high unemployment. As a result, policymakers might decide that such an attempt would not be worthwhile and so would be less likely to try to reduce inflation if it were undesirably high. If used in model simulation exercises, the flatter Phillips curve might also suggest that getting inflation down to a particular desired level could take an inordinately long time.

However, if we instead attribute the observed changes in inflation dynamics to better monetary policy and a resultant better anchoring of inflation expectations, then such policy conclusions are unwarranted. Under this alternative interpretation, the reason that inflation has become less persistent is that monetary policy, in carrying out its dual mandate of promoting

both price stability and maximum sustainable employment, has been vigilant in maintaining a low rate of inflation on average. But if the monetary authorities were to become complacent and to think that they could get away with not reacting to shocks that, in their mistaken view, no longer have the potential to cause inflation to rise persistently, then inflation expectations would surely become unhinged again. In short, complacency that might arise from the current low inflation persistence might result in *deja vu* all over again and return us to an era like the Great Inflation. These are exactly the concerns expressed in Tom Sargent's (2000) book on the rise and fall of U.S. inflation, in which he worries that a misunderstanding of the inflation process might again lead to a high-inflation equilibrium.

If inflation has indeed become less persistent because better monetary policy has anchored inflation expectations more solidly, the monetary authorities may find that they have less need to induce large swings in economic activity to control inflation. This is a key benefit of establishing a strong nominal anchor. Because the public has become confident that the Fed will do the right thing, expectations now behave in a manner that makes the economy more stable to begin with. If this hypothesis is correct, cyclical movements in interest rates need not be as great as was necessary when expectations were unanchored. However, these favorable circumstances will persist only so long as the monetary authorities continue to ratify the public's expectations. Consistent with its dual mandate, the Fed will therefore continue to respond aggressively to shocks that have potentially persistent adverse effects on both inflation and real activity. Because long-run inflation expectations are a key driver of trend inflation, monetary authorities monitor long-run inflation expectations closely. If they find that they are losing

credibility with the markets, so that inflation expectations begin to drift and rise above (or fall below) a desired level, they will take actions to restore their credibility.

At the Federal Reserve, we understand the importance to the health of the economy of anchoring inflation expectations. This is why Federal Reserve officials continually reiterate our commitment to maximum sustainable employment and price stability, why we have been willing to make preemptive strikes against both inflationary and deflationary pressures, and why we remain vigilant about developments in the economy that could lead to persistent departures of inflation from levels that are consistent with price stability.

My view--that recent changes in inflation dynamics result primarily from better-anchored inflation expectations and not from structural change or simply the achievement of a persistent low rate of inflation--implies some very good news: Potentially inflationary shocks, like a sharp rise in energy prices, are less likely to spill over into expected and actual core inflation. Therefore, the Fed does not have to respond as aggressively as would be necessary if inflation expectations were unanchored, as they were during the Great Inflation era. Indeed, this can help explain why the recent sharp rises in energy prices have had a much more benign effect on the real economy than they did in the 1970s--a point that then-Governor Ben Bernanke made three years ago.

Although solidly anchored inflation expectations are indeed highly desirable, they could pose a bit of a problem for monetary policy if they were at a level somewhat above or below the rate preferred by policymakers. Under such circumstances, the central bank would likely be interested in shifting the public's expectations in a more favorable direction. Whether such adjustment would be easy or difficult is, unfortunately, quite uncertain because we do not

understand the expectations-formation process very well. In some early models that used the rational expectations assumption, changing inflation expectations was relatively easy and thus implied sacrifice ratios that were extremely low, suggesting that the monetary authorities could shift inflation at little cost. However, the historical record suggests that permanently lowering inflation expectations may require keeping monetary policy tight for a substantial period, resulting in considerable output and employment losses for a time.

