



## **Remarks by Chairman Ben S. Bernanke**

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### **Inflation Expectations and Inflation Forecasting**

I would like to thank Christina Romer and David Romer for giving me the chance to address participants in the Summer Institute, sponsored by the National Bureau of Economic Research (NBER). As an academic, I regularly attended the Summer Institute and presented or commented on research here. I also served for a time as the director of the Monetary Economics group, the position now shared by David and Christina. The informal nature of the institute, the large number of talented people in attendance, and the opportunity to hear about the very latest work in the field--often while in early draft form--made these few weeks each summer one of the most stimulating times of the year for me. In my current position, I am keenly aware of the long history of fruitful interaction between economists inside and outside of central banks, and I am eager to see this interaction continue. This ongoing intellectual exchange, by improving our understanding of the economy and the workings of monetary policy, has had and will continue to have sizable benefits.

Today I will offer a few remarks on the relationships among monetary policy, inflation, and the public's expectations of inflation, focusing--as seems appropriate for this audience--on some important open questions. I will also give a short overview of the way the Federal Reserve Board staff forecasts inflation, including some discussion of how the staff incorporates information about expected inflation into its forecasting process.

As you know, the control of inflation is central to good monetary policy. Price stability, which is one leg of the Federal Reserve's dual mandate from the Congress, is a good thing in itself, for reasons that economists understand much better today than they did a few decades ago. Inflation injects noise into the price system, makes long-term financial planning more complex, and interacts in perverse ways with imperfectly indexed tax and accounting rules. In the short-to-medium term, the maintenance of price stability helps avoid the pattern of stop-go monetary policies that were the source of much instability in output and employment in the past. More fundamentally, experience suggests that high and persistent inflation undermines public confidence in the economy and in the management of economic policy generally, with potentially adverse effects on risk-

taking, investment, and other productive activities that are sensitive to the public's assessments of the prospects for future economic stability. In the long term, low inflation promotes growth, efficiency, and stability--which, all else being equal, support maximum sustainable employment, the other leg of the mandate given to the Federal Reserve by the Congress.

Admittedly, measuring the long-term relationship between growth or productivity and inflation is difficult. For example, it may be that low inflation has accompanied good economic performance in part because countries that maintain low inflation tend to pursue other sound economic policies as well. Still, I think we can agree that, at a minimum, the opposite proposition--that inflationary policies promote employment growth in the long run--has been entirely discredited and, indeed, that policies based on this proposition have led to very bad outcomes whenever they have been applied.

**Inflation                      Expectations:                      Conceptual                      Frameworks**  
Undoubtedly, the state of inflation expectations greatly influences actual inflation and thus the central bank's ability to achieve price stability. But what do we mean, precisely, by "the state of inflation expectations"? How should we measure inflation expectations, and how should we use that information for forecasting and controlling inflation? I certainly do not have complete answers to those questions, but I believe that they are of great practical importance. I hope my remarks here will stimulate some of you to work on these issues.

What is the right conceptual framework for thinking about inflation expectations in the current context? The traditional rational-expectations model of inflation and inflation expectations has been a useful workhorse for thinking about issues of credibility and institutional design, but, to my mind, it is less helpful for thinking about economies in which (1) the structure of the economy is constantly evolving in ways that are imperfectly understood by both the public and policymakers and (2) the policymakers' objective function is not fully known by private agents. In particular, together with the assumption that the central bank's objective function is fixed and known to the public, the traditional rational-expectations approach implies that the public has firm knowledge of the long-run equilibrium inflation rate; consequently, their long-run inflation expectations do not vary over time in response to new information.

But in fact, as I will discuss in more detail later, long-run inflation expectations do vary over time. That is, they are not perfectly *anchored* in real economies; moreover, the extent to which they are anchored can change, depending on economic developments and (most important) the current and past conduct of monetary policy. In this context, I use the term "anchored" to mean relatively insensitive to incoming data. So, for example, if the public experiences a spell of inflation higher than their long-run expectation, but their long-run expectation of inflation changes little as a result, then inflation expectations are well anchored. If, on the other hand, the public reacts to a short period of higher-than-expected inflation by marking up their long-run expectation considerably, then expectations are poorly anchored.

Although variations in the extent to which inflation expectations are anchored are not easily handled in a traditional rational-expectations framework, they seem to fit quite naturally into the burgeoning literature on learning in macroeconomics. The premise of this literature is that people do not have full information about the economy or about the objectives of the central bank, but they instead must make statistical inferences about the unknown parameters governing the evolution of the economy. In a learning context, the concept of anchored expectations is easily formalized in a variety of ways; in general, if the public is modeled as being confident in its current estimate of the long-run inflation rate, so that new information has relatively little effect on that estimate, then the essential idea of well-anchored expectations has been captured.

