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The attached paper was prepared by a team of economists in the Division of Research and Statistics headed by David Wilcox and including Douglas Elmendorf, Deborah Lindner, David Reifschneider, John Roberts, Jeremy Rudd, and Robert Tetlow. The authors explore some of the pros and cons surrounding the establishment of a quantitative price objective for monetary policy and some of the key issues that would need to be considered in setting a quantitative objective should that be deemed desirable. Doug Elmendorf and David Wilcox will summarize the findings in a briefing to the Committee at the upcoming meeting.

Considerations Pertaining to the Establishment of a Specific, Numerical, Price-Related Objective for Monetary Policy

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Until the past few years, a broad majority of observers inside and outside the Federal Reserve agreed that inflation was above its long-run optimum rate and should be brought down over time.[1] The ultimate objective of monetary policy in this regard was "price stability"—the state in which the economic decisions of households and businesses are not substantially distorted by inflation-related considerations. Price stability was not identified with a specific numerical reading on a particular published index, but that lack of numerical clarity was not a pressing issue so long as the consensus regarding the preferred next step on inflation continued to hold.

Of late, however, circumstances have changed. In 2003, Chairman Greenspan declared that the long-sought-after objective of price stability had finally been achieved.[2] And in the same year, the FOMC confronted for the first time in recent decades a realistic possibility that inflation might soon fall low enough to adversely affect the performance of the economy. Because of these developments and an evolution in thinking—both within and outside central banks—about the appropriate conduct of monetary policy, some analysts have proposed that the Federal Reserve establish a specific numerical price-related objective in terms of a particular published index. Others have argued that taking such a step might generate greater costs than benefits.

This paper discusses the pros and cons of adopting a specific, numerical, price-related objective, and it examines some issues the Committee would need to consider if it decided to adopt such an objective. We address the following issues in turn: First, what do we mean by a specific, numerical, price-related objective? Second, what benefits and costs might be associated with establishing such an objective? Third, what operational issues would the Committee need to resolve if it adopted such an objective? Finally, how accurately could the Federal Reserve achieve an inflation objective? The aim of this paper is not to resolve these difficult issues but rather to facilitate Committee deliberation by providing the main arguments on each side.

To be clear, we see the question of whether the Committee should or should not adopt an explicit, numerical, price-related objective as distinct from the question of whether it should or should not adopt an inflation-targeting regime. While the required elements of an inflation-targeting regime are not universally agreed upon, they are generally thought to include the preparation of regular monetary policy reports that present explicit forecasts of inflation and real activity and describe steps that the central bank is taking to achieve or maintain the inflation objective. Some, but not all, analysts assert further that an inflation-targeting central bank must also establish the primacy of its price-related objective over its obligation to stabilize real activity. These broader aspects of inflation targeting are not addressed in the paper.

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[2] In testimony before the Joint Economic Committee on May 21, 2003, Chairman Greenspan stated, "Inflation is now sufficiently low that it no longer appears to be much of a factor in the economic calculations of households and businesses."

A. What We Mean by a Specific, Numerical, Price-Related Objective

When we refer to "a specific, numerical, price-related objective," we mean to denote an objective with three key characteristics: It is numerical rather than qualitative; it is defined in reference to a particular published index; and it is defined specifically in reference to either the level of that index or its rate of change. To give meaning to such an objective, the Committee would presumably aim to achieve it on average over some long period of time. An objective of this type need not be written in stone but could be adjusted from time to time.

A premise of the paper is that, in setting such an objective, the Committee would be aiming to minimize the costs of deviations from price stability. In that case, the objective would most naturally be stated in reference to the measure of the price level or inflation rate that is most closely related to such costs. Note that we are thinking of a price *objective* as distinct from a price *indicator*. An indicator is a measure of price or inflation that provides a reliable gauge of underlying price trends and pressures. (More broadly, one might think of an indicator as any variable that helps to predict future inflation; under this view, measures of resource utilization, productivity growth, commodity prices, and so on would qualify as price indicators.) Thus, if movements in food and energy prices affect economic welfare, the overall PCE price index might be the most appropriate price *objective* even if the core PCE price index or market-based core PCE price index are better real-time *indicators* of underlying inflation trends in the short run.

As we discuss below, the choice of an overall (and hence more volatile) measure implies that the focal index will fall within a band of given width somewhat less frequently. A central bank can address that circumstance by a number of means, including choosing a wider band for the objective, and communicating to the public that the focal variable will fall within the stated range a smaller fraction of the time. In this and other important ways, specification of a numerical, price-related objective would pose important challenges for the Federal Reserve pertaining to its communications with both the general public and the Congress; Vincent Reinhart will discuss these challenges in his briefing.

Most aspects of the current policy process could remain unchanged if the Committee chose to establish a numerical, price-related objective. In particular, the staff would continue to analyze the same wide range of indicators in making projections for various measures of inflation and real economic activity, and the Committee could continue to use this broad set of information in determining the appropriate setting of the federal funds rate.

Furthermore, establishing a specific price objective would not be inconsistent with actual values of the price level or inflation rate deviating from the chosen objective. Prices are continually buffeted by a variety of disturbances, and, given the substantial lags in the monetary transmission mechanism, the Committee has only limited ability to offset these shocks even over a period as long as two or three years. Moreover, the Committee might not be particularly concerned about short-run deviations from its objective, either because the forces driving these deviations are transitory or because concerns about real activity

are deemed more pressing. Thus, if the FOMC were to adopt a numerical objective, the success of the new policy would not depend on always keeping the actual inflation rate or price level close to the objective, or even always within a specified range about the objective. Instead, success could be judged by average performance over the medium to long run, and by the credibility of the explanations for such deviations as do occur.

In setting a price-related objective, the Committee might prefer to focus on the level of a particular index or on its rate of change. Operationally, the difference between these two approaches pertains to the treatment of deviations in the goal variable from the objective. Under inflation control, errors in the price level are ignored and the sole concern is with the rate of inflation going forward. To borrow a phrase from the old money-control literature, "base drift" is allowed in the price level. Under price-level control, any error in the price level is eventually offset and the actual price level is brought back in line with the stated objective. In other words, base drift is not allowed. An important note is that when we refer to "price-level control," we mean to encompass not only regimes involving a flat trajectory for prices but also ones involving an upward-sloping trajectory.[3]

B. The Potential Benefits and Costs of Adopting a Specific Price-Related Objective

Given that inflation is low, any costs that the U.S. economy may currently be sustaining because of deviations from price stability are surely small. However, advocates of establishing a specific, numerical, price-related objective perceive a risk of backsliding on the part of some future FOMC in terms of inflation performance and even see some opportunity for improving a current situation that they concede to be good. Skeptics, on the other hand, question the wisdom of meddling with what has been a successful policy and see some potential for material harm from doing so. In this section, we summarize first the possible benefits of setting an explicit objective and then the possible costs. We conclude with a brief consideration of the empirical evidence on this issue.

Potential Benefits

Adopting an explicit price-related objective might prove beneficial to the policymaking process, macroeconomic performance, and public welfare more generally for four main reasons.

First, publicly announcing a numerical objective might help preserve the present commitment to price stability. A Committee that allowed inflation, for example, to drift persistently away from an announced objective could face more public pressure to rectify the situation than a Committee that had been less specific about its long-run goals. By restraining the FOMC's discretion in this way, a publicly announced numerical objective

[3] In theoretical models, an upward-sloping trajectory for the price level can insulate the central bank from much of the risk associated with the zero lower bound.

could reduce the risk that future policy errors would undermine the hard-won gains in price stability achieved since the late 1970s. If so, the benefit to society would be great: As discussed in detail later, inflation hurts households and firms by making long-range planning more difficult, by creating distortions related to the tax code, and by sowing confusion between nominal and real quantities (among other costs).

Second, announcing an explicit objective could induce beneficial changes in the way that private agents form their expectations. For example, if the Committee committed itself to a numerical long-run goal for inflation and if the public accepted that commitment as fully credible, then public expectations of long-run inflation could become less sensitive to changes in economic conditions. Such a shift in expectations formation would, in principle, reduce the volatility of actual inflation through its effect on price setting. In addition, output volatility might fall because monetary policy would have greater scope to stabilize real activity if inflation expectations were more firmly anchored. That is, policymakers could adopt a more expansionary policy in response to adverse shocks to real output if they did not need to worry that such an action might be misinterpreted as signaling a weakened commitment by the Federal Reserve to price stability in the long run. Finally, better-anchored expectations could lead to lower risk premiums on bonds and less uncertainty about longer-run developments. Overall, the firmer anchoring of expectations may be the most consequential benefit, but it is also the most speculative.

Third, the Committee might be able to use an announced price objective to improve public understanding about monetary policy. For example, the public might have an easier time understanding the logic underlying movements in the funds rate if it had a better grasp of the FOMC's long-run goals. Admittedly, not all increases in transparency are beneficial because some details of the policy process are sufficiently complicated that their release would serve only to create confusion. But because the concept of price stability is so frequently used, providing the public with a more precise definition would arguably not have this effect. Instead, it could be viewed as just another step toward eliminating the mystery of monetary policymaking.[4]

Fourth, benefits might accrue from improvements to the Committee's deliberations. For example, such an action could sharpen the internal policy debate by taking at least one issue off the table. In the absence of a common definition of price stability, disagreements over the current stance of monetary policy may arise because of different opinions about the desired long-run rate of inflation. But if Committee members could reach a common understanding on this issue, then the policy debate could focus on other sources of disagreement, such as the outlook.

Potential Costs

We identify four potential pitfalls associated with adopting an explicit price-related objective.

[4] Announcing an explicit objective might also improve the accountability of the Federal Reserve to the Congress and the nation at large. We note this possibility here but do not analyze it further. Vincent Reinhart will address issues related to the governance of monetary policy in his briefing.

First, if the Committee formulated and publicly discussed a price objective—but not an output or unemployment objective—the Fed might be perceived as unduly emphasizing one component of its dual mandate. Assuming no actual change in the relative emphasis placed by the Committee on stabilizing output and prices, such a perception would mean that setting an explicit objective had reduced public understanding of monetary policy, not improved it. Specifying a price objective in terms of one particular price index might also give rise to the impression that the FOMC no longer monitored a wide range of price indicators, when in fact it would continue to do so.

Second, adopting a specific objective for prices but not for activity could cause the Committee to alter its behavior, even if only subtly, in ways that could de-emphasize output stabilization over time. Under the assumption that the public is happy with the relative emphasis placed by current policy on the two legs of the dual mandate, such a development would diminish economic welfare. In principle, the Committee could try to minimize this risk by also being more specific about its goals as regards resource utilization. But the latter step would be much more controversial than setting an explicit price-related objective given the practical difficulties in measuring potential output and economic slack.

Third, given the inherent variability of inflation, announcing a formal numerical objective could reduce the FOMC's credibility when actual inflation differed from the stated point objective or fell outside the stated range for "too long." Although the Committee could attempt to minimize this problem by emphasizing the probabilistic nature of a range, successfully communicating this idea to the public could be a challenge. It might also require a substantial increase in the resources devoted to public discussion, as deviations of inflation from the objective would need to be explained, perhaps in some detail.

Fourth, any commitment to a specific numerical objective might, in some circumstances, constrain future actions of the Federal Reserve in an unhelpful manner. For example, setting an explicit objective might make offsetting the contractionary output effects of a permanent oil shock more difficult because the Committee might face more pressure than it does now to respond to the initial transitory jump in inflation. Setting a specific objective might also make it difficult for the Committee to change its thinking on the proper definition of price stability after, for example, a reassessment of price measurement bias or the threat posed by the zero lower bound. Thus, any potential benefits from restrictions on Federal Reserve policy would need to be balanced against potential costs.

Empirical Evidence

Evidence on many of the costs and benefits just discussed is scarce and, in some cases, non-existent. For example, we know of no evidence bearing on the risk of a future Committee's reducing its commitment to low inflation. Similarly, institutional differences among central banks make the foreign experience with inflation targeting extremely difficult to apply to the question of whether the FOMC's internal deliberations would be facilitated or distorted by an explicit price objective.

The situation with regard to evidence about the communication-related costs and benefits of an announced objective is not much better. Although Kohn and Sack (2003), Connolly and Kohler (2004), and Gurkaynak, Sack and Swanson (2003) have shown that central bank talk can influence investor beliefs, this result is not equivalent to showing that such talk has improved public understanding. Moreover, we are not aware of any formal analysis of the efficacy of the communication strategies of the inflation-targeting central banks. That said, our reading of the anecdotal evidence from abroad (summarized in the report by the Division of International Finance) is that any miscommunication problems associated with an explicit price objective cannot have been great, as no inflation-targeting central bank has as yet abandoned the strategy. Moreover, the tendency of these institutions has been to increase the amount of information disseminated to the public over time, not diminish it.

