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Securing the Peace after a Truce in the War on Inflation

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Abstract

Central bankers in the major industrial economies have come close to securing the peace, or in some cases, have secured it in the battle against inflation, hostilities that lasted almost as long as the Cold War. It is important to remember that this battle has been a good fight: Both the theory and the empirics reviewed in this paper support the central tenet of central banking that lower inflation supports faster economic growth. However, the observation that low inflation is associated with a macroeconomic benefit does not imply that disinflation should be pursued without limit. A particularly compelling argument in the body of work on the optimal inflation rate is the view that price deflation, or even very low inflation, may pose unacceptable macroeconomic risks given the lower bound of nominal interest rates of zero. Empirical work in this paper suggests that the zero bound is not an artifact of theoreticians but a palpable reality. That said, the perils of the zero bound to nominal interest rates may be seen as less threatening if a central bank is willing to be both aggressive in providing policy accommodation when the economy may be nearing the zero bound and flexible in using the available tools of policy.

Key words: Monetary policy, Zero bound, Equilibrium interest rate
JEL classification: E31, E52, E5

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1. Introduction

In the war against inflation, in hostilities that have lasted almost as long as the Cold War, central bankers in the major industrial economies have come close to securing the peace or, in some cases, have already done so. In most major countries, consumer price inflation has fallen to around 2 percent, about one-third the pace of twenty years ago (table 1). The prevailing inflation rate of the past ten years in the United States, about 2-1/4 percent, was last routinely achieved in the 1950s. And the deflation of the past five years in Japan implies that the current level of consumer prices is now the same as in 1995. In this fight, as in the Cold War, considerable resources were devoted to the effort, and there were no decisive victories but rather a slow grinding down of the enemy as the advantages of the alternative regime became increasingly obvious.

Table 1

Average consumer price inflation

Percent, annual rate over the period:

Country	*1980-84*	*1985-89*	*1990-94*	*1995-99*	*2000-04*
Canada	8.7	4.3	2.8	1.6	2.4
France	11.1	3.6	2.6	1.3	1.8
Germany	4.6	1.3	3.7	1.1	1.2
Italy	16.6	6.2	5.4	3.0	2.5
Japan	3.9	1.1	2.0	0.4	-0.7
United Kingdom	9.4	4.7	5.0	2.7	2.3
United States	7.5	3.6	3.6	2.3	2.2

Source: International Monetary Fund, *World Econmic Outlook* (April 2004).

Military history counsels two lessons for securing the peace after a long war. First, do not underestimate the resilience of the old foe. Central banks should view

subdued inflation as merely a temporary truce rather a final victory. Such watchfulness and responsiveness is important because inflation can be kept low only as long as a nation's citizenry rightly believes that their central bank will not tolerate its resurgence. Second, shift at least some resources to position yourself to tackle the next possible enemy. If inflation is low and not thought likely to rise appreciably, central banks should focus at least some attention on understanding how to deal with adverse shocks given low inflation. These two lessons combine to a simple aphorism for the conduct of monetary policy: Lock in the gains from the last battle and prepare for the next.

This paper will expand on the aphorism by discussing three lines of argument.

First, the battle against inflation has been a good fight. A changeable price level clouds household and firm decision making and exacerbates distortions in the tax system, pulling economic activity below its maximum sustainable level and possibly impairing the expansion of its potential. After presenting the arguments from the theoretical literature in section 2, I examine the data for 178 countries over the past quarter century in Section 3 and find that they appear consistent with a decidedly negative effect of inflation on real economic growth. Moreover, this effect is robust across econometric techniques. Thus, over time much could be lost by a failure to secure the current low inflation.

Second, the observation that low inflation is associated with a macroeconomic benefit does not imply that disinflation should be pursued without limit—the subject of section 4. In particular, the empirical evidence of the way a modern economy

performs in deflation is scant. Brief episodes of deflation have occurred in the past quarter century, but they have been the exception, not the rule. A particularly compelling argument in the body of work on the optimal inflation rate is that price deflation, or even very low inflation, may pose unacceptable macroeconomic risks given the lower bound of nominal interest rates of zero. In particular, a prevailing expectation of either low inflation or declines in the general price level limits how far the central bank can push down the real short-term interest rate. That may lead to output losses, on average, if because of occasional adverse shocks to aggregate demand a very low—perhaps negative—real interest rate is needed to encourage spending. Regression evidence presented on the Japanese and U.S. economies over the past thirty years, including estimates of expected real short-term interest rates and their relation to the output gap, suggests that the full employment of resources required low real short-term interest rates in more than a few years.