Allowing for learning has important implications for how we think about the economy and policy. For example, some work has shown that the process of learning can affect the dynamics and even the potential stability of the economy (see, of many possible examples, Bullard and Mitra, 2002). Considerations of how the public learns about the economy affect the form of optimal monetary policy (Gaspar, Smets, and Vestin, 2006). Notably, in a world with rational expectations and in which private agents are assumed already to understand all aspects of the economic environment, talking about the effects of central bank communication would not be sensible, whereas models with learning accommodate the analysis of communication-related issues quite well (Orphanides and Williams, 2005; Bernanke, 2004). Macroeconomic models with learning also give content to the idea of an economy moving gradually from one regime to another, particularly if the central bank as well as the public is assumed to be updating its beliefs. For example, if the central bank and the public learn from experience that high inflation imposes greater costs and fewer benefits than previously thought, then the equilibrium will adjust toward one with lower inflation and lower inflation expectations. This line of explanation of how economies move between monetary regimes, which has been explored by Sargent and others, strikes me as quite plausible as a historical description (Sargent, 1999). In sum, many of the most interesting issues in contemporary monetary theory require an analytical framework that involves learning by private agents and possibly the central bank as well.

### **Implications of Anchored Inflation Expectations**

Why do we care about the variability of inflation expectations? As my colleague Rick Mishkin recently discussed, the extent to which inflation expectations are anchored has first-order implications for the performance of inflation and of the economy more generally (Mishkin, 2007). Mishkin illustrated this point by considering the implications of the fact that inflation expectations have become much better anchored over the past thirty years for the estimated coefficients of the conventional Phillips curve, which I define here to encompass specifications that use lagged values of inflation to proxy for expectations or other sources of inflation inertia. As he noted, many studies of the conventional Phillips curve find that the sensitivity of inflation to activity indicators is lower today than in the past (that is, the Phillips curve appears to have become flatter);<sup>1</sup> and that the long-run effect on inflation of "supply shocks," such as changes in the price of oil, also appears to be lower than in the past (Hooker, 2002). These findings are of much more than academic interest. To the extent that the Phillips curve may have

flattened, inflation will now tend to be more stable than in the past in the face of variations in aggregate demand. (Of course, this can be a good thing or a bad thing, depending on whether inflation expectations are anchored in the vicinity of price stability.) Likewise, a lower sensitivity of long-run inflation to supply shocks would imply that such shocks are much less likely to generate economic instability today than they would have been several decades ago. Notably, the sharp increases in energy prices over the past few years have not led either to persistent inflation or to a recession, in contrast (for example) to the U.S. experience of the 1970s.

Various factors might account for these changes in the Phillips curve, but, as Mishkin pointed out, better-anchored inflation expectations--themselves, of course, the product of monetary policies that brought inflation down and have kept it relatively stable--certainly play some role. If people set prices and wages with reference to the rate of inflation they expect in the long run and if inflation expectations respond less than previously to variations in economic activity, then inflation itself will become relatively more insensitive to the level of activity--that is, the conventional Phillips curve will be flatter.

Similar logic explains the finding that inflation is less responsive than it used to be to changes in oil prices and other supply shocks. Certainly, increases in energy prices affect overall inflation in the short run because energy products such as gasoline are part of the consumer's basket and because energy costs loom large in the production of some goods and services. However, a one-off change in energy prices can translate into persistent inflation only if it leads to higher expected inflation and a consequent "wage-price spiral." With inflation expectations well anchored, a one-time increase in energy prices should not lead to a permanent increase in inflation but only to a change in relative prices. A related implication is that, if inflation expectations are well anchored, changes in energy (and food) prices should have relatively little influence on "core" inflation, that is, inflation excluding the prices of food and energy.

Although inflation expectations seem much better anchored today than they were a few decades ago, they appear to remain imperfectly anchored. A number of studies confirm that observation. For example, Gürkaynak, Sack, and Swanson (2005) found that long-run inflation expectations, as measured by the difference in yields between nominal and inflation-indexed bonds, move in response to news about the economy, rather than remaining unaffected. Levin, Natalucci, and Piger (2004) have shown that some survey measures of inflation expectations in the United States respond to recent changes in the actual rate of inflation, which would not be the case if expectations were perfectly anchored. Models of the term structure of interest rates better fit the data under the assumption that both inflation expectations and beliefs about the central bank's reaction function are evolving (Kozicki and Tinsley, 2001; Rudebusch and Wu, 2003; Cogley, 2005).