Empirical evidence is also limited on whether the adoption of an explicit price-related objective would improve U.S. macroeconomic performance. What evidence does exist comes in three main varieties: evidence from the international experience, evidence from recent U.S. history, and evidence from model simulations.

One difficulty of applying the international evidence is that it uses the experience of countries that have adopted full-fledged inflation-targeting regimes to make inferences about the merits of the more limited step of establishing a numerical objective. In addition, the international evidence is based on central banks that generally adopted specific price objectives before they had achieved price stability, while effective price stability has already been attained in the United States. For both of these reasons, the adoption of a specific objective for U.S. monetary policy would constitute a less dramatic innovation than the adoption of inflation-targeting in other countries, suggesting that any benefits or costs associated with the announcement of an objective would be more moderate here. Furthermore, these policies have been in place in many foreign countries for only a short period of time—less than a decade on average—making it statistically difficult to detect any change in performance.

In spite of these limitations, the international evidence is suggestive of the effects that might occur in the United States, and thus useful to consider. As documented more fully in the background paper from the IF division, explicit price-stability objectives have led to increased stability in long-term inflation expectations and less persistence in inflation. For example, some measures of long-run inflation expectations derived from financial-markets appear more firmly anchored in the developed inflation-targeting countries than in the United States. On the other hand, survey-based expectations measures have been

remarkably stable in the United States of late. On balance, the evidence only hints at the possibility of expectational gains if the FOMC adopted an explicit price-related objective. Moreover, while inflation expectations may behave somewhat better in inflation-targeting countries, all else equal, we have no clear evidence that the adoption of inflation targeting abroad has either improved or degraded the macroeconomic performance of these countries.

Recent U.S. history cannot provide direct evidence on the effect of adopting a specific, numerical price objective. However, it can shed light on whether expectations formation—and macroeconomic dynamics more generally—respond to a monetary policy regime. Most researchers have found that, since the late 1970s, the United States has seen a marked reduction in the volatility of GDP growth and inflation as well as an apparent decrease in the sensitivity of inflation to real activity—all developments that plausibly could be related to the improved conduct of monetary policy during that time. Some authors have gone further and looked for statistical evidence that the improved conduct of monetary policy was actually responsible for the changes. Clarida, Gali, and Gertler (2000), Roberts (2004), and Boivin and Giannoni (forthcoming) find such evidence, but Ahmed, Levin, and Wilson (2002), Stock and Watson (2002), and others conclude that the improvement in U.S. economic performance over this period was the result not of monetary policy but of other factors. Thus, the evidence on this point is inconclusive.

In such circumstances of limited data, model simulations can be useful in gauging the possible consequences of permanent changes in monetary policy. Simulations of the FRB/US model indicate that the volatility of both output and inflation would decline appreciably if long-run inflation expectations became more firmly anchored (see section D of this report). However, whether the announcement of an explicit price-related objective would in fact more firmly anchor expectations is an open question, as noted above. Moreover, even if we were confident that such an announcement would lead to more-stable long-run expectations, one could not be sure that macroeconomic performance would improve to the degree predicted by FRB/US: While some models (particularly ones using rational expectations) yield similar results, others predict little or no improvement.

C. Operational Issues Related to Specifying a Numerical Price-Related Objective

If the FOMC opted for specifying a price-related objective, it would have to resolve which index to use to define the objective and whether the objective should be specified in terms of the level of the chosen index or its rate of change (the inflation rate). If the Committee chose to establish an objective in terms of an inflation rate, it would also need to specify what average rate it wished to achieve and whether the objective should be stated as a point or a range.

Choice of Index

We consider three broad types of considerations bearing on the choice of a focal index: theoretical, practical, and empirical.

Theoretical Considerations

Economists have identified many sources of cost associated with deviations from price stability. Each source points to a particular broad class of price indexes as the most logical focus of central-bank attention. We identify here several of the broad classes that are implicated by these arguments.

Consumer prices. Some researchers have postulated that economic agents cannot distinguish accurately between real and nominal magnitudes—that is, they suffer from "money illusion."[5] Problems of money illusion plausibly are more acute for households than for other economic decisionmaking units because households must be generalists in decisionmaking and face many decisions only once or infrequently and on a small scale, whereas all but the smallest firms and government units can afford to foster some specialization in financial decisionmaking and often face the same decisions repeatedly. On this rationale, a price-related objective might best be specified in terms of an index of consumer prices.

Official indexes of consumer prices, however, may not correspond exactly to the collection of prices that affect household decisions. The consumer price index (CPI) generally measures only households' out-of-pocket costs.[6] The PCE price index reflects a broader view of consumption, adding items (such as banking services) for which prices must be imputed, items paid for by employers (such as health care funded through employer-sponsored insurance), and items paid for by the government (such as health care provided through Medicare). The prices that are imputed presumably enter into household decisions, even if not precisely in the way that is implicit in the methodology of the statistical agencies. The prices of items financed by employers probably enter as well because changes in those prices are typically reflected in offsetting changes in compensation over several years (albeit not on a year-to-year basis). But whether the prices of government-financed consumption should be included in the chosen index is less clear. If households "pierce the government veil," then an index with even broader scope than the PCE price index might be desirable because consumers would, in their decisionmaking, be taking account of the prices not only of government-financed health care but also of other types of government-financed consumption, such as public education, national parks, and fire-fighting services, that are not part of PCE. If households instead focus on their direct expenses, perhaps because governments can shift financing burdens to other generations, then a price index with a scope narrower than PCE would be preferable. On balance, the scope of the PCE price index may represent a reasonable compromise between these alternatives.

[5] The phrase "money illusion" appears to come from Keynes, but the most thorough early treatment can be found in Fisher (1928). Shafir, Diamond, and Tversky (1997) present a theory of the psychological factors that may contribute to money illusion and evidence of its effects on the economy.

[6] A notable exception is the CPI's inclusion of owners' equivalent rent, an imputed price that also appears in the PCE price index.

Production prices. Inflation (and especially variability in inflation) can create confusion about relative prices—in particular, about whether an observed change in a relative price reflects a change in the scarcity of the item in question or is purely a transitory consequence of generally rising prices combined with asynchronized adjustment of prices.[7] To avoid the mistaken decisions that might be made by producers in response to such confusion, the Federal Reserve could focus on anchoring a broad index of production prices. In principle, a very broad collection of prices—including those of intermediate goods and raw materials—might be relevant in this context. In practice, however, a reasonable choice for an index might be the GDP price index.

Transaction prices. If the distortions mentioned above are even more pervasive, the Committee could consider focusing on an even broader index of prices—one that, as noted by Lebow and others (1997, p. 9), encompasses the prices of "intermediate inputs, assets, used goods, and labor—that is, an index of 'transactions prices,' which includes prices of all items exchanged in any economic transaction." At present, no official index answers to this description, so if the Committee were inclined toward this point of view, it might choose to focus on the broadest index currently available, the GDP price index.[8]

Expected inflation as reflected in nominal interest rates. One reason—emphasized by Feldstein (1997, 1999)—for focusing on the measure of expected inflation embedded in nominal interest rates is to minimize the distortions induced by the many aspects of the U.S. tax code that are not fully indexed to inflation. For example, depreciation allowances are fixed in nominal terms and can be claimed only over the tax life of the associated investment asset; accordingly, an increase in expected inflation diminishes the present-discounted value of these allowances, raises the cost of capital, and thus discourages saving and investment.

Another reason for focusing on expected inflation as reflected in nominal interest rates is to minimize the arbitrary redistributions of wealth that occur when nominal interest rates

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[7] Lucas (1972) introduced a now-classic model in which relative price confusion stemming from incomplete information about real disturbances led monetary shocks to induce inefficient fluctuations in output. The effects of inflationary disturbances on relative prices in "sticky price" models are also the key factor driving inefficient economic fluctuations in the literature on New-Keynesian economics; a thorough introduction can be found in Woodford (2003).

[8] Regarding the role of asset prices, some analysts have argued that central banks should aim to stabilize the prices of both current and future consumption. They have further argued that, although prices of future consumption are not directly available, current asset prices may be a useful proxy and thus should be included in any index that becomes an explicit focus of Federal Reserve policy (see Alchian and Klein, 1973; Bryan, Cecchetti, and O'Sullivan, 2001; and Goodhart, 2001). Moreover, many of these authors have suggested that monetary policy should respond directly to asset prices if a central bank perceives the emergence of a market "bubble" in order to limit the consequences of its eventual bursting. However, other researchers (see Bernanke and Gertler, 1999 and 2001) have argued that conventional monetary policies that stabilize current prices also serve to stabilize future prices. Furthermore, they have argued that the effect of monetary policy on bubbles is too uncertain, and the difficulties of identifying such bubbles (except in hindsight) is too great, to make a direct response practical. Instead, these researchers have suggested that a central bank should respond *indirectly* to asset prices to the degree that they predict undesired movements in future output and inflation. We find the latter arguments persuasive.

change in unanticipated ways. Although these redistributions are neutral for the economy as a whole, their capriciousness probably has social costs. No published measure adequately captures expected inflation that is implicit in nominal interest rates. As Lebow and others (1997, pp. 5-6) noted, "through the interaction of millions of borrowers and lenders in capital markets, interest rates probably come to embody expectations about an extremely broad range of prices (albeit with an unclear set of weights)."

A weighted average of prices with weights determined by relative stickiness. Finally, some theories suggest that it is often (nearly) optimal to anchor a weighted average of sectoral inflation rates, with—all else being equal—a larger weight assigned to sectors with "stickier" prices."[9] In these models, inflation's welfare cost stems from the presence of nominal rigidities, which prevent agents from setting prices at their optimal levels in every period. The distortionary effect of inflation is greater in sectors in which prices are stickier, so an optimal monetary policy will place more emphasis on anchoring the inflation rate in these sectors. Similarly, when prices *and wages* are sticky, the near-optimum policy will involve anchoring a weighted average of price and wage inflation, with a larger weight being placed on the measure that exhibits relatively more nominal rigidity.[10]

Practical Considerations

Besides the theoretical arguments discussed above, some practical considerations could influence the choice of a focal price index. The key issues are the following:

Quality of price measurement. Not surprisingly, the prices of goods and services that are traded in markets are easier to measure than the prices of nonmarket items. Indeed, defining the price of something not sold in a market raises difficult conceptual and practical issues for the statistical agencies. For example, the prices of many services produced by the government are defined to equal the cost of the inputs (on the implicit assumption of no productivity change over time). In other sectors, observed prices may not provide an accurate reading of true prices. For example, transactions prices for residential and nonresidential structures often include the price of land as well as the construction itself, and statistical agencies' ability to separate the two aspects of the transaction is highly imperfect. Accordingly, indexes—like the CPI or the market-based component of PCE prices—that primarily reflect market transactions in the items being priced probably provide a better measure of the prices they are intended to capture than do indexes—like GDP prices and, to a lesser extent, PCE prices—that place substantial weight on nonmarket transactions or other difficult-to-measure prices.[11]

[9] See Woodford (2003), chapter 6, for an overview of these theories.

[10] The notion that wages should receive substantial weight in the price objective has important antecedents in Phelps (1978) and in the nominal-income targeting literature—including Meade (1978), Tobin (1980), and Okun (1981)—where it was often noted that a stable wage share implies that targeting wages and nominal income are similar. In addition, the stickiness of wages and prices is the major factor making inflation costly in most of the new-Keynesian literature, as discussed in Goodfriend and King (2001), Woodford (2003), and Erceg, Henderson, and Levin (2000).

[11] As noted earlier, owners' equivalent rent is an imputed transaction and yet is included in the CPI.

Familiarity. The public is more familiar with broad measures of consumer prices—especially the consumer price index—than with other price measures. Specifying the policy objective in terms of a familiar index would likely ease the task of explaining monetary policy to the Congress and the general public. This consideration may be of greatest concern in the earliest phase of a new policy regime; if some other index became the object of policy focus, it would undoubtedly become more familiar over time.