Thus, central bankers face a difficult tradeoff in choosing their long-run inflation objective. Low inflation fosters economic growth and keeps distortions to a minimum. But too low an inflation goal—particularly if it allows veering into deflation at times—may threaten the attainment of maximum sustainable employment by raising the lower bound on real interest rates.

A third objective of this paper, as laid out in section 5, is to show that the perils of the zero bound to nominal interest rates may be seen as less threatening if a central bank is willing both to be aggressive in providing policy accommodation when the economy may be nearing the zero bound and to be flexible in using the available

tools of policy. In particular, policymakers may have scope to be explicit about their outlook for the economy and expectations for the likely path of policy so as to ensure that investors' expectations are correctly aligned. In extremis, central banks may need to resort to more direct attempts to influence market yields through outright purchases of securities, perhaps in large volume. In any circumstance, it is important that the public understand that the central bank has the tools—and the willingness to use them—so as to prevent doubts by households' and firms' doubts about economic prospects from becoming self-reinforcing.

The entire discussion reflects my own views, which are not necessarily shared by others within the Federal Reserve System.

2. Why Should Inflation Be Kept Low?

Many elegant theoretical models support the routine assertion of central bankers that keeping inflation low in the long run generates many benefits. Some of these benefits are that a low inflation rate allows firms to avoid costs associated with changing the prices of the goods and services they sell, permits potential purchasers to detect relative price changes more easily, reduces the cost associated with holding money balances (thereby cutting down on transactions costs), and vitiates nominal distortions in the tax code. As opposed to these benefits, some analysts argue that a bit of inflation enables relative prices to adjust without imposing the burden on reluctant workers to have their nominal wages decline. Inflation may also look attractive if there is a concern that the zero lower bound to nominal interest rates imposes an unattractively high lower limit on real interest rates. And concerns about

the seignorage from money creation, especially in developing economies, may raise the attractiveness of inflation. These arguments can be treated in order of their implication for how low inflation should go.

1. Lowering transactions costs. The central bank is a zero cost provider of a useful resource. That is, money balances in the hands of the public may reduce the cost of transacting, aid firms in producing, and make households feel better off.[1] A central bank could maximize welfare by satiating the demand for money balances and subsequently maintaining money growth in a manner so that the public willingly holds that high level of balances. This is the Friedman rule, which calls for steady contractions in the nominal money stock so that prices decline at the rate equal to the rate of time preference, thereby ensuring that the nominal short-term interest rate equals zero and the public demands a level of real balances at the satiation point.[2] Thus, deflation is to be welcomed, not feared, because agents will no longer devote resources in an effort to conserve their holdings of something that the central bank can provide at zero cost.

2. Saving menu costs and reducing distortions. An economy may have mechanisms—including institutional strictures or governmental distortions—that require the expending of resources when nominal prices change. Canonical examples include menu costs that require a firm to devote some resources to changing prices, search costs as households have to distinguish between changes in the general price

[1] More formally, real money balances may enter the budget constraint by influencing transactions costs, the firm production function, and household welfare. Feenstra (1986) discusses the equivalences among these approaches.

[2] As discussed in Friedman (1969).

level (whether up or down) and changes in relative prices, and distortions in the tax system in which the real burden of a tax changes with the nominal price level.[3] Because of such resource costs, policymakers may be inclined not to go as far as the Friedman rule—and impose the burden on the private sector in responding to a changing (that is, falling) general price level—especially if they think that the welfare benefit of increasing real balances to the satiation point is modest. In general, such mechanisms add to the attractiveness of achieving price stability—a zero inflation rate—because at that point none of these resource costs are incurred.[4]

3. Offsetting downward rigidities. An older argument emphasized concerns about a potential asymmetry in price setting.[5] In particular, in their wage-setting behavior, workers may have an element of money illusion or view norms of fairness and relative performance as especially important. If so, they may respond poorly to wage bargains requiring declines in nominal compensation even if their real wages were actually unchanged or rising because of a falling general price level. Such resistance to price declines poses a barrier that may imply a less-than-full employment of resources, at least for a time, if prices are declining. And the heterogeneity of a modern industrial economy may imply resource losses at positive, but low, inflation rates because of such a barrier. In particular, in a complicated economy with a range of goods and services being produced, some relative prices will be increasing and

[3] Menu costs are discussed by Mankiw (1985), search costs are the key feature of Lucas's island parable (Lucas, 1972), and tax distortions are central to Feldstein's view of the optimal inflation rate (as discussed in Feldstein, 1999).