On the other hand, as Christy and David Romer (2002) have pointed out, the Federal Reserve in the 1970s overestimated the cost of reducing inflation because estimates of sacrifice ratios by Arthur Okun and other economists at that time proved to be too high.¹² As a historical note, this provides one explanation for the Federal Reserve's tolerance of such high inflation at the time. The disinflation after October 1979, carried out by the Federal Reserve under the leadership of Paul Volcker using words, procedures, and actions that were a sharp break from the past, produced a much lower cost of disinflation than policymakers had anticipated during the 1970s.

I think these considerations leave us with fairly wide bounds on what the costs might be of permanently shifting long-run inflation expectations that are already anchored. On the one hand, the historical record gives us little reason to think the costs would be as minimal as the simplest models with rational expectations might suggest. On the other hand, overly pessimistic estimates have proved to be wrong in the past.

Implications for Inflation Forecasts

I have argued here that the most attractive explanation for recent changes in inflation dynamics is that expectations have become better anchored. Inflation is now less persistent and more likely to gravitate to a trend level that is determined by where long-run inflation expectations have settled. What implication does this have for forecasts of future inflation? In this framework, the first priority is to determine where inflation expectations may be anchored. This task is somewhat tricky. According to the latest reading from the Survey of Professional Forecasters (SPF), long-term inflation expectations are currently around 2 percent, as measured by the PCE price index that the FOMC has emphasized. The private forecasters appear to have held this view for many years, given that long-run expectations for CPI inflation in the SPF have been running at around 2-1/2 percent since the late 1990s, and that the average historical wedge between the CPI measure and the PCE measure of inflation has been about 50 basis points.¹³

Of course, the views of professional forecasters may not be representative of what the average person or firm is thinking. If we turn to the financial markets, we find that inflation expectations extracted from a comparison of the yields between Treasury inflation-protected securities (TIPS) and standard Treasury securities seem consistent with an anchor at or perhaps a little above 2 percent in terms of PCE inflation.¹⁴ I say “seem consistent,” because we cannot be sure about at least one of the items used in the extraction, the premium paid to investors to compensate them for inflation risk. In the case of households, long-term inflation expectations from the Reuters/Michigan survey have been running much higher for a number of years, at around 3 percent. However, this figure seems overstated in light of the persistent bias found in the short-term inflation expectations reported by this survey. Correcting for the bias, these survey results are probably more in line with PCE inflation closer to 2 percent.¹⁵ As for firms,

we unfortunately have no good data on their inflation expectations. More information on this score would be particularly welcome, but expectations in general is an area worthy of further study.

Taken together, the data suggest to me that long-run inflation expectations are currently around 2 percent. That said, I think it should be clear that the evidence points to a range of estimates; moreover, this range is itself uncertain because of the assumptions needed to tease point estimates from the available data. So, although I think that 2 percent is a reasonable estimate of current long-run expectations, I don't want to overstate the precision of this figure. We still face some uncertainty in this regard, and policymakers are therefore cautious about placing too much confidence in any one estimate.

If long-run expectations are in fact about 2 percent, where is actual inflation likely to be headed in the next year or two? While recognizing how embarrassingly wrong such prognostications often turn out to be, I think that we can be reasonably optimistic that core PCE inflation will gradually drift down from its latest twelve-month reading of 2-1/4 percent. This process may take a while in light of the recent rebound in prices for gasoline and other petroleum products. These price increases have boosted the cost of producing many non-energy goods and services, and as firms gradually pass on these higher costs to their customers, monthly readings on the change in core prices are likely to be higher than they otherwise would be. Once this process is completed, however, we might expect consumer price inflation to move into better alignment with long-run expectations and thus settle in around 2 percent. Of course, our understanding of the empirical links between our measures of expected inflation and actual inflation is sufficiently poor that things could well go awry with this forecast. Moreover, many

things could happen in the coming months to alter the outlook, as the recent fluctuations in energy markets and swings in GDP growth illustrate.