Empirical Considerations

A particularly convenient circumstance would be if a central bank could anchor many inflation rates and price indexes simultaneously. In this case, the choice of a single index as the focus of monetary policy would be of much less consequence. But can a central bank, in fact, anchor more than one price index or inflation rate at a time? If not, how far afield could nonfocal inflation rates or price indexes wander? Historical experience and statistical analysis support the following conclusions regarding the long-term co-movement of inflation rates and price indexes (for details of the analysis and results, see the appendix):

- Inflation rates of the broad price measures (CPI, PCE, and GDP) tend to move together over the long run, although average rates of inflation can differ—reflecting differences in the mix of goods and services in the indexes as well as differences in measurement bias—and spreads between inflation rates can be fairly sizable in the short run even when average rates are similar. Thus, if the Committee focused on an inflation rate, the choice of a particular measure of inflation probably would not matter greatly in the long run, as defining an objective for one broad measure would likely anchor the other measures as well.

- Levels of broad indexes show no tendency to move together in the long run. However, this result may not be especially important from a policy perspective. Although most of the price indexes have diverged over the post-World War II period, some have not drifted far. Furthermore, uncertainty about the future values of alternative price indexes may be small over time periods relevant for many planning purposes.[12]

Summary

We interpret the relevant theory, practical arguments, and empirical evidence as suggesting that a specific, numerical, price-related objective, if established, should be framed with reference to consumer prices: Because households can afford to invest little in financial expertise, the most serious costs of deviation from price stability plausibly arise from that sector. On the practical front, indexes of consumer prices are probably the best measured and the most familiar to the public. And the historical behavior of the broad price aggregates suggests that, if the Committee specified an objective in terms of consumer price *inflation*, other broad measures of inflation would be anchored as well.

[12] The estimated uncertainty surrounding the forecasts of CPI or GDP price levels when another broad price index is stabilized is considerably lower than the historical forecast errors estimated for those broad price indexes (Lebow, Roberts, and Stockton, 1992).

Moreover, even if the Committee specified an objective in terms of the *level* of a consumer price index, the levels of other leading broad price indexes would be reasonably tightly—even if not perfectly—contained.

Price Level or Inflation Rate

A number of theoretical arguments reviewed earlier point to price-level control rather than to inflation-rate control as the appropriate focus for monetary policy. For example, if an important source of the cost of deviations from price stability is an inability on the part of households to distinguish accurately between real and nominal amounts, then the optimal monetary policy objective may be to ensure that the purchasing power of a nominal dollar remains reasonably constant over time. Such an outcome would help even relatively unsophisticated households to gauge more readily how much they need to save for a financially secure retirement. For a second example, another cost of deviations from price stability occurs because virtually all debt contracts are written in nominal terms. As a result, unexpected deviations from price stability cause arbitrary redistributions of wealth. The magnitude of such redistributions would be reduced, however, if all relevant parties understood that price surprises in either direction would be reversed reasonably expeditiously.[13]

Moreover, some recent research makes a strong case for price-level control. Work by Svensson (1999) and Wolman (forthcoming), among others, suggests that adjusting the funds rate in response to undesired movements in output, inflation, *and* the price level might enable a central bank to reduce the volatility of both inflation and real activity relative to that achieved by a policy that focuses on output and inflation alone. This result arises in the models used in this analysis because inflation today is assumed to depend on expected future inflation and because inflation expectations are assumed to respond in a rational way to the central bank's determination to control the price level. Under these assumptions and presuming that the central bank is engaged in price-level control, an inflationary shock is expected to be followed by a period of below-trend inflation, which in turn prevents current inflation from rising as much as it otherwise might. Simulations of the FRB/US model confirm these results when expectations are formed in a fully rational, model-consistent manner.

However, the simulation results seeming to show the macroeconomic stabilization benefits of a price-level objective are not robust in that they depend crucially on the assumption of forward-looking (and model-consistent) expectations. As demonstrated by Batini and Yates (2003), if expectations are instead formed in a more backward-looking manner, then output and inflation volatility may be dramatically *worse* under a price-level objective than under an inflation objective. In models with backward-looking expectations that are fit to the U.S. experience over the past thirty or forty years, returning to a target price level is associated with a prolonged output gap without any benefits in the form of a smaller initial movement in inflation. Again, these results are

[13] If price surprises are reversed, a shock that is inflationary in the short run will cause forward interest rates to decline, reducing the upward move in long-term rates.

confirmed by FRB/US simulations when expectations, instead of being fully model-consistent, are formed using a small-scale VAR model.

In addition, some of the theoretical arguments discussed earlier do point to inflation control rather than price-level control. For example, Feldstein's work on tax-induced distortions underscores the importance of aiming for low inflation, but it does not suggest that the central bank should do other than "let bygones be bygones" in the wake of an inflation surprise in either direction. A similar conclusion is implied by the line of reasoning regarding confusion about whether an observed change in relative price reflects a change in scarcity or is a transitory consequence of asynchronous increases in all prices. This reasoning suggests the desirability of zero inflation going forward rather than any particular response to past fluctuations in the price level.

There are other arguments against price-level targeting as well. Most price indexes undergo routine revisions (the not-seasonally-adjusted version of the CPI being the exception to the rule). A central bank engaged in inflation control could let level shifts in a price index pass through without consequence for the policy stance, but a central bank engaged in price-level control would be forced to respond. One might argue that the welfare analysis underpinning price-level control would warrant—even demand—such a response, but whether the public would agree is an open question.

Also, the welfare gain to price-level control (as opposed to inflation control) might be quite small. Much of the uncertainty that an individual household faces in its personal financial planning stems from uncertainty about the relative prices that are most relevant to that household—for example, college tuition, if the household includes children, or pharmaceuticals, if the household includes elderly persons. Pinning down the future value of an aggregate series may therefore do relatively little to reduce the uncertainty about the future price of the particular consumption bundle each household purchases. Finally, we note that no other central bank claims to be engaged in price-level control.

In sum, we read the evidence as suggesting that, if a price-related objective is to be set, it should be set in terms of inflation control rather than price-level control. And, even if the Committee had as its long-term aim a policy of price-level control, it might wish to begin with inflation control and move to price-level control later.

If an Inflation Goal, at What Value?

If the Committee decides to set an inflation objective, it will need to choose the numerical value of the objective.[14] We build our analysis in steps, beginning with measurement error, then discussing considerations that argue for aiming to achieve zero true inflation, and finally turning to arguments for positive true inflation.

[14] If the Committee decides to set a price-level target, it will need to choose the rate at which the target will drift up over time. The issues raised in this section would be relevant for that decision as well.

Estimates of Measurement Bias

To this point, the discussion has implicitly assumed that published measures of prices and inflation are unbiased. However, a large literature documents that published inflation rates are biased upward considerably, suggesting that a central bank aiming for zero true inflation will need to aim for positive reported inflation. The Board's staff estimates that the CPI currently overstates changes in the cost of living 0.9 percentage point per year, with a subjective 90 percent confidence interval ranging from 0.3 percentage point on the low side to 1.4 percentage points on the high side.[15] Other commonly used price indexes are less biased than the CPI owing to the use of superlative aggregation formulas and better weights. The chained CPI (which uses Tornquist aggregation to capture shifts in spending patterns following relative price changes) is biased upward an estimated 0.6 percentage point per year, while estimated bias in the PCE price index (which uses more-accurate spending weights and Fisher aggregation to capture shifting spending patterns) is about 0.5 percentage point; this latter measurement error feeds directly into the GDP price index. With far less information to go on than in the consumer area, the Board staff assumes that mismeasurement of prices for investment, government, and net exports contributes ¼ percentage point to bias in GDP prices, bringing the overall bias in the GDP price index to an estimated 0.6 percentage point per year.

Arguments for Zero True Inflation

Four main considerations argue for aiming at zero true (bias-adjusted) inflation.

Money illusion. To the extent that inflation imposes costs because of money illusion, the optimal inflation objective would be zero: With inflation averaging zero, over time, consumers would have much less need to distinguish between real and nominal magnitudes.[16]

Relative-price confusion. The costs of inflation associated with confusion about relative prices would be minimized with a stable inflation rate and especially an inflation rate of zero. Stable inflation would be predictable, which would allow economic agents to adjust observed prices of individual items for overall inflation; zero inflation would eliminate the need for such adjustments.

Imperfect indexation of the tax code. Inflation imposes costs by raising the effective tax rate on capital, thereby discouraging saving and investment. Those costs would be lower, and economic welfare would be higher, with an inflation objective of zero than with any positive inflation objective.[17]

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[15] See Lebow and Rudd (2003) for a comprehensive examination of measurement error in the CPI (which, besides being one of the most visible price indexes, serves as an important input to other measures of price change).

[16] This conclusion holds even under the assumption that the Committee has chosen to engage in inflation control rather than price-level control, and thereby has allowed the level of prices to drift. Such drift would likely generate some confusion about real and nominal quantities; aiming for an inflation rate above zero, however, would lead to positive average drift and thus exacerbate any confusion.

[17] Feldstein (1999) estimated that cutting inflation as measured by the CPI from 4 percent to 2 percent would raise individuals' economic welfare about 1 percent of GDP each year. Of course, as Feldstein recognized, quantitative estimates of this sort depend on a variety of assumptions about individual

Wealth redistributions. To minimize arbitrary redistributions of wealth owing to changes in nominal interest rates, the inflation rate should be predictable. As a practical matter, greater predictability probably requires greater stability of inflation. Such stability seems most likely when inflation is as low as possible; for example, the level and variability of inflation are positively correlated across countries and over time in this country.[18]

Arguments for Positive True Inflation

Two main considerations argue for aiming for positive true (bias-adjusted) inflation.[19]

The zero lower bound on nominal interest rates. Aiming for a very low inflation rate may undercut the Federal Reserve's ability to stabilize resource utilization. In particular, very low inflation might reduce the equilibrium nominal interest rate—the equilibrium real rate plus the expected inflation rate—to a level that would limit the Federal Reserve's scope for cutting interest rates as much as it would prefer under some circumstances. Indeed, in 2003, with inflation close to 1 percent and the funds rate at 1 percent, some observers were concerned that the Federal Reserve would not be able to counteract effectively an additional adverse demand shock.

The quantitative implications of the zero bound depend on the responsiveness of output and inflation to changes in the real funds rate, the magnitude and persistence of economic shocks, the equilibrium real interest rate, and the conduct of monetary policy. Table 1 presents some illustrative estimates based on simulations of the FRB/US model similar to those developed by Reifschneider and Williams in a 2000 paper and 2002 presentation to the Committee.[20] If monetary policy follows the Taylor rule as originally specified (that is, with coefficients of ½ on both the output gap and the gap between actual and target inflation) and the bias-adjusted inflation objective is 3 percent, then the funds rate equals zero just 2 percent of the time, assuming that the disturbances hitting the economy are

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behavior, about the effective marginal tax rate on capital income, and about changes in pre-tax rates of return in response to a permanent decline in inflation. Feldstein noted that his logic would imply that the optimal inflation rate is negative, but he argued that such a policy would have other costs and is not a realistic option.

[18] A considerable literature documents a positive relationship between the level and the variance of inflation. Classic examples include Okun (1971) and Taylor (1981), who used international cross-sectional comparisons. More recently, Kiley (2000, 2004) reported a similar correlation across and within the G7 countries and a larger sample of countries.

[19] We are aware of only two arguments in favor of aiming for deflation: Feldstein's tax-based argument, and Friedman's "shoe-leather" argument. As was noted earlier, Feldstein himself dismissed the deflationary implication of his theory as unrealistic. Fischer (1981) judged the shoe-leather argument to be not very important quantitatively. Accordingly, we confine our attention in the text to rationales for zero or positive inflation objectives.

[20] The current results differ from the original Reifschneider-Williams estimates partly because of changes that have been made to the specification of FRB/US since 2002. The results also differ by allowing for errors in the measurement of potential GDP and thus in the output gap The errors are calibrated to have the same variance and persistence as those made by Board staff in estimating the output gap in real time between 1980 and the mid-1990s (see Orphanides and others, 2000). As with the earlier analysis, the estimates here assume that the medium-run equilibrium real funds rate is 2½ percent when measured using PCE prices.