[4] Of course, in a heterogeneous economy facing many shocks, relative prices may need to change frequently, implying that menu costs would be incurred at a stable general price level and lessening the benefit of low inflation.

some decreasing in response to changes in taste and production possibilities. At a zero or low general inflation rate, firms in the sector with declining relative prices would have to cut their nominal prices and possibly the wages of their workers. If such cuts in money terms are resisted, some portion of the workforce will have inappropriately high real-wage demands, a situation resolved over time only by less-than-full employment. The logical extension of this argument is that a higher general inflation rate provides cover for reductions in real wages without outright cuts in money wages and, thereby, will be associated with a higher level of resource utilization on average.[6]

4. Providing insurance against adverse outcomes. The practice of modern central banking incorporates an important element of risk management; policy needs to be designed not only to deliver the best possible average performance of the economy but also to minimize the risks of especially adverse outcomes. One concern is that an economy's performance may entail significant and uncertain nonlinearities in regions that are less traveled. As one example, if inflation were allowed to drift up to a high level, household inflation expectations might worsen dramatically and contracts might change to include an element of indexation in a manner that would make checking a further rise in inflation difficult. As another, if aggregate demand softened precipitously in the face of adverse shocks, the associated worsening of household and business confidence and increased fragility of the financial system might exacerbate the downdraft in spending.

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[5] A modern treatment is provided by Akerlof, Dickens, and Perry (1996).

One region of potential nonlinearity is mapped out by the zero bound to nominal interest rates.[7] Once the nominal policy rate moves down to zero, the real short-term interest rate equals the negative of the inflation rate expected to prevail. Such a real rate may be too high to ensure the full employment of resources. If it is too high, then the associated output gap will put more downward pressure on inflation and lead households to lower their inflation expectations further, pushing the real rate up and further increasing its spread above its equilibrium level. Unless some other force provides an offsetting impetus—or monetary policy has a means to influence the economy beyond the level of the short-term nominal interest rate (see section 5)—it would be only a matter of time before a deflationary dynamic sets in.[8] To insure against such an eventuality, the argument goes, the central bank should set a goal of nonzero inflation in the long-run; the higher the goal, the less likely the economy is to enter into the region of suspected nonlinearities.

5. *Preserving the revenue from money creation.* A particular relevant argument for a developing or emerging market economy is that money creation represents an important source of revenue. Reducing inflation and forgoing that revenue may prove risky if alternative means of taxation or spending reduction are unavailable because it will require an increased reliance on debt finance, all else being equal. Finding alternative means of funding may be problematic for countries that

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[6] This argument might be particularly telling in a currency union where members exhibited varying degrees of structural flexibility.

[7] McCallum (2000) explains why the zero bound binds, and Reifschneider and Williams (2000) and Coenen, Orphanides, and Wieland (2003) discuss its implications for the strategy of monetary policy. Ahearne et al. (2002) apply this logic to the Japanese situation.

have weak institutional structures that make them susceptible to funding difficulties—those that are "debt intolerant" in the phrase of Reinhart, Rogoff, and Savastano (2003).

A discussion. These arguments are not competing but rather different possible mechanisms in modern industrial economies that have to be weighed in settling on the desired long-run goal for inflation. The analysts who favor a low, potentially negative, number as the appropriate goal tend to stress the inefficiencies associated with the public's economizing on a resource that the central bank can make for free. The difficulty with that argument is that estimates of significant welfare loss associated with achieving the Friedman rule as opposed to, say, a zero inflation rate are hard to come by.[9] An emphasis on menu costs or tax distortions creates a fixed point at zero for the optimal inflation rate that is hard to dislodge, but, again, the quantitative significance of such effects is hard to assess, especially when real shocks require relative prices to adjust fairly frequently. As for a reliance on money illusion or other factors that argue for some inflation "grease" in the price system, the norms representing an obstacle to price declines presumably would change over time as workers saw increases in purchasing power at unchanged or declining money wages. The empirical evidence, at least in the United States, is ambiguous as to whether declines in wages are uncommon (as discussed in Lebow, Saks, and Wilson, 2003). And the risk-management approach weighs average

[8] The other force could be exogenous, such as fiscal policy, or endogenous, such as an important role for wealth that ultimately leads to increases in aggregate demand through a Pigou effect.