Looking to the medium term, I am less optimistic about the prospects for core PCE inflation to move much below 2 percent in the absence of a determined effort by monetary policy. For the most part, this assessment--which I should stress is subject to considerable uncertainty--flows from my view that long-term expectations appear to be well anchored at a level not very far below the current rate of inflation. If so, a substantial further decline in* inflation would require a shift in expectations, and such a shift could be difficult and time consuming to bring about, as I noted earlier.

As I mentioned at the start, central bankers are acutely interested in the inflation process. This is why I have thought about the topic a lot and hope that my musings on this subject will stimulate more thinking on this topic.

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¹Two recent studies that report a marked decline in inflation persistence in the United States are Nason (2006) and Williams (2006). The conclusion that the sum of the lagged coefficients on inflation has declined should, however, be treated carefully, as analysis by the staff of the Federal Reserve Board suggests that modest changes in methodology, such as lengthening the sample period, correcting for small-sample bias, or changing the particular price index used in the analysis, can alter both the magnitude and the statistical significance of the estimated decline in persistence.

²Levin and Piger (2004) find significant declines in inflation persistence since the 1980s for the major European economies as well as for Japan, Canada, Australia and New Zealand. However, O'Reilly and Whelan (2005) find little or no evidence for a recent decline in persistence for the euro area as a whole.

³Cecchetti et al. (2007) have the following conclusion that appears to be at odds with the conclusion here that inflation expectations are a key driver of inflation dynamics. They state: "Theoretical exercises have persuaded some policymakers to focus intensively on inflation expectations as the primary determinant of inflation itself. Our results suggest this practice may be misguided." Their conclusion is based on Granger causality tests which indicate that in recent years, inflation expectations are unable to forecast the trend component of inflation. However, this conclusion does not follow from the Granger causality results. When inflation expectations are anchored, the trend component of inflation will also be anchored and will thus fluctuate less: trend inflation will necessarily be harder to forecast and inflation expectations will then not have forecasting power for trend inflation. Indeed, this is the logic behind the title of Stock and Watson (2007), "Why Has U.S. Inflation Become Harder to Forecast?" and the Cecchetti et al. paper is using a variant of the Stock-Watson framework. Furthermore, for reasons discussed in the text, measures of inflation expectations are likely to have substantial measurement error and when the inflation trend is hard to forecast, this measurement error makes it even less likely that measures of inflation expectations will have forecasting power for trend inflation. A more reasonable characterization of the results in Cecchetti et al. is that policymakers should not focus on measures of inflation expectations alone nowadays to forecast inflation, since inflation is so hard to forecast. This characterization is consistent with the conclusions in this paper.

⁴Studies that present evidence of a marked decline in the sensitivity of U.S. inflation to unemployment and other measures of resource utilization include Roberts (2006) and Williams (2006). Unpublished work by staff at the Federal Reserve Board indicates that this result generally holds across a variety of regression specifications, estimation methods, and data definitions. Other studies find similar declines in many foreign industrial economies; see, among others, Borio and Filardo (2006) and Ihrig and others (forthcoming). However, the empirical evidence on this question is such that the exact magnitude, timing, and statistical significance of these changes remain a subject of debate.

⁵Hooker (2002) finds that oil price movements during the 1980s and 1990s had little or no effect on core inflation, in contrast to a substantial influence in previous decades. Recent empirical work carried out at the Federal Reserve Board confirms Hooker's findings using data through 2006; however, some of this work also hints that the surge in energy prices since 2004 may have had a larger influence on core inflation.

⁶Interestingly, Ihrig and others (forthcoming) find that the sensitivity of inflation to movements in import prices has fallen in several foreign industrial economies.

⁷For evidence on U.S. exchange rate pass-through effects, see Marazzi and others (2005). Hellerstein, Daly, and Marsh (2006) also find that pass-through has declined in the United States, although by a considerably smaller amount. Empirical results for other developed countries are reported in Sekine (2006).