An indirect but elegant way to make the point that inflation expectations remain imperfectly anchored comes from a statistical analysis of inflation by Stock and Watson (2007). Stock and Watson model inflation as having two components, which may be interpreted as the trend and the cycle. Changes in the trend component are highly

persistent whereas shocks to the cyclical component are temporary.<sup>2</sup> The key finding of this research is that the variability of the trend component of inflation (and thus the share of the overall variability of inflation that it can explain) appears to have fallen significantly after about 1983. That is, unexpected changes in inflation are today much more likely to be transitory than they were before the early 1980s. Because it seems quite unlikely that changes in inflation could persist indefinitely unless long-run expectations of inflation also changed, I interpret the Stock-Watson finding as consistent with the view that inflation expectations have become much more anchored since the early 1980s. At the same time, that the variability of the trend component of inflation, though modest, remains positive, implies that long-run expectations of inflation are not perfectly anchored today.

The policy implications of the much-improved but still imperfect anchoring of inflation expectations are not at all straightforward. To evaluate these implications, we must understand better the historical variation in inflation expectations, the effect of this variation on actual inflation and economic activity, and the relationship between policy actions and the formation of inflation expectations. With the hope of promoting progress on these broad topics, I pose three questions to researchers, the answer to any of which would be quite useful for practical policymaking.

First, how should the central bank best monitor the public's inflation expectations? Theoretical treatments tend to neglect the fact that in practice many measures of inflation expectations exist, including the forecasts of professional economists, results from surveys of consumers, information extracted from financial markets such as the market for inflation-indexed debt, and limited information on firms' pricing plans. In a very interesting paper, Mankiw, Reis, and Wolfers (2003) compared the available measures, emphasizing in particular that median measures of inflation expectations often obscure substantial cross-sectional dispersion of expectations.<sup>3</sup> On which measure or combination of measures should central bankers focus to assess inflation developments and the degree to which expectations are anchored? Do we need new measures of expectations or new surveys? Information on the price expectations of businesses--who are, after all, the price setters in the first instance--as well as information on nominal wage expectations is particularly scarce.

Second, how do changes in various measures of inflation expectations feed through to actual pricing behavior? Promising recent research has looked at price changes at very disaggregated levels for insight into the pricing decision (Bils and Klenow, 2004; Nakamura and Steinsson, 2007). But this research has not yet linked pricing decisions at the microeconomic level to inflation expectations; undertaking that next step would no doubt be difficult but also very valuable. Third, what factors affect the level of inflation expectations and the degree to which they are anchored? Answering this question essentially involves estimating the learning rule followed by the public or various components of the public, although one could consider alternative frameworks like Carroll's (2003) epidemiological model of the propagation of information among private agents. A fuller understanding of the public's learning rules would improve the central bank's capacity to assess its own credibility, to evaluate the

implications of its policy decisions and communications strategy, and perhaps to forecast inflation. Realistically calibrated models with learning would also inform our thinking about policy and the economy.

### **Inflation Forecasting at the Federal Reserve**

I would like to shift gears at this point to tell you a bit about how the Federal Reserve Board staff goes about forecasting inflation. Obviously, this activity provides critical inputs into the making of monetary policy, and as I will discuss, the staff's long-term track record in forecasting inflation is quite good by any reasonable benchmark. I hope that my brief description will stimulate your interest in the complex and challenging problems of real-time macroeconomic forecasting. But, as you will see, the discussion of practical inflation forecasting will bring us back to one theme of my remarks--that our ability to forecast inflation and predict how inflation will respond to policy actions depends very much on our capacity to measure and to understand what determines the public's expectations of inflation.

The Board staff employs a variety of formal models, both structural and purely statistical, in its forecasting efforts. However, the forecasts of inflation (and of other key macroeconomic variables) that are provided to the Federal Open Market Committee are developed through an eclectic process that combines model-based projections, anecdotal and other "extra-model" information, and professional judgment. In short, for all the advances that have been made in modeling and statistical analysis, practical forecasting continues to involve art as well as science.