[9] The intuition is that the demand for money balances is not that elastic at the range below zero, implying that not much consumer surplus is lost when moving from a zero nominal interest rate to a nonzero level.

economic performance against adversities in the tail of potential outcomes—but the tails of distributions, by definition, are infrequently observed events that make quantification difficult. Emphasis on the revenue from money creation is not particularly to the point of this paper's consideration of industrial economies.

By my reading, the weight of the evidence should incline a central bank to a low, but non-zero, inflation goal. That judgment rests on (1) the view that the welfare gain associated with the Friedman rule as opposed to a small positive inflation rate is modest, (2) the lack of evidence indicating significant menu or distortionary costs, (3) the belief that money illusion is at most transitory and that can be ameliorated by explaining the central bank's goal for inflation, and (4) an empirical assessment about the desirability of insurance against the zero bound and the availability of monetary policy tools with uncertain effectiveness in that eventuality. But this matter ultimately is empirical: One must first establish whether output growth and inflation are associated and then address the quantitative significance of the zero bound.

3. Some Evidence on Inflation and Growth

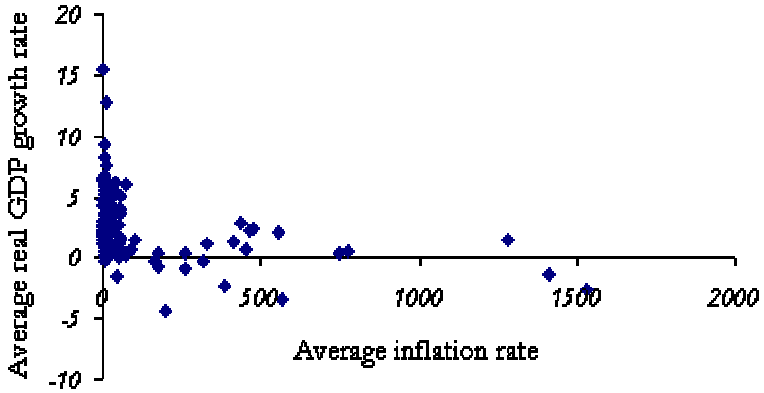
Without question, there has been a considerable volume of work on the correlation between output growth and inflation over time and across countries, as exemplified by Bruno and Easterly (1996) and Barro (1996).[10] A message from this work is that properly identifying the correlation depends critically on including appropriate control variables in the regression. From a central bank's perspective,

however, the unconditional correlation may provide important information, in part because inflation may be under policymakers' control in a way that most of the conditioning variables in standard growth regressions are not.

In that regard, the unconditional association shows through in even the simplest representations of the data, as in figure 1, which plots average inflation rates (along the horizontal axis) against average real GDP growth (along the vertical axis) for the 178 countries in the International Monetary Fund's *World Economic Outlook* database.[11] These averages are taken from the annual data available for 1980-2004 (with the WEO forecast filling in the observations for the final two years of the sample). A negative association is evident in the data, with a simple regression through those points indicating that a decline of 10 percentage points in the average rate of inflation raises real GDP growth 0.04 percentage point. Such a decline in inflation may seem outsized relative to the contained performance of price growth of most industrial countries in recent years, but enough observations lie in the right portion of figure 1 to suggest that high inflation has been a fixture in a significant fraction of the globe. And that fraction of the world well may have lower economic growth, in part, because of outsized changes in the price level.[12]

Figure 1
Inflation and real GDP growth, Averages
For 178 countries from 1980 to 2004

[10] This pairing of papers highlights the range of views on the subject. The theoretical literature just reviewed is scattered as to whether inflation should be associated with economic welfare or level or growth rate of output.
[11] These data are available at www.inf.org/weo/database/april04
[12] Of course, the causation likely runs both ways. Governments with a collection of poor policies that hinder growth may also be reduced to rely more heavily on the inflation tax. That is, inflation is an indicator of poor macroeconomic performance. Alternatively, a central bank targeting a fixed growth of nominal income in an economy with variable productivity growth would also generate such an association.