Table 1
The Effect of the Zero Lower Bound on Economic Performance: Alternative Target Inflation Rates and Policy Rules

Policy rule and measure of economic performance	Target PCE inflation rate (measured inflation rate, with bias-adjusted rate in parentheses)			
	½ (0)	1½ (1)	2½ (2)	3½ (3)
Original Taylor rule[1]				
Fraction of time with funds rate at zero	.10	.05	.02	.02
Standard deviation of output gap	2.74	2.59	2.50	2.49
Standard deviation of unemployment rate	1.52	1.43	1.38	1.37
Updated Taylor rule[1]				
Fraction of time with funds rate at zero	.16	.10	.06	.04
Standard deviation of output gap	2.53	2.31	2.21	2.13
Standard deviation of unemployment rate	1.40	1.27	1.22	1.17

1. Both Taylor rules take the form $r(t) = r^* + \pi(t) + \alpha [\pi(t) - \pi^*] + \beta x(t)$, where r is the nominal funds rate, r^* is the equilibrium real rate, π is the four-quarter average rate of PCE inflation, π^* is the target rate of inflation, and x is the output gap. For the original Taylor rule, $\alpha = 0.5$ and $\beta = 0.5$. For the updated Taylor rule, $\alpha = 0.5$ and $\beta = 1.0$.

similar to those experienced over the past 35 years. As the inflation objective is reduced, the fraction of the time that the funds rate equals zero rises at an increasing rate, reaching 10 percent for an inflation objective of zero. The increasingly binding constraint on the funds rate causes a deterioration in economic performance. As the bias-adjusted inflation objective falls from 3 percent to zero, the standard deviation of the output gap rises from 2.5 percentage points to 2.7 percentage points.[21]

Simulations also suggest that the threat from the zero lower bound can be reduced if monetary policy responds more aggressively to movements in the output gap than it would under the original Taylor rule. If, for example, the coefficient on the output gap equals 1.0—closer to the responsiveness of the funds rate to output movements observed since the late 1980s—rather than the 0.5 of the original Taylor rule, a decline in the inflation objective from 3 percent to zero raises the standard deviation of the output gap from 2.1 percentage points to 2.5 percentage points. Thus, the updated, more aggressive Taylor rule makes real output less volatile than the original Taylor rule for any given target inflation rate, and it reduces the extent to which output volatility increases as the target inflation rate falls. Even with the updated rule, however, a lower inflation objective implies that the funds rate will be pinned at zero a higher percentage of the time and that real output will be more volatile.

[21] By comparison, the standard deviation of the historical output gap from 1968 to 2004 was 2.8 percent; over the past twenty years the comparable figure is 1.7 percent.

Economists have also proposed some "unorthodox" policy solutions for situations in which the funds rate is stuck against the zero lower bound. For example, Krugman (1998), Reifschneider and Williams (2000), and Eggertsson and Woodford (2003) suggested that a central bank could pledge to run an easy monetary policy for a time once the constraint no longer binds in order to influence the public's long-run expectations in a way that reduces current real bond rates. In a related idea, Wolman (forthcoming) and Lilico (2002) proposed that the central bank adopt a price-level target. Alternatively, Meltzer (1999), Svensson (2001), and McCallum (2000) called for unsterilized intervention in the foreign exchange market to boost inflation expectations and lower real interest rates, as well as to stimulate the economy directly by depreciating the currency. Clouse and others (2000) and Bernanke, Reinhart, and Sack (2004) discussed a similar program of quantitative easing, but through the mechanism of large-scale purchases of bonds. During a zero-bound episode, all these policies could substitute, in principle, for conventional open-market operations; however, they have the drawback of being much less familiar than traditional monetary policy and therefore less predictable in their effects. In this regard, it is noteworthy that the only modern attempt to use such unorthodox policy tools during a zero-bound episode—the Bank of Japan's current policy of expanding the monetary base—has not yet not pulled that country out of its extended slump.

As noted, any specific estimates of the effect of the zero lower bound are sensitive to economic conditions and to various issues in model specification. For example, if the FRB/US simulations are re-run drawing shocks from the past twenty years, instead of the more turbulent 1968-2004 period, almost no degradation in economic performance is seen until the target bias-adjusted inflation rate falls below 1 percent. However, the basic conclusion of the FRB/US analysis—specifically, that a cushion of about 1 percentage point on the bias-adjusted inflation rate would provide adequate protection for the risks posed by the zero lower bound—is supported by research using other models, as documented by Orphanides and Wieland (1998), Black, Colletti, and Monnier (1997), and Hunt and Laxton (2004).

Downward nominal wage rigidity. The dynamism that is characteristic of market economies requires that, at times, some individuals experience reductions in real wages or other forms of compensation. The lower the inflation rate, the more likely that a given decline in real wages would also imply a decline in nominal wages. Yet, empirical analyses of microeconomic data on wages suggest that individuals resist nominal wage cuts even more than can be explained by their dislike for the associated reduction in real wages and that businesses are therefore less likely to impose nominal wage cuts for fear of adverse effects on worker morale and productivity.[22] As a result, lower inflation may

[22] Lebow, Saks, and Wilson (2003) examined the microdata that underlie the employment cost index (ECI) and found that nominal wage cuts were only half as frequent over 1981-98 as would be expected in the absence of rigidity. Fallick, Lettau, and Wascher (2004) obtained similar estimates using ECI data through 2003. Earlier analyses that used different large datasets (including Lebow, Stockton, and Wascher, 1995; Card and Hyslop, 1997; and Kahn, 1997) generally found somewhat less downward rigidity, although measurement error in these datasets may mask the true extent of rigidity. Downward nominal wage rigidity may be one manifestation of money illusion; such rigidity points to the desirability of an inflation rate

lessen firms' ability to implement a market-clearing set of changes in real wages and may therefore result in a higher equilibrium rate of unemployment.

Despite the evidence in microeconomic data, downward nominal wage rigidity has left little noticeable imprint on macroeconomic outcomes. Low inflation over the past fifteen years has not been associated with elevated levels of unemployment, and efforts to discern the effects of downward wage rigidity in estimated Phillips curves have not produced compelling results. Perhaps these benign outcomes have occurred because firms have been able to trim nonwage elements of compensation—although bonuses, which are often mentioned in this context, do not appear to be sufficiently large or widespread to provide much buffer.[23] An alternative possibility is that firms have been able to make the necessary real wage adjustments over a period of a few years without needing to reduce nominal wages. That said, downward nominal wage rigidity might have mattered more for equilibrium unemployment in recent years if low inflation had not been accompanied by rapid increases in productivity, which served to boost equilibrium wage changes. Moreover, downward rigidity may have sharply nonlinear effects (as suggested by Akerlof, Dickens, and Perry, 1996), and inflation below the 1 percent level observed in 2003 could have noticeable adverse consequences for unemployment.

Were the Committee to set an inflation objective, it might wish to make clear that the objective would not be fixed for all time, in light of the fact that several factors discussed in this section vary over time. One example is measurement bias in the CPI. Since 1994, methodological improvements introduced by the BLS have reduced CPI bias about ½ percentage point. In addition, upper-level substitution bias—which arises from the CPI's use of a fixed market basket of goods and does not affect the PCE price index—appears to fluctuate significantly.[24] Another example is structural productivity growth. Its variation over time changes the economy's equilibrium real rate and implies a differential need for an inflation buffer to protect against costs from the zero bound and downward nominal wage rigidity.[25]

On the surface, these variations suggest a potential benefit from frequent adjustments to an inflation objective. However, other considerations suggest that the Committee might wish to approach the question of adjustments with caution. First, as the preceding discussion makes clear, the analytical basis for such adjustments would be incomplete at best, suggesting that frequent adjustments could be difficult to defend and could even exact a toll of reduced credibility. Second, because the public has only limited ability to process information regarding long-run monetary policy objectives, the Committee might

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above zero, even though other aspects of money illusion point toward an objective of zero inflation, as we argued earlier.

[23] Bonuses represent less than 3 percent of total compensation in the ECI.

[24] This component of bias stayed close to 0.2 percentage point per year between 1990 and 1997 but then moved up sharply to 0.7 percentage point in 2000 before falling back somewhat more recently. (Note that final estimates of the chained CPI—upon which estimates of upper-level substitution bias are based—are available only through 2002.)

[25] Variations in productivity growth might also affect the desired reported inflation rate by changing unmeasured quality change and thus the measurement error in reported inflation.

risk sowing confusion if it made frequent adjustments to the objective. In foreign countries, adjustments of inflation objectives are infrequent but hardly unheard of; by and large, the experience seems to have been that with careful attention to clear communication, occasional adjustments can be made without either damage to credibility or increased general confusion. (See the background paper from the Division of International Finance for further discussion.)

Point Objective or a Range

Our discussion so far has focused on the issues pertaining to the selection of a specific value for an inflation objective, but for number of reasons, such an objective might be stated as a range rather than a point estimate.

Variability of Inflation

Expressing the price objective as a range might help communicate, both internally and externally, that inflation is not wholly under the control of the central bank in the short run. Moreover, a central bank with a dual mandate may well choose to miss an inflation target for the sake of achieving greater stability in real activity. On a related point, specifying a range might help the Committee preserve credibility because the range could be set wide enough so that inflation outcomes would fall within it a reasonably high percentage of the time.

Uncertainty about the Appropriate Numerical Value

A range might also be motivated as reflecting uncertainty about the choice of price index and the extent and variation in measurement bias in that index. Setting a range might reduce the risk of suggesting a false sense of precision about the central bank's ability to identify the appropriate long-run rate of inflation; it also might reduce the need to adjust the objective over time.

Divergent Views

Alternatively, a range might reflect heterogeneous views among FOMC members about the appropriate long-run inflation objective. If the members could not agree on a single objective for long-run inflation, the Committee could announce a range, as it does for the members' year-ahead inflation forecasts in the Monetary Policy Report.

Signal of Nonlinear Reaction Function

A range might be a signal that the Committee intends to respond in a nonlinear fashion to rates of inflation that are judged to be "far away" from the preferred rate as opposed to rates that are "close." However, considerable analysis of the merits of such a nonlinear strategy would seem advisable before the Committee adopted such an approach.

The economic consequences of announcing a range rather than a point objective would depend on the underlying motivation for the range. For example, if a range were announced either as a means of encompassing divergent views among the members of the Committee or as a way of expressing a "zone of indifference," the announcement might

do relatively little to resolve uncertainty, relative to the status quo, about the long-run price-related objective of monetary policy.

Summary

We read the available evidence as suggesting that, if the Committee chooses to specify a numerical price-related objective, it would be well served to do so in terms of a measure of consumer prices and in terms of an inflation rate rather than a price level. If a numerical objective were framed in terms of PCE price inflation, a measurement-related cushion of ½ percentage point would be about appropriate; if an objective were framed in terms of CPI inflation, a measurement-related cushion of 1 percentage point would be appropriate.

Beyond that cushion for measurement error, we see the available evidence as suggesting that an additional cushion of 1 percentage point would provide sufficient insurance against the costs associated with the zero lower bound on nominal interest rates and with downward nominal wage rigidity. That insurance would come at some cost because of the factors arguing for zero true inflation. The literature does not allow precise quantification of this cost, but our reading of the evidence is that the cost would not be great.

D. Accuracy in Achieving an Inflation Objective

Inflation is volatile, and its future evolution is uncertain. Moreover, monetary policy is able to influence inflation only indirectly, imperfectly, and with a lag. Therefore, the Federal Reserve could not hit a point inflation objective precisely nor even guarantee to keep inflation within a narrow range. That said, the relevant uncertainties are finite so there should be some range within which the Federal Reserve could contain inflation most of the time.

Historical experience can be used to gauge the likely width of such a range. Since 1970, the standard deviation of four-quarter overall PCE inflation has been about 2.5 percentage points. Given this volatility, the Committee could expect to keep this measure of inflation within ±1 percentage point of its average only about 30 percent of the time. Since the mid-1980s, however, both inflation and real economic activity have been much more stable than in the preceding few decades. In particular, overall PCE inflation has been within ±1 percentage point of its average almost 60 percent of the time. If one believes that the recent period has been an aberration and that the earlier experience might be repeated—in terms of both shocks and Federal Reserve behavior—then observations from the longer period should be used when judging likely future volatility. However, if one believes that the high-inflation period of the late 1960s and the 1970s was the aberration, then observations from that period should be excluded when assessing future volatility.

Table 2
The Influence of Economic Volatility on the Percentage of Time that Inflation Could Be Held within ±1 Percentage Point of Desired Inflation Rate: FRB/US Stochastic Simulation Results
(Percent)

Measure of inflation and period over which averaged	Low volatility (1984 to 2004)[1]	High volatility (1968 to 2004)[1]
Total PCE inflation averaged over:		
Four quarters	68	59
Eight quarters	74	65
Twelve quarters	78	68
Core PCE inflation averaged over:		
Four quarters	73	64
Eight quarters	77	67
Twelve quarters	79	70

Note. In the FRB/US simulations, the funds rate is set using a Taylor rule with coefficients of 1.0 and 0.5 on the output gap and inflation gaps, respectively. Expectations are derived from forecasts of a small VAR model in which projected inflation is constrained to converge to the public's perception of the FOMC's target rate of inflation. Monetary policy does not enjoy perfect credibility, and the perceived target drifts in response to movements in actual inflation.
1. Historical period from which stochastic shocks drawn.