The forecasting procedures used depend importantly on the forecast horizon. For near-term inflation forecasting--say, for the current quarter and the next--the staff relies most heavily on a disaggregated, bottom-up approach that focuses on estimating and forecasting price behavior for the various categories of goods and services that make up the aggregate price index in question. For example, we know from historical experience that the prices of some types of goods and services tend to be quite volatile, including not only (as is well known) the prices of energy and some types of food but also some "core" prices such as airfares, apparel prices, and hotel rates. The monthly autocorrelations of price changes in these categories tend to be low or even negative. In contrast, changes in inflation rates in some services categories, such as shelter costs, tend to be more persistent. In assessing what price changes in a particular category imply for future price changes in that category, the staff uses not only various forms of time-series analysis but also specialized knowledge about how the various indexes are constructed--for example, whether certain categories are sampled every month in all localities and how seasonal adjustments are performed. In making very near-term price forecasts, the staff also uses diverse information from a variety of sources, such as surveys of prices of gasoline and other important items, news reports about price-change announcements, and anecdotal information from our business contacts. Conceptually, one might think of this effort to distinguish transitory from persistent price changes as a more nuanced way of estimating the underlying inflation trend, analogous to the trend measures provided by more mechanical indicators such as trimmed-mean or weighted-median inflation rates.

An accurate forecast of very near-term inflation is important not only for its own sake but also because it provides a better "jumping-off point" for the longer-term forecast. Because inflation continues to exhibit some inertia, improved near-term forecasts translate into more-accurate longer-term projections as well.

For forecasting horizons beyond a quarter or two, detailed analyses of individual price components become less useful, and thus the staff's emphasis shifts to inflation's fundamental determinants. Food and energy inflation are forecasted separately from the core, using information from futures prices and other sources. However, forecasts of core inflation must take into account the extent to which food and energy costs are passed through to other prices.

To project core inflation at longer-term horizons, the staff consults a range of econometric models. Most of the models used are based on versions of the new Keynesian Phillips curve, which links inflation to inflation expectations, the extent of economic slack, and indicators of supply shocks. Despite the common conceptual framework, the model specifications employed differ considerably in their details, including how lagged inflation enters the equation, how resource utilization is measured, and whether a survey-based measure of inflation expectations is included. In principle, formal econometric tests could determine how much weight should be put on the forecast of each model, but in practice the data do not permit sharp inferences; moreover, estimated forecasting equations may not reflect information about special factors affecting the outlook. Because of these considerations, as I have already noted, the staff's inflation forecasts inevitably reflect a substantial degree of expert judgment and the use of information not captured by the models.

Another reason for the reliance on judgment in the forecasting process is the practical requirement that the forecast for inflation be consistent with the staff's overall view of the economy, including the forecasts for key economic variables such as wages, interest rates, and consumption spending. Achieving this consistency requires a thoughtful understanding of why sectoral forecasts may be at odds and how best to reconcile those differences. Again, in principle, consistency of sectoral forecasts could be ensured by estimating the inflation equation as part of a general equilibrium system. Indeed, considerable progress has been made in recent years, at the Board and elsewhere, in developing dynamic stochastic general equilibrium (DSGE) models detailed enough for policy application. These models have become increasingly useful for policy analysis and for the simulation of alternative scenarios. They are likely to play a more significant role in the forecasting process over time as well, though, like other formal methods, they are unlikely to displace expert judgment.

A potential drawback of the simple Phillips curve model for analyzing and forecasting inflation is that it does not explicitly incorporate the possible influence of labor costs on the inflation process. The Board's large macroeconomic simulation model, known as FRB/US, projects inflation through a system approach that captures the interaction of wage and price determination. Interestingly, however, the system approach does not seem to forecast price inflation as well as single-equation Phillips curve models do. This

weaker performance appears to reflect, at least in part, the shortcomings of the available data on labor compensation. The two principal quarterly indicators of aggregate hourly compensation are the employment cost index (ECI) and nonfarm compensation per hour (CPH). Both are imperfect measures of the labor costs relevant to pricing decisions. For example, the ECI's fixed employment and occupation weights may not reflect changes in the labor market, and the ECI excludes stock options and similar forms of payment. CPH is volatile, perhaps in part because it measures stock options at exercise rather than when granted, and it is subject to substantial revisions. Moreover, these two hourly compensation measures often give contradictory signals. Despite these problems, labor market developments certainly influence how the staff and policymakers view the inflation process and inflation risks, illustrating yet another point in the forecasting process at which judgment must play an important role. In particular, in evaluating labor-market conditions and trends in labor costs, the staff takes note of a wide range of data, anecdotes, and other qualitative information as well as the official data on compensation.

Overall, the Board staff's inflation forecasting has been remarkably good, at least compared with the available alternatives (Romer and Romer, 2000; Sims, 2002). To cite a recent study, Faust and Wright (2007) show that real-time staff forecasts of inflation reliably outperform statistical benchmarks at all horizons and that this advantage is not solely the result of the staff's expertise at estimating near-term inflation rates.