Ordinary Least Squares Estimation: Average real GDP growth

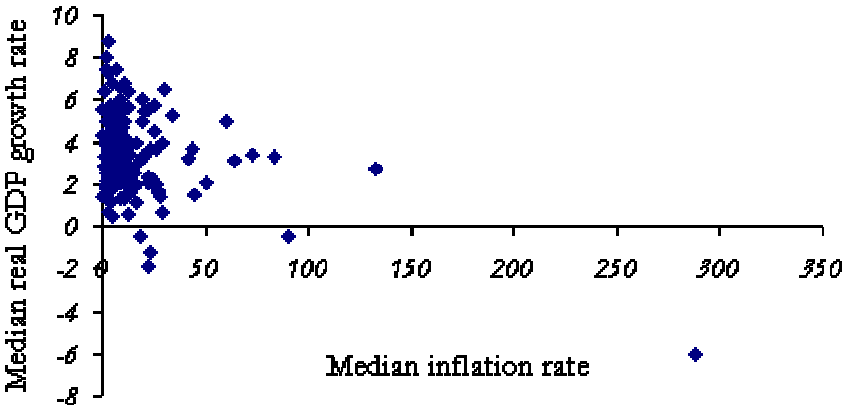
Variable	*Estimate*	*Standard error*	*t-statistic*
Constant	3.181	0.177	17.953
Average inflation rate	-0.004	0.001	-5.336
R-squared		0.139	
Adjusted R-squared		0.134	

Source: Data from International Monetary Fund, *World Economic Outlook* (April 2004).

Simple averages of inflation and real GDP growth may be influenced by large outliers and an estimation technique, such as ordinary least squares, that particularly penalizes deviations from the norm. However, as is evident in figure 2, the negative association between inflation and output growth holds when medians are used instead of averages. Indeed, reducing the range of variation in the horizontal axis by a factor of five and that of the vertical axis by a factor of two makes the negative relationship between inflation and output growth show through more clearly. By this estimate, a reduction in inflation of 10 percentage points raises output growth 0.25

percentage points, not a trivial amount economically, especially when compounded over time.

Figure 2
Inflation and real GDP growth, Medians
For 178 countries from 1980 to 2004



Ordinary Least Squares Estimation: Median real GDP growth

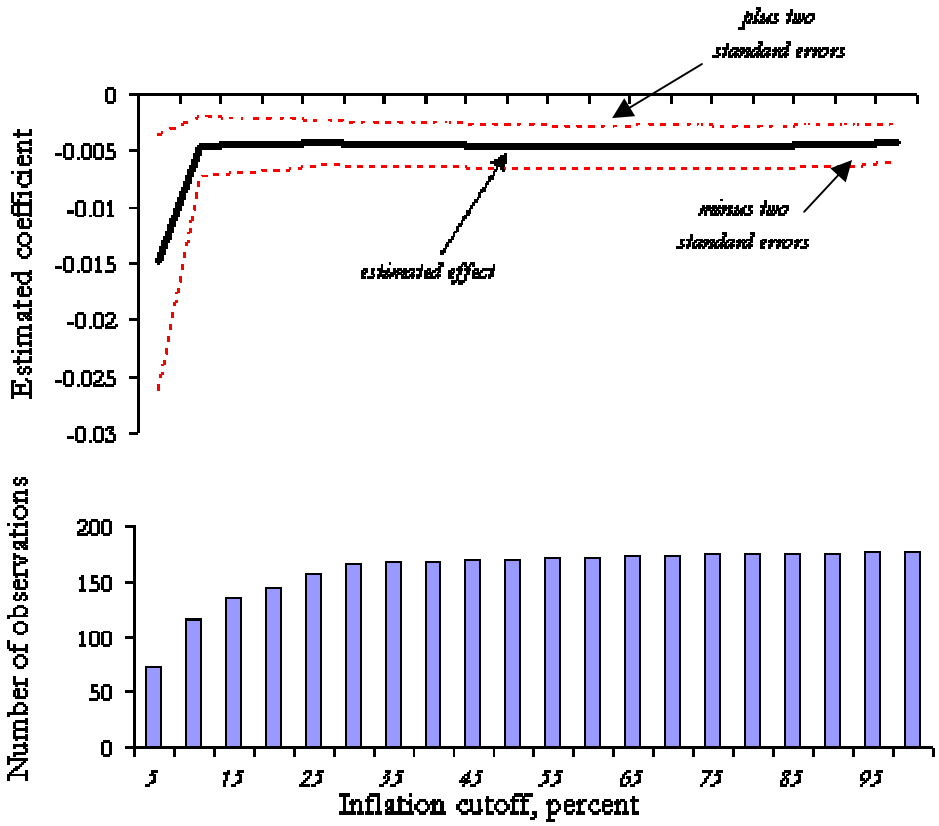
Variable	*Estimate*	*Standard error*	*t-statistic*
Constant	3.753	0.149	25.210
Median inflation rate	-0.026	0.005	-5.275
R-squared		0.137	
Adjusted R-squared		0.132	

Source: Data from International Monetary Fund, *World Economic Outlook* (April 2004).