An alternative way to estimate the likely degree of accuracy with which inflation could be controlled is to run stochastic simulations of an economic model, such as the Board staff's FRB/US model. Table 2 reports results using the version of FRB/US that is typically used for short-run forecasting and for developing the alternative scenarios presented in the Greenbook. This version of the model assumes that expectations are formed using a small-scale VAR model. In the VAR model, the public's perception of the FOMC's long-run inflation objective importantly influences shorter-run forecasts of inflation. In the simulations presented here, we assume that the perceived objective is based on the historical experience of inflation; thus, the public does not accept as fully credible any commitment by the FOMC to a specific long-run inflation objective. We further assume that monetary policy is governed by a Taylor rule that approximates the behavior of monetary policy since 1987.[26] We will shortly consider variations on these assumptions.

The underlying volatility of the economy has an important bearing on the variability of inflation in these simulations. In the first column of the table, we assume that future

[26] Specifically, we use a version of the Taylor rule in which the nominal funds rate is set equal to the sum of four variables: the medium-run equilibrium real interest rate; the four-quarter rate of PCE inflation; the output gap multiplied by a coefficient of 1.0, and the gap between four-quarter PCE inflation and a fixed inflation target multiplied by a coefficient of 0.5. In the stochastic simulations, the objective for published PCE inflation equals 1½ percent, and the long-run equilibrium real funds rate equals 2½ percent.

Table 3
The Influence of Expectations Formation and Credibility on the Percentage of Time that Inflation Could Be Held within ±1 Percentage Point of Desired Inflation Rate: FRB/US Stochastic Simulation Results
(Percent)

Measure of inflation and period over which averaged	VAR-based expectations with imperfect credibility	VAR-based expectations with perfect credibility	Rational expectations with perfect credibility
Total PCE inflation averaged over:			
Four quarters	68	80	68
Eight quarters	74	89	75
Twelve quarters	78	95	79
Core PCE inflation averaged over:			
Four quarters	73	89	75
Eight quarters	77	94	79
Twelve quarters	79	97	82

Note. In the FRB/US simulations, the funds rate is set using a Taylor rule with coefficients of 1.0 and 0.5 on the output gap and inflation gaps, respectively. Stochastic shocks are drawn from the 1984-2004 historical period. Under VAR-based expectations, expectations are derived from forecasts of a small VAR model in which projected inflation is constrained to converge to the public's perception of the FOMC's target rate of inflation. Under rational expectations, expectations are derived from the full FRB/US model. When monetary policy is not perfectly credible, the perceived target drifts in response to movements in actual inflation; under perfect credibility, the perceived target is fixed at the actual target.

economic disturbances will be similar to those that occurred between 1984 and 2004. As can be seen in the upper portion of the table, according to these simulation results, the four-quarter percent change in the overall PCE price index could be held within 1 percentage point of the desired inflation rate 68 percent of the time. Not surprisingly, percent changes computed over longer periods (but expressed at an annual rate) can be held within the range somewhat more often. As might be expected given the volatility of food and energy prices, core PCE inflation could be held within any stated interval a somewhat greater percentage of the time than could overall inflation. The second column of the table presents results assuming that future shocks to the U.S. economy will be more like those over the past thirty-five years than those over the past twenty years. These results suggest that the Fed's ability to control inflation would be somewhat diminished under such circumstances.

A key uncertainty about the inflation process and a key source of risk in these estimates is the nature of expectations formation; we explore this risk in table 3. Throughout table 3 we present results based on the volatility of economic shocks observed since 1984. The first column of table 3 repeats the results from the first column of table 2, in which

expectations are derived from a simple VAR forecasting model and the public's perception of the FOMC's long-run inflation objective responds gradually to actual movements in inflation. In the second column of the table, we continue to assume that the public's short-run inflation expectations evolve according to the simple VAR model, but we assume that the public's long-run inflation expectations are fixed at the FOMC's announced inflation objective; in this sense, policy is fully credible. In this case, the probability of keeping the four-quarter change in overall PCE prices within a range of ±1 percentage point rises sharply from 68 percent to 80 percent.

In the third column of the table, we assume that expectations are formed in a manner consistent with the full FRB/US model. Thus, individuals not only accept as fully credible the Federal Reserve's commitment to an explicit inflation objective, they also completely understand all other aspects of the economy as embodied in FRB/US. If expectations are formed rationally, the announcement of a numerical inflation objective may have significant implications.

Intuition might suggest that inflation should be less volatile under rational expectations than under VAR expectations, but this need not always be the case. Indeed, if the VAR model tends to underestimate the average persistence of economic shocks affecting the inflation rate, and so incorrectly projects that the price effects of disturbances will fade away more quickly than is actually the case, then the switch to rational expectations will make inflation more volatile. And this turns out to be so in FRB/US: If expectations are assumed to be rational (thereby embodying the true persistence of shocks), the model predicts that the four-quarter change in overall PCE prices could be kept within ±1 percentage point of the target less than 70 percent of the time, assuming shocks of the magnitude and persistence seen over the past twenty years.[27]

As noted, the ability of the Federal Reserve to keep inflation within a specified range depends on the nature of the economy and the shocks that hit the economy—two factors outside the control of monetary policy. But in principle the Committee may be able to improve its control of inflation by responding more aggressively to undesired movements in inflation and (possibly) output. This potential is illustrated in table 4, which shows stochastic simulation results under two different monetary policies—the version of the Taylor rule used in tables 2 and 3, and one that is twice as responsive to fluctuations in both output and inflation gaps. Results are computed under the assumption that expectations are formed in a fully rational, model-consistent manner in order to ensure that private agents' beliefs about monetary policy are consistent with the actual behavior of the funds rate. Under these conditions, the more-aggressive policy yields modestly higher probabilities of staying within either specified range. Moreover, this greater control of inflation is achieved without an increase in the variability of output.

[27] Of course, expectations formation is only one source of model uncertainty, and other plausible variations in model specification might yield estimates quite different from those reported in table 3. As a check on this possibility, we ran stochastic simulations of a much simpler estimated model of the U.S. economy; expectations in this small, reduced-form model are implicit and completely backward-looking. The results from these simulations were in the same ballpark as those obtained using the FRB/US model.

Table 4
The Influence of Monetary Policy on the Percentage of Time that Inflation Could Be Held within ±1 Percentage Point of Desired Inflation Rate: FRB/US Stochastic Simulation Results
(Percent)

Measure of inflation and period over which averaged	Updated Taylor rule[1]	Aggressive Taylor rule[1]
Total PCE inflation averaged over:		
Four quarters	68	72
Eight quarters	75	79
Twelve quarters	79	84
Core PCE inflation averaged over:		
Four quarters	75	80
Eight quarters	79	84
Twelve quarters	82	87

Note. In the FRB/US simulations, shocks are drawn from the 1984-2004 historical period. Expectations are derived from the full structure of the FRB/US model, and monetary policy is fully credible.
1. In the updated Taylor rule, the output gap and the inflation gap have coefficients of 1.0 and 0.5, respectively. In the aggressive Taylor rule, these coefficients are doubled.

Yet another approach to judging the likely precision with which inflation could be controlled is to consider the experience of the industrialized countries that have adopted inflation targeting. Although the economies of these nations are in some ways quite different from the economy of the United States and they are subject to different shocks, it is nonetheless instructive that most have been able to keep their target inflation indexes within fairly narrow ranges. Moreover, for those countries that breached their ranges, the time spent outside the range was relatively brief. (See the background paper from the IF division for a more complete discussion.)

In sum, a conservative estimate is that the Committee could expect to keep four-quarter overall PCE inflation within a ±1-percentage-point band at least 60 percent of the time. Moreover, given the relative stability of the real economy over the past twenty years and the degree to which long-term inflation expectations now appear to be well anchored, the actual accuracy obtainable could be closer to 70 or 80 percent. Even greater stated degrees of precision would be possible if the Committee chose to focus on core measures of inflation.

Appendix: Empirical Issues Associated with the Choice of a Broad-Based Price Index

In this section, we investigate the empirical relationships between various price measures to determine whether it matters which index is targeted.[28] Our discussion focuses on an output price—the GDP chain price index—and two consumption prices—the CPI and the PCE chain price index—but we will also discuss consumption prices excluding food and energy.[29]

Co-movements among Price Levels

As can be seen in the top panels of figures 1 and 2, all of these major price indexes have drifted up considerably since World War II. The GDP and PCE chain price indexes have diverged from the overall CPI for extended periods, as has the CPI excluding food and energy; the divergence in these price indexes reflects largely persistent changes in relative prices.[30] Because these price indexes do not appear to be stationary, we examine whether they are co-integrated.[31] The presence of co-integration would imply that some long-run equilibrium relationship is tying the two price levels together; in contrast, price measures that are not co-integrated tend to wander away from each other in an unpredictable fashion over time. The statistical results, summarized in table A.1, are consistent with our observations based on figures 1 and 2: We fail to find stable long-run relationships between any of the major price indexes.

The observation that price indexes are not cointegrated indicates that anchoring one particular price index does not prevent uncertainty about the other indexes from growing without bound over a long period. Nonetheless, this result may not be especially important from a policy perspective, depending, in part, on the period relevant for economic decision making.[32] Although most of the price indexes have diverged over much of the postwar period, some have not drifted very far away. Furthermore, the uncertainty about the future values of alternative price indexes may be modest over periods relevant for many policy and planning purposes.[33]

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[28] The section updates the results of empirical work presented in more detail in Lebow and others (1997).

[29] The published consumer price index contains numerous breaks when the BLS changed methodology. The largest of these occurred in 1983, when the BLS adopted the owners' equivalent rent concept for measuring rent of owner-occupied dwellings in lieu of an asset-price approach. The consumer price indexes used here are the BLS's "current-methods" CPIs, which are methodologically consistent historical series that start in 1978. For the years between 1967 and 1977, we use the "experimental" CPI, which substitutes tenants' rent for the former CPI homeownership component. For the years before 1967, we use—for lack of any practical alternative—the published CPI, which includes the index for homeownership based on the asset-price approach.

[30] The divergences are quite a bit larger when the CPI is compared with producer price indexes or commodity prices.

[31] These series do not appear to be either mean stationary or trend stationary (stationary around a deterministic time trend).

[32] Unit root and stationary processes differ in their implications at infinite time horizons, but for a finite number of observations, they may be observationally equivalent.

[33] The estimated uncertainty surrounding the forecasts of CPI or GDP price levels when another broad price index is stabilized is considerably lower than the historical forecast errors estimated for those broad price indexes (Lebow, Roberts, and Stockton, 1992).

Table A.1
Do Price Levels Diverge over Long Periods?
Summary of Statistical Analysis Results

Measure	CPI	CPI ex. food and energy	PCE	PCE ex. food and energy	GDP
CPI	. . .	Yes	Yes	Yes	Yes
CPI ex. food and energy	Yes	. . .	Yes	Yes	Yes
PCE	Yes	Yes	. . .	Yes	Yes
PCE ex. food and energy	Yes	Yes	Yes	. . .	Yes
PCE ex. food and energy, market-based components	Yes	Yes	Yes	Yes	Yes
GDP	Yes	Yes	Yes	Yes	. . .

Co-movements among Inflation Rates

Although price levels tend to diverge for significant periods, inflation rates appear not to drift apart, as seen in the bottom panels of figures 1 and 2. Nonetheless, a number of key inflation rates also appear to exhibit the statistical properties, such as a high degree of persistence, that are characteristic of nonstationary time series. We can employ the same statistical procedures as above to address the question of whether inflation rates drift apart over long periods.[34] In contrast to the results for levels, the answer is generally no. As summarized in table A.2, we found long-run relationships between most major price inflation rates using co-integration tests, with the key exception of GDP price inflation, which may not be co-integrated with the core inflation measures (core CPI, core PCE, and core market-based components of PCE).[35] This measured divergence between the GDP and core consumer price inflation measures may reflect differences in productivity growth underlying capital equipment and core consumer goods and services, as well as large and persistent oil shocks, that have driven wedges between these inflation rates.[36]

[34] Co-integrating relationships can exist only among integrated variables that contain the same number of unit roots. Using a variety of test statistics, all the inflation rates shown above appear to be I(1) in the sample beginning in 1960. However, starting earlier—in 1950—the results for the overall inflation rates (core series are not available that far back) are mixed; these inflation rates are either stationary or I(1), with the results sensitive to lag length and alternative test statistics. We report the results of the co-integration tests with the recognition that a finding of co-integration may be tenuous given the possibility that the indexes may not have the same order of integration.