To link this discussion of forecasting to the first portion of my remarks, I turn to the treatment of inflation expectations in staff forecasts. As I noted earlier, while inflation expectations doubtless are crucial determinants of observed inflation, measuring expectations and inferring just how they affect inflation are difficult tasks. A popular shortcut is to include lagged inflation terms in the Phillips curve equation; besides being a convenient means of capturing the inertial component in inflation, the estimated coefficients on lagged inflation almost certainly reflect to some degree the formation of inflation expectations and their influence on the inflation process. However, using lagged inflation as a proxy for inflation expectations has drawbacks, notably its susceptibility to the Lucas critique.<sup>4</sup> The staff consequently analyzes a number of survey measures of inflation expectations. One question in choosing among measures of expectations is whether to focus on measures of short-term inflation expectations (say, twelve months ahead) or of longer-term expectations (five to ten years ahead). Generally, measures of longer-term inflation expectations, such as the five-to-ten-year expected inflation measures from the Michigan/Reuters survey of households and from the Survey of Professional Forecasters, seem to be better gauges of the expectations that influence wage- and price-setting behavior.

The staff also looks at measures derived from comparing yields on nominal and inflation-indexed Treasury securities (the breakeven inflation rate). Measures of inflation compensation derived from the market for inflation-indexed securities are influenced by changes in inflation risk premiums and liquidity premiums, and analyses are constrained by the fact that these markets have been operating in the United States for only a relatively short period. Nevertheless, unlike survey measures, breakeven inflation rates are determined in a market in which investors back their views with real money.



Moreover, breakeven measures of inflation expectations provide information on the expectations of a different group of agents--financial-market participants--which can be compared with the views of economists and consumers as represented by surveys.

Measurement is only one aspect of understanding inflation expectations. We also need a better understanding of how inflation expectations affect actual inflation and of the factors that determine inflation expectations. I will say a few words about the latter issue in the context of the practical problems of forecasting and policy analysis faced by the staff of the Federal Reserve Board.

Model-based simulations of the inflation process are useful tools for both forecasting and policy analysis. In conducting such simulations, the analyst must specify how inflation expectations are formed--in particular, how they react to actual changes in the economy and in policy. In most simulations of the FRB/US model, the public is assumed to update its inflation projections based on the historical relationship between inflation and other key economic variables. Essentially, this approach assumes that the public updates its inflation expectations in a sensible way based on economic developments but does not assume that the public has full knowledge of the underlying model of the economy, consistent with the structure of learning models (Brayton and others, 1997).

Recent staff work at the Board has analyzed the implications of expanding the set of variables allowed to influence the public's long-term inflation expectations to include, among others, the federal funds rate.<sup>5</sup> If the public's long-term inflation expectations are influenced directly by Fed actions, as this specification suggests, a number of interesting implications follow. One is that the output costs of disinflation may be lower than those suggested by reduced-form-type Phillips curves. Intuitively, if the Fed attempts to disinflate by raising the federal funds rate, the disinflationary effect will be felt not only through the usual output gap channel but also through a direct restraint on long-term inflation expectations. This interpretation is consistent with some analyses of the Volcker disinflation; although the costs of that disinflation were high, they were perhaps less than economists would have predicted in advance, given conventional estimates of the sacrifice ratio (Erceg and Levin, 2003).

To be sure, this and similar analyses remain speculative. A good deal more must be done before such work proves a reliable basis for policy choices. Nevertheless, I hope this example illustrates for you the theme of my remarks, that a deeper understanding of the determinants and effects of the public's expectations of inflation could have significant practical payoffs.

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## Footnotes

1. Roberts (2006) provides a recent overview. He attributes most of the "flattening" of the Phillips curve to changes in the conduct of monetary policy. See also Nason (2006). Gordon (2007) provides an opposing view.

2. Stock and Watson assume that transitory shocks last only one quarter. Cogley and Sargent (2007) explore the Stock-Watson specification in more detail, arguing that the transitory component of inflation is best modeled as having somewhat greater persistence.

3. A particularly valuable part of the paper is a case study of the evolution of expectations during the Volcker disinflation of 1979-1982. Histograms of the quarterly range of inflation expectations show only a very gradual adjustment of inflation expectations as the disinflation proceeded, with significant reductions in expectations occurring only in the third year of the disinflation. Moreover, the range of disagreement widened (and even became somewhat bimodal) as individual respondents evidently differed in their willingness to accept the Fed's declared commitment to reducing inflation as being a true break from the past. Capturing this behavior in a formal model would be challenging but worthwhile.

4. The Lucas critique holds that reduced-form empirical relationships estimated on historical data may break down when policies change.

5. In this empirical work, the public's long-run inflation expectations are proxied for by the long-run inflation projections taken from the Survey of Professional Forecasters (Mishkin, 2007).