A few outliers of very high inflation rates are evident in this figure, even after a switch to a more robust measure of central tendency. To control for these outliers in a more systematic matter, I carried out regressions of output growth on inflation in which the sample of observations was truncated at median inflation rates ranging from 5 percent to 100 percent, in increments of 5 percentage points. In figure 3,

which reports these regressions, the solid line plots the point estimate as the sample varies; it is surrounded by dashed lines that give a ninety-fifth percentile confidence band. Even if the sample is limited to the seventy economies that have a median inflation rate at or below 5 percent, a distinct negative relationship between inflation and economic growth emerges. Adding higher-inflation countries actually lowers the estimated effect but appreciably narrows the confidence band around those point estimates. Limiting the sample to countries with median inflation rates no higher than 100 percent does trim the size of the estimated effect, but the broad flat range of the estimates suggests that it is a robust rule of thumb is that a decline of 10 percentage points in inflation raises output growth about 0.05 percentage point.

Figure 3
Estimated effect of inflation on growth
As the sample varies by the median inflation rate

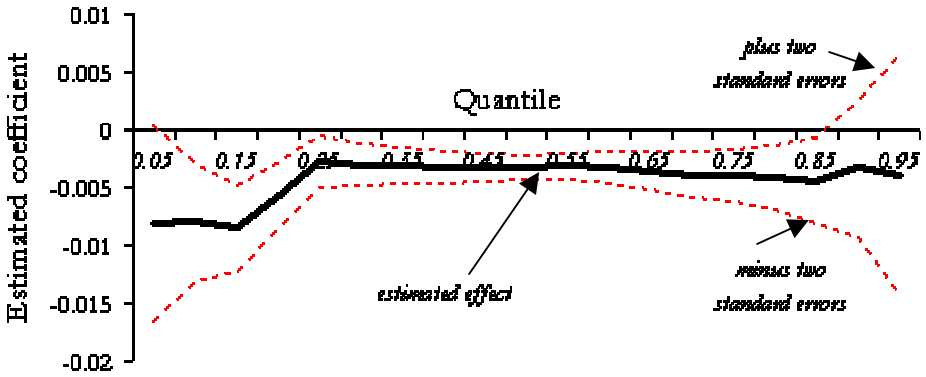


Note: The sample of observations on median annual inflation and real GDP for 178 countries is truncated (as shown along the horizontal axis) at median inflation rates ranging from 5 percent to 100 percent.
Source: Data from International Monetary Fund, *World Economic Outlook* (April 2004).

Varying the sample size is a crude attempt to control for the heterogeneity of the sample. A more robust way is to fit the relationship so as to minimize a specific percentile of the distribution of the absolute value of the errors.[13] Figure 4 reports such quantile regressions in which the coefficients are chosen to fit the percentiles ranging from the fifth to the ninety-fifth, in increments of 5 percentage points as measured along the horizontal axis. Again, for the broad range of the sample, the

estimate effect of inflation on output growth is in the neighborhood of -0.005 and is tightly estimated, except in the attempt to explain the two extreme tails of the distribution of the absolute value of the errors.

Figure 4
Estimated effect of inflation on growth
Using quantile regressions



Note: Quantile regression estimates in which the objective is to minimize the absolute value of the errors at quantiles ranging (along the horizontal axis) from the fifth percentile to the ninety-fifth.
Source: Data from International Monetary Fund, *World Economic Outlook* (April 2004).

To be sure, the estimated effect of inflation on output growth is not large across the range of regressions, particularly from the perspective of the industrial countries, listed in table 1, that posted declines in inflation on the order of 5 to 10 percentage points. However, the effect differs statistically from zero and would cumulate in a present-value sense to raise wealth and perhaps lessen the need to resort to distortionary policy interventions.

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[13] Fitting the fiftieth percentile, for instance, is equivalent to the least absolute median estimator. See Koenker and Hallock (2002) for an introduction to quantile regression.