[35] The results of the test for co-integration between GDP price inflation and either core CPI inflation, core PCE price inflation, or market-based core PCE price inflation are sensitive to the number of lags included in the augmented Dickey-Fuller tests.

[36] More generally, changes in commodity prices, such as the producer price index for crude materials, are not co-integrated with CPI, PCE, or GDP price inflation.

Table A.2
Do Inflation Rates Drift Apart over Long Periods?
Summary of Statistical Analysis Results

Measure	CPI	CPI ex. food and energy	PCE	PCE ex. food and energy	GDP
CPI	. . .	No	No	No	No
CPI ex. food and energy	No	. . .	No	No	Possibly
PCE	No	No	. . .	No	No
PCE ex. food and energy	No	No	No	. . .	No
PCE ex. food and energy, market-based components	No	No	No	No	Possibly
GDP	No	Possibly	No	Possibly	. . .

Since most of the inflation rates of interest appear to move together over the long run, it may be useful to look at the spreads between key inflation rates. As indicated in figures 3 and 4, the *average* spreads between key inflation rates since 1950 are very small, but these spreads are quite variable and have taken on large values for periods of time. For example, in the top panel of figure 3, the spread between the four-quarter changes in the CPI and PCE chain price index has been about zero on average since 1950, but four-quarter CPI inflation has deviated from PCE price inflation as much as 1.2 percentage points on both the upside and downside. The variances of the other spreads are larger. For example, the average spread between the CPI and CPI excluding food and energy since 1950, shown in the top panel of figure 4, is also close to zero, but CPI inflation has exceeded core CPI inflation as much as 4.8 percentage points and has fallen below core CPI inflation 2.6 percentage points.

In contrast to the averages over the full postwar period, the spreads between broad inflation rates have not been zero on average in recent years. Over the past ten years, CPI inflation has exceeded both PCE price inflation and GDP price inflation nearly ½ percentage point on average. However, the variation in these spreads has declined over this same period.

In summary, if CPI or PCE price inflation were targeted, in general, the other inflation rates would also remain anchored over time. However, the nontargeted inflation rates would likely have different average values from the targeted rate, and those inflation rates could vary considerably from quarter to quarter.

References

Ahmed, Shaghil, Andrew Levin, and Beth Anne Wilson (2002). "Recent U.S. Macroeconomic Stability: Good Policies, Good Practices, or Good Luck?" International Finance Discussion Paper Series 2002-730. Washington: Board of Governors of the Federal Reserve System, July.

Akerlof, George A., William T. Dickens, and George L. Perry (1996). "The Macroeconomics of Low Inflation," *Brookings Papers on Economic Activity, 1:1996*, pp. 1-76.

Alchian, Armen A., and Benjamin Klein (1973). "On a Correct Measure of Inflation," *Journal of Money, Credit and Banking*, vol. 5 (February), pp. 173-91.

Batini, Nicoletta, and Anthony Yates (2003). "Hybrid Inflation and Price-Level Targeting," *Journal of Money, Credit and Banking*, vol.35 (June), pp. 283-300.

Bernanke, Ben S. and Mark Gertler (1999). "Monetary Policy and Asset Price Volatility," in *New Challenges for Monetary Policy*. Kansas City: Federal Reserve Bank of Kansas City, pp. 77-128.

Bernanke, Ben S., and Mark Gertler (2001). "Should Central Banks Respond to Movements in Asset Prices?" *American Economic Review*, vol. 91 (May, Papers and Proceedings), pp. 253-57.

Bernanke, Ben S., Vincent R. Reinhart, and Brian P. Sack (2004). "Monetary Policy Alternatives at the Zero Bound: An Empirical Assessment," Finance and Economics Discussion Series 2004-48. Washington: Board of Governors of the Federal Reserve System, September.

Black, Richard, Donald Coletti, and Sophie Monnier (1997). "On the Costs and Benefits of Price Stability," in *Price Stability, Inflation Targets, and Monetary Policy.* Ottawa: Bank of Canada.

Boivin, Jean, and Marc Giannoni (forthcoming). "Has Monetary Policy Become More Effective?" *Review of Economics and Statistics.*

Bryan, Michael F., Stephen Cecchetti, and Roisin O'Sullivan (2001). "Asset Prices in the Measurement of Inflation," *De Economist*, vol. 149 (December), pp. 405-31.

Card, David, and Dean Hyslop (1997). "Does Inflation 'Grease the Wheels of the Labor Market'?" in Christina D. Romer and David H. Romer, eds., *Reducing Inflation: Motivation and Strategy*. Chicago: University of Chicago Press, 1997.

Clarida, Richard, Jordi Gali, and Mark Gertler (2000). "Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory," *Quarterly Journal of Economics* vol. 115 (February), pp. 147-80.

Clouse, James, Dale Henderson, Athanasios Orphanides, David Small, and Peter Tinsley (2000). "Monetary Policy when the Nominal Short-term Interest Rate Is Zero," Finance and Economics Discussion Series 2000-51. Washington: Board of Governors of the Federal Reserve System, November.

Connolly, Ellis, and Marion Kohler (2004). "News and Interest Rate Expectations: A Study of Six Central Banks," Research Discussion Paper Series 2004-10. Sydney: Reserve Bank of Australia, November.

Eggertsson, Gauti B., and Michael Woodford (2003). "The Zero Bound on Interest Rates and Optimal Monetary Policy," *Brookings Papers on Economic Activity, 1:2003,* pp. 139-211.

Erceg, Christopher J., Dale W. Henderson, and Andrew T. Levin (2000). "Optimal Monetary Policy with Staggered Wage and Price Contracts," *Journal of Monetary Economics,* vol. 46 (October), pp. 282-313.

Fallick, Bruce, Michael Lettau, and William Wascher (2004). "The International Wage Flexibility Project: The United States," unpublished paper.

Feldstein, Martin (1997). "The Costs and Benefits of Going from Low Inflation to Price Stability," in Christina D. Romer and David H. Romer, eds., *Reducing Inflation: Motivation and Strategy*. Chicago: University of Chicago Press, pp. 123-66.

Feldstein, Martin (1999). "Capital Income Taxes and the Benefit of Price Stability," in M. Feldstein, ed., *The Costs and Benefits of Achieving Price Stability*. Chicago: University of Chicago Press.

Fischer, Stanley (1981). "Towards an Understanding of the Cost of Inflation: II," *Carnegie-Rochester Conference Series on Public Policy*, vol. 15, pp. 5-41.

Fisher, Irving (1928). *The Money Illusion*. New York: Adelphi.

Goodfriend, Marvin, and Robert G. King (2001). "The Case for Price Stability," NBER Working Paper W8423, August.

Goodhart, Charles (2001). "What Weight Should Be Given to Asset Prices in the Measurement of Inflation?" *Economic Journal*, vol. 111 (no. 472), pp. 335-56.

Gurkaynak, Refet S., Brian Sack, and Eric Swanson (2003). "The Excess Sensitivity of Long-Term Interest Rates: Evidence and Implications for Macroeconomic Models,"

Finance and Economics Discussion Series 2003-50. Washington: Board of Governors of the Federal Reserve System, November.

Hunt, Benjamin, and Douglas Laxton (2004). "The Zero Interest Rate Floor (ZIF) and Its Implications for Monetary Policy in Japan," *National Institute Economic Review*, vol. 187 (no. 1), pp. 76-92.

Kahn, Shulamit, (1997). "Evidence of Nominal Wage Stickiness from Microdata," *American Economic Review*, vol. 87 (December), pp. 993-1008.

Kiley, Michael T. (2000). "Endogenous Price Stickiness and Business Cycle Persistence," *Journal of Money, Credit, and Banking*, vol. 32 (February), pp. 28-53.

Kiley, Michael T. (2004). "Is Moderate-to-High Inflation Inherently Unstable?" Finance and Economics Discussion Series 2004-43. Washington: Board of Governors of the Federal Reserve System, August.

Kohn, Donald L., and Brian P. Sack (2003). "Central Bank Talk: Does It Matter and Why?" Finance and Economics Discussion Series 2003-55. Washington: Board of Governors of the Federal Reserve System, November.

Krugman, Paul R. (1998). "It's Baaack: Japan's Slump and the Return of the Liquidity Trap," *Brookings Papers on Economic Activity, 2:1998*, pp. 137-205.

Lebow, David E., John M. Roberts, and David J. Stockton (1992). "Economic Performance under Price Stability," Finance and Economics Discussion Series 1992-125. Washington: Board of Governors of the Federal Reserve System.

Lebow, David E., David J. Stockton, and William L. Wascher (1995). "Inflation, Nominal Wage Rigidity, and the Efficiency of Labor Markets," Finance and Economics Discussion Series 1995-94. Washington: Board of Governors of the Federal Reserve System.

Lebow, David E., Deborah Lindner, Daniel Sichel, and Robert Tetlow (1997). "Toward a Working Definition of Price Stability," paper for the Federal Open Market Committee.

Lebow, David E., and Jeremy B. Rudd, (2003). "Measurement Error in the Consumer Price Index: Where Do We Stand?" *Journal of Economic Literature*, vol. 41 (March), pp. 159-201.

Lebow, David E., Raven E. Saks, and Beth Anne Wilson (2003). "Downward Nominal Wage Rigidity: Evidence from the Employment Cost Index," *Advances in Macroeconomics*, vol. 3 (no. 1), pp. 1-30.

Lilico, Andrew (2002). "The Liquidity Trap and Price-Level Targeting," *Economic Affairs*, vol. 22 (June), pp. 47-52.

Lucas, Robert E., Jr. (1972). "Expectations and the Neutrality of Money," *Journal of Economic Theory,* vol 4 (April), pp. 103-24.

McCallum, Bennett T. (2000). "Theoretical Analysis Regarding a Zero Lower Bound on Nominal Interest Rates," *Journal of Money, Credit, and Banking*, vol. 32 (November), pp. 870-904.

Meade, James (1978). "The Meaning of 'Internal Balance'," *Economic Journal,* vol. 88 (no. 351), pp. 423-35.

Meltzer, Allan H. (1999). "Commentary: Monetary Policy at Zero Inflation," in *New Challenges for Monetary Policy*. Kansas City: Federal Reserve Bank of Kansas City, pp. 261-76.

Okun, Arthur M. (1971). "The Mirage of Steady Inflation," *Brookings Papers on Economic Activity, 2:1971,* pp. 485-98.

Okun, Arthur M. (1981). *Prices and Quantities: A Macroeconomic Analysis.* Washington: Brookings Institution.

Orphanides, Athanasios, and Volker Wieland (1998). "Price Stability and Monetary Policy Effectiveness When Nominal Interest Rates Are Bounded at Zero," Finance and Economics Discussion Series 1998-35. Washington: Board of Governors of the Federal Reserve System, August.

Orphanides, Athanasios, Richard D. Porter, David Reifschneider, Robert Tetlow, and Frederico Finan (2000). "Errors in the Measurement of the Output Gap and the Design of Monetary Policy," *Journal of Economics and Business*, vol. 52 (January-April), pp. 117-41.

Phelps, Edmund S. (1978). "Inflation Planning Reconsidered," *Economica*, vol. 45 (May), pp. 109-23.

Reifschneider, David, and John C. Williams (2000). "Three Lessons for Monetary Policy in a Low-Inflation Era," *Journal of Money, Credit, and Banking*, vol. 32 (November), pp. 936-66.

Reifschneider, David, and John C. Williams (2002). "The Implications of the Zero Bound on Nominal Interest Rates," presentation to the Federal Open Market Committee, January 29.

Roberts, John M. (2004). "Monetary Policy and Inflation Dynamics," Finance and Economics Discussion Series 2004-62. Washington: Board of Governors of the Federal Reserve System, October.

Shafir, Eldar, Peter Diamond, and Amos Tversky (1997). "Money Illusion," *Quarterly Journal of Economics*, vol. 112 (no. 2), pp. 341-74.