⁸The FRB/US series splices data from two surveys of expected long-run inflation--the Hoey survey of financial market participants from 1981 through 1989, and the Survey of Professional Forecasters from 1990 on. After

splicing, a 50-basis-point constant factor is subtracted from the series to put it on a PCE price index basis, on the assumption that survey respondents reported their expectation for CPI inflation, not PCE inflation. (The average wedge between CPI inflation and PCE inflation was about 50 basis points from 1980 through 2006.) I have made a similar adjustment to the Livingston survey data plotted in figure 3 to put it on a PCE price basis.

⁹ Clarida, Gali, and Gertler (2000) make a similar argument, but for a dissenting view, see Rudebusch (2005).

¹⁰ This is why Milton Friedman's *Theory of the Consumption Function* is one of my favorite pieces of empirical research. What is extraordinary about this book is that it has only a handful of regressions but nonetheless shows that the basic idea of permanent income has to be right because the theory explains numerous facts derived from numerous studies. This book is not widely read by graduate students nowadays, but it should be.

¹¹ See Borio and Filardo (2006) and Ihrig and others (forthcoming) for opposing views on this issue. Borio and Filardo provide evidence that global output gaps may be just as important as conventional domestic output gaps in the determination of inflation; moreover, they argue that these effects have been rising over time. However, Ihrig and her co-authors find that Borio and Filardo's results are sensitive to small changes in specification; they also find little support for an independent role of global output gaps and no evidence that globalization can account for falling coefficients on domestic gaps.

¹² Okun (1978) estimated that a 10 percent reduction in real GDP for one year would reduce the inflation rate only 1.0 percentage point. By the mid-1980s, however, Federal Reserve Board staff estimates of the sacrifice ratio were roughly half as large.

¹³ Recently, the Survey of Professional Forecasters (SPF) has begun to report long-run expectations for the PCE price index as well as the CPI. Long-run expectations for PCE price inflation were 2 percent in the latest release, the same rate as indicated by the FRB/US estimate since the late 1990s. (The FRB/US estimate since 1991 derives from the SPF reading on expected long-run CPI inflation less an average historical wedge between the CPI measure and the PCE measure of inflation of about 50 basis points.) Interestingly, long-run expectations for CPI inflation in the SPF ticked down to 2-1/3 percent in the latest survey, suggesting that private forecasters may have lowered their estimate of the average CPI-PCE wedge to about 30 basis points. Such a revision would be in line with current Board staff estimates, which indicate that the wedge has declined in recent years and now stands at about 30 basis points.

¹⁴ Inflation compensation--the difference between nominal and indexed Treasury yields--has recently been about 2-1/2 percent. However, two adjustments are necessary to translate inflation compensation into an estimate of expected long-term inflation on a PCE price basis. First, because the difference between nominal and indexed yields equals the sum of inflation expectations and an inflation term premium, we must subtract an estimate of the premium. Given that term premiums on nominal Treasury yields are extremely low at present, the inflation term premium is probably less than 25 basis points currently, and could even be zero. Second, because the inflation series used to index the Treasury securities is the CPI, not the PCE price index, we must subtract an estimate of the wedge between the two measures of inflation. If we use the same 30 basis points wedge expected by private forecasters in the latest reading from the SPF, indexed and nominal yields appear to be consistent with expected long-term PCE inflation of about 2 percent or a little higher.

¹⁵ According to the Reuters/Michigan survey, long-term inflation expectations of households are currently around 3 percent, as they have been for the past few years. This survey does not specify a price index. However, expectations from the companion one-year-ahead expectations have come in about 75 basis points higher than actual PCE inflation since 1990, suggesting that there may be a systematic bias in the responses to the Reuters/Michigan survey relative to this measure of inflation. If this bias also applies to longer-run inflation expectations, then household expectations may be in line with PCE inflation running in the vicinity of 2-1/4 percent in the long run.