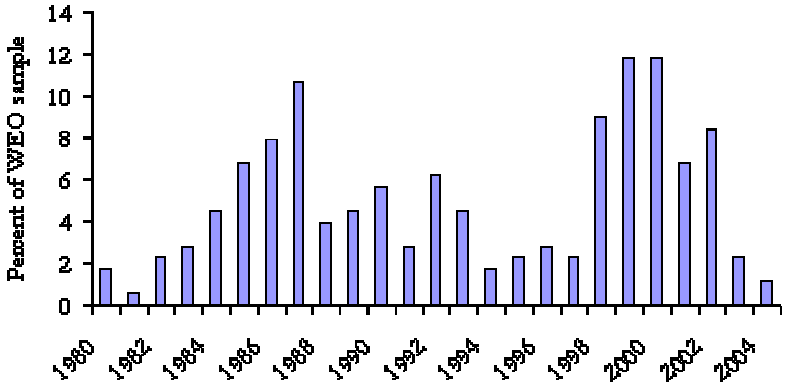
4. How Can There be Too Much of a Good Thing?

While the historical record of the past quarter-century supports the contention of central banks that benefits accrue from keeping inflation low, there is a limit to the inferences possible from that data set. In particular, in the *World Economic Outlook* sample of 178 economies, no economy posted an average or median inflation below zero from 1980 to 2004. Indeed, of the sample only 2-1/4 had medians as low as 1 percent and only 6-3/4 percent had them as low as 2 percent. That result, however, does not mean that inquiries into an economy's performance in deflation are irrelevant. Again using WEO data set, figure 5 documents the results of a simple counting exercise, with each bar recording the number of countries with deflation in any given year. An occasional bout of deflation is not uncommon: In every year since 1980 at least some country had declining prices, and in three years (1987, 1999, and 2000) more that 10 percent of the sample posted price declines.[14] As shown in the note to the figure, 72 economies out of the sample of 178 experienced at least one year of outright deflation since 1980. These calculations, which use measured consumer price inflation, probably overstate actual inflation because of various biases in their construction. If we use the rule-of-thumb bias of 1 percentage point, which seems appropriate in the United States, then 106 countries experienced a decline in prices measured correctly in at least one year.[15]

[14] The bars in this chart seem to track the weighted foreign exchange value of the dollar, perhaps because the economies keeping their exchange rate unchanged to the dollar receive a deflationary impulse when the U.S. currency is strong.

[15] Schultze (2003) provides an update on the biases in major price indexes in the United States.

Figure 5
Fraction of economies in the WEO database experiencing deflation
by year, 1980-2004



Note: Of the 178 countries in the WEO sample since 1980, 72 experienced at least one year of deflation and 106 experienced at least one year of inflation under 1 percent.
Source: Data from International Monetary Fund, World Economic Outlook (April 2004).

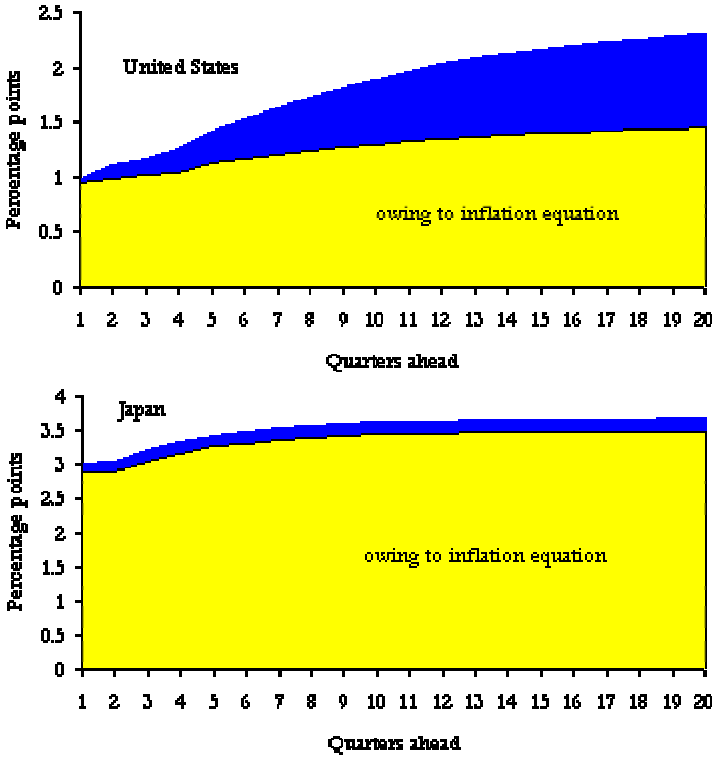
From a planning perspective, another aspect of the dynamics of inflation in industrial countries is of note. In particular, inflation tends both to be inertial in the short run and unpredictable over longer periods.[16] One way of seeing the latter property is through a simple forecasting exercise. I constructed a measure of the output gap by applying the Hodrick-Prescott filter to quarterly real GDP in Japan and the United States from 1970 to 2003.[17] I then fit two bivariate vector autoregressions in the estimated output gap and inflation (as measured by the logarithmic change in the GDP deflators) using quarterly data from 1976 to 2000 and four lags of each variable. The moving average representation of those vector autoregressions produce the striking results evident in Figure 6: In both countries, the standard error of the