Stock, James H., and Mark W. Watson (2002) "Has the Business Cycle Changed and Why?" *NBER Macroeconomics Annual 2002.*

Svensson, Lars E.O. (1999). "Price-Level Targeting versus Inflation Targeting: A Free Lunch?" *Journal of Money, Credit and Banking*, vol. 31 (August), pp. 277-95.

Svensson, Lars E.O. (2001). "The Zero Bound in an Open Economy: A Foolproof Way of Escaping from a Liquidity Trap," *Monetary and Economic Studies*, vol. 19 (February), pp. 277-312.

Taylor, John B. (1981). "On the Relation between the Variability of Inflation and the Average Inflation Rate." *Carnegie-Rochester Conference Series on Public Policy*, vol. 15, pp. 57-85.

Tobin, James (1980). "Stabilization Policy Ten Years After," *Brookings Papers on Economic Activity, 1:1980*, pp. 19-71.

Wolman, Alexander L. (forthcoming). "Real Implications of the Zero Bound on Nominal Interest Rates," *Journal of Money, Credit, and Banking*.

Woodford, Michael (2003). *Interest and Prices: Foundations of a Theory of Monetary Policy*. Princeton: Princeton University Press.

Figure 1

Price Measures

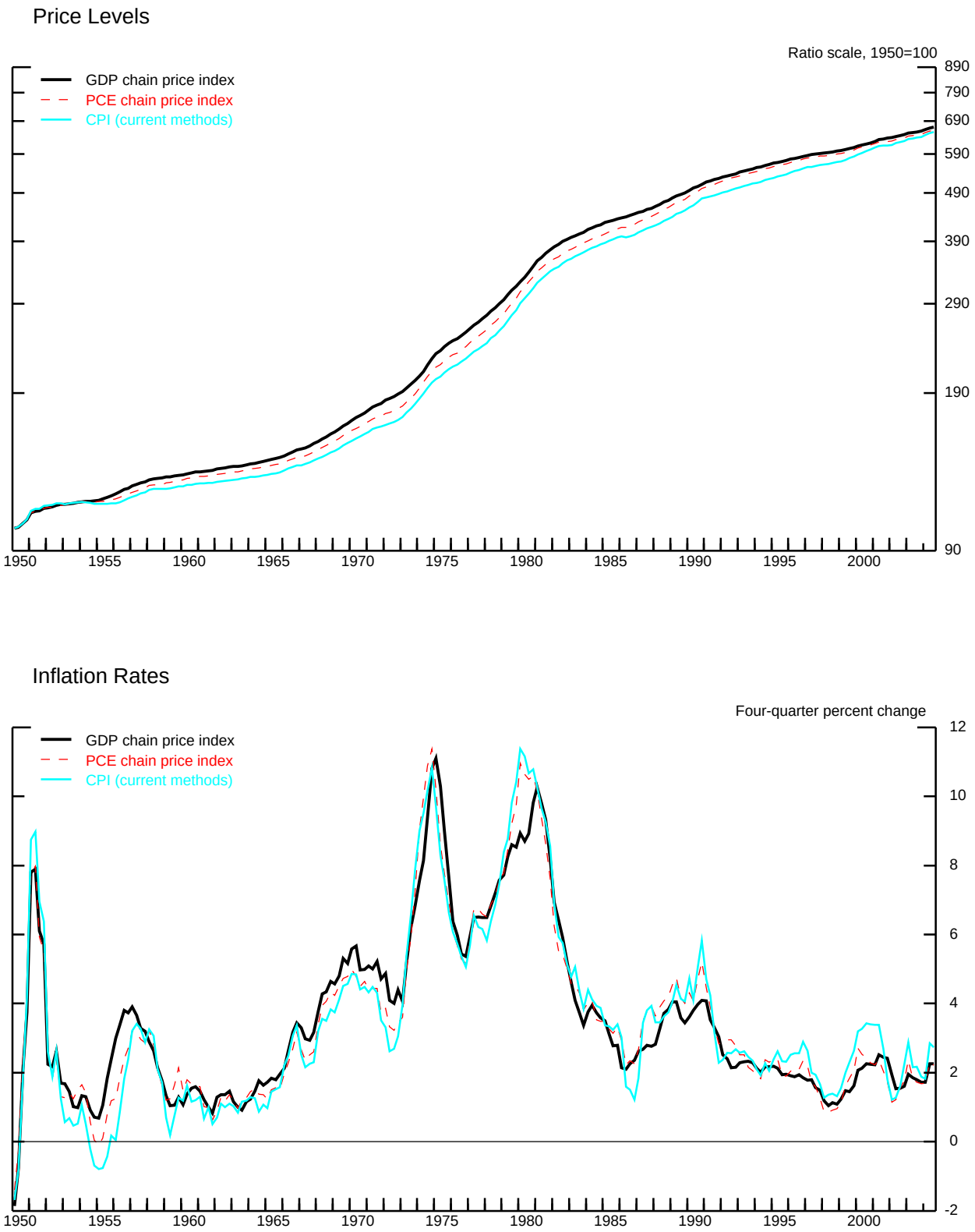
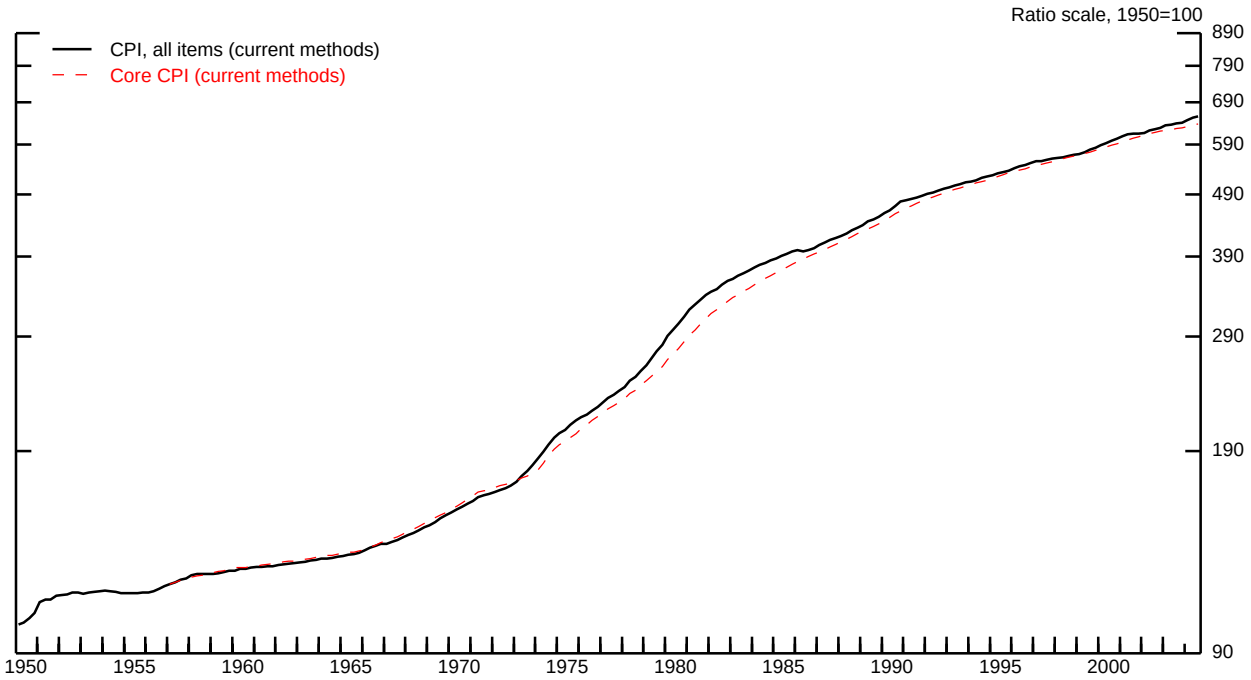


Figure 2a

Core CPI Measures

Price Levels



Inflation Rates

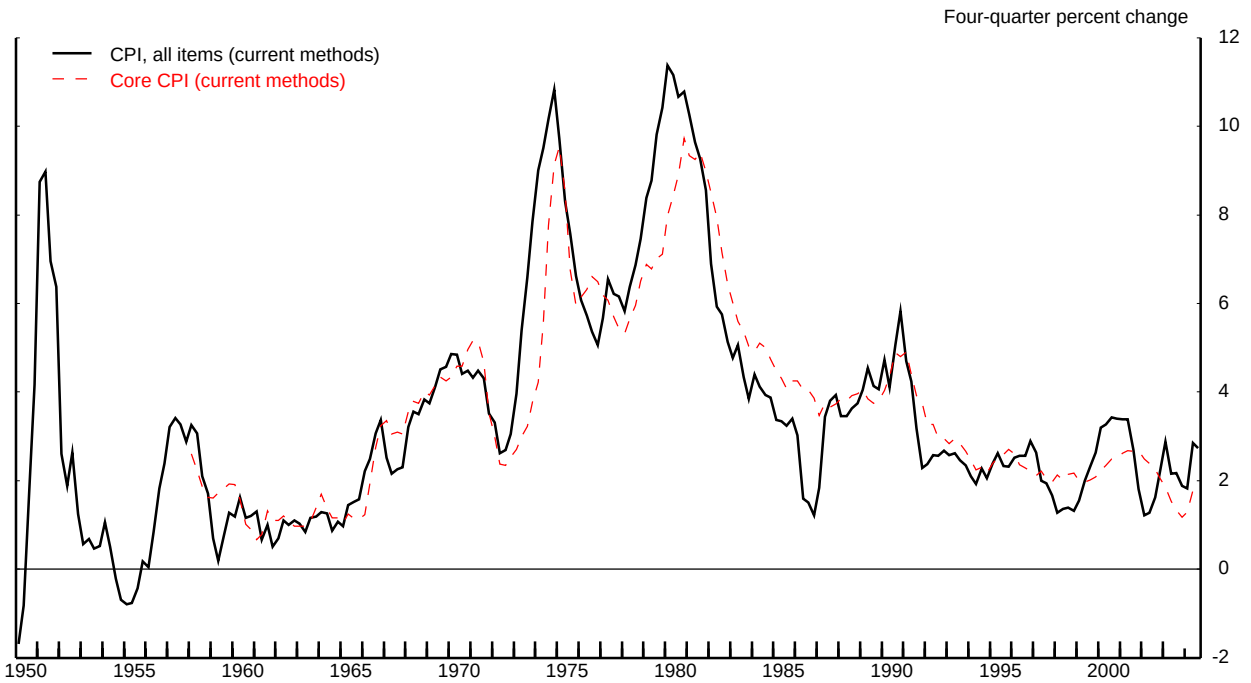


Figure 2b

Core PCE Measures

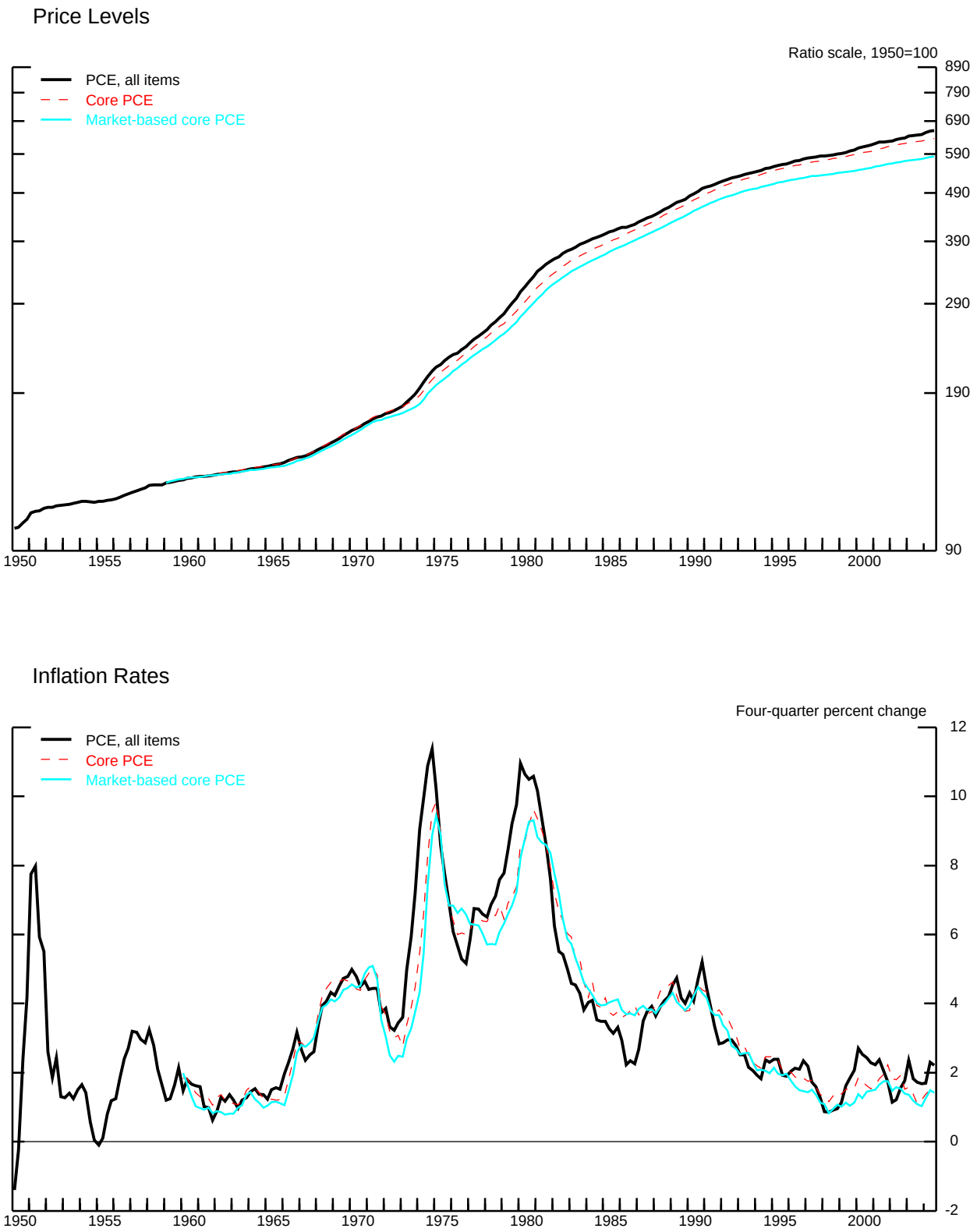
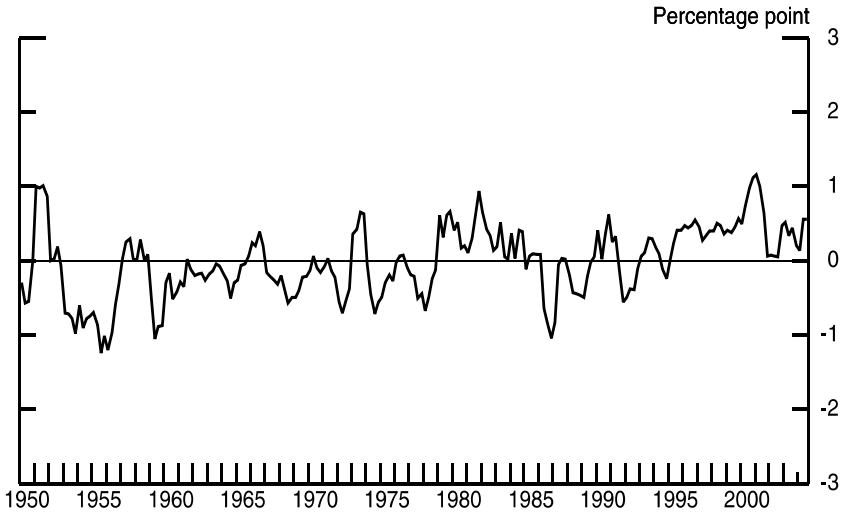


Figure 3

Spreads Between Inflation Rates

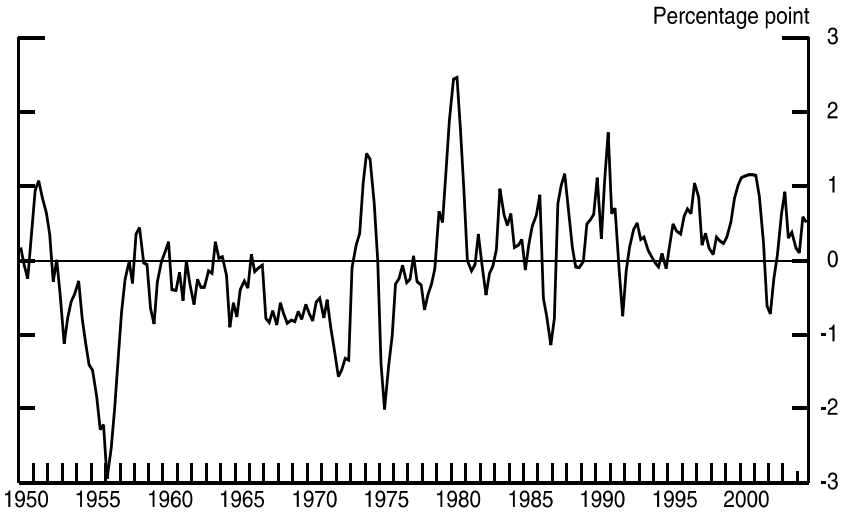
(Differences Between Four-Quarter Percent Changes)

CPI - PCE chain price index



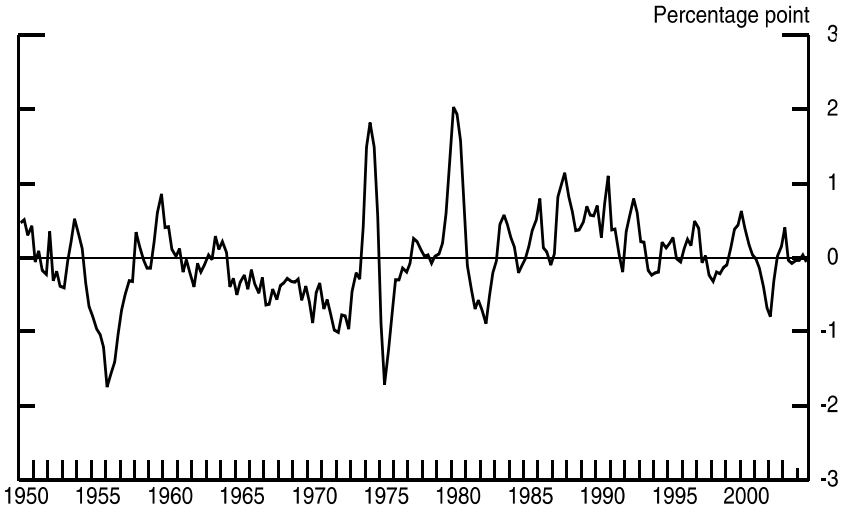
1950:1 - 2004:3	1994:3 - 2004:3
Mean -.02	Mean .42
Standard Deviation .5	Standard Deviation .3
Minimum -1.2	Minimum -.2
Maximum 1.2	Maximum 1.2

CPI - GDP chain price index



1950:1 - 2004:3	1994:3 - 2004:3
Mean -.04	Mean .45
Standard Deviation .8	Standard Deviation .5
Minimum -2.9	Minimum -.7
Maximum 2.5	Maximum 1.2

PCE - GDP chain price index



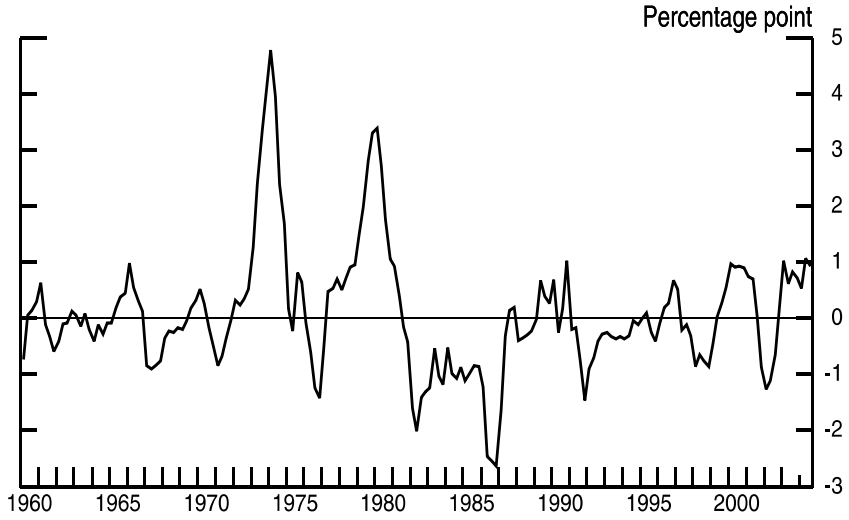
1950:1 - 2004:3	1994:3 - 2004:3
Mean -.02	Mean .03
Standard Deviation .6	Standard Deviation .3
Minimum -1.7	Minimum -.8
Maximum 2.0	Maximum .6

Figure 4

Spreads Between Inflation Rates

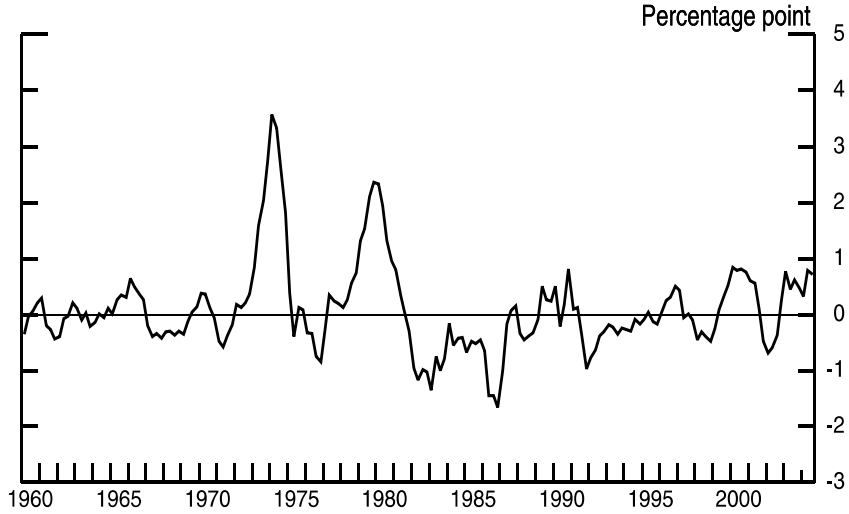
(Differences Between Four-Quarter Percent Changes)

CPI - core CPI



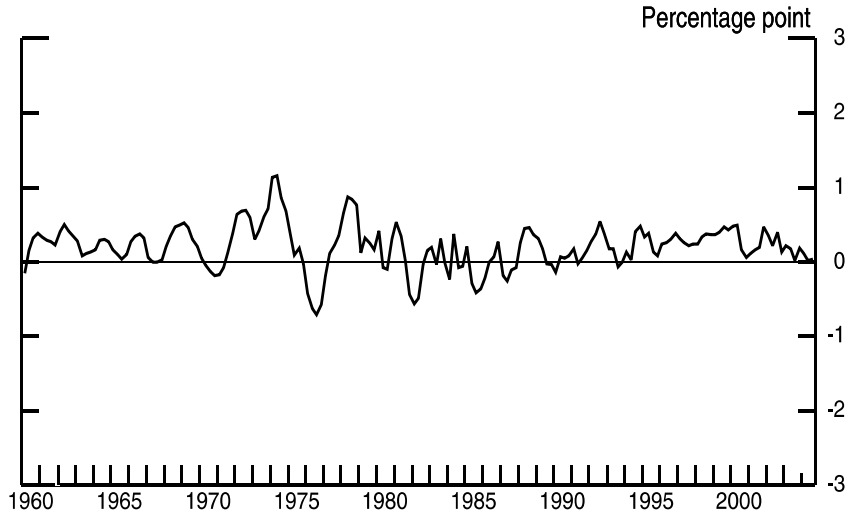
1960:1 - 2004:3	1994:3 - 2004:3
Mean .08	Mean .12
Standard Deviation 1.1	Standard Deviation .7
Minimum -2.6	Minimum -1.3
Maximum 4.8	Maximum 1.1

PCE chain price index - core PCE chain price index



1960:1 - 2004:3	1994:3 - 2004:3
Mean .09	Mean .16
Standard Deviation .8	Standard Deviation .4
Minimum -1.7	Minimum -.7
Maximum 3.6	Maximum .8

Core PCE - market-based core PCE chain price index



1960:1 - 2004:3	1994:3 - 2004:3
Mean .20	Mean .27
Standard Deviation .3	Standard Deviation .1
Minimum -.7	Minimum 0
Maximum 1.2	Maximum .5