[16] Atkenson and Ohanian (2001) emphasize this point.
[17] The results do not depend much on the type of filter used. Because there both countries had a similar decline in inflation over that period, it seemed reasonable that they both had a positive output gap on average. I adjusted the H-P-filtered gaps (which by construction average to zero) so that the sample average could explain the secular decline in inflation on the assumption that the sacrifice rate was four. (That is, an output gap of 4 percent for one year is needed to produce a decline of 1 percentage point decline in inflation.)

forecast of inflation is quite high to begin with, and it widens as the forecast interval lengthens. A two-year-ahead forecast of inflation has a standard error of 3-1/2 percentage points in Japan and of 1-3/4 percentage points in the United States. Moreover, the preponderance of that uncertainty is due to shocks to the inflation equations (the light shaded area) rather than to the gap equations, particularly for Japan.

Figure 6

Standard errors of the forecasts of inflation



Note: From a bivariate VAR estimated from 1976:Q1 to 2000:Q4 using inflation and the output gap, with four lags of each.

One consequence of this imprecision is that, even beginning at a moderate rate of inflation, considerable mass may still rest on the possibility that prices could be declining in a few years. Thus, although the empirical record does not provide

sufficient examples of sustained deflation to assess if there are systematic effects on output growth, it has enough episodes of deflation and the inflation process is sufficiently unforecastable to suggest that it is important to understand how an economy and policy perform during deflation, in part so that we can see if or how strenuously it should be avoided.

Part of the argument that a positive inflation rate helps protect against the zero bound rests on the belief that a negative real rate is sometimes needed to spur spending. To assess that possibility, I embarked on a two-step process of ascertaining the relationship between the output gap and the real short-term interest rate in Japan and the United States. First, we must recognize that it is the expected, or ex ante, real short-term interest rate that matters for spending decisions. In that regard, Mishkin (1984) provides a means of estimating the ex ante real interest rate under the null hypothesis of the rationality of expectations. In particular, the ex post real rate, $r^{ex\ post}$, will differ from the ex ante real rate, $r^{ex\ ante}$, only because of forecast errors, which under rational expectations should be uncorrelated with anything observed concurrently or previously. Thus, the predictions of the regression of the ex post real rate at time *t* on macroeconomic variables observed at or before time *t* should provide an inefficient but unbiased estimate of the ex ante real rate.

Tables 2 and 3 report those first-stage regressions for Japan and the United States, respectively. In both cases, the ex post real rate is defined as the nominal policy rate less the realized four-quarter-ahead inflation rate as measured by the GDP deflator. In the Japanese case, the availability of policy rate data limits the time span

of the regression to 1977-2002 (with the sample ending in 2002 because of the forward-looking nature of the inflation-compensation term). However, because I include only those explanatory variables that are available for a longer period—the discount rate, lagged inflation rates, and equity returns in Japan and the nominal short rate in the United States—this relationship can be extrapolated outside the period of availability of the nominal policy rate.

Table 2

Japan

Estimation of the ex ante real policy interest rate

1977:Q4 to 2002:Q4

	Estimate	*Standard Error*	*t-statistic*
Constant	1.21	0.29	4.21
Discount rate	-0.57	0.25	-2.27
Lagged disc. rate	1.40	0.25	5.62
U.S. short rate	-0.10	0.05	-2.08
Equity returns	-0.57	1.46	-0.39
Lagged infl. (once)	-23.63	18.06	-1.31
Lagged infl. (twice)	-27.04	17.64	-1.53
Variance of residuals			1.25
Std. error of regression			1.12
R-squared			0.67
Adjusted R-squared			0.64
Durbin-Watson			0.89

Note: Estimated using ordinary least squares.

Table 3

United States
Estimation of the ex ante real policy interest rate
1971:Q1 to 2002:Q4

	Estimate	*Standard Error*	*t-statistic*
Constant	-2.70	0.47	-5.74
Nominal short rate	0.66	0.08	8.69
Lagged short rate	0.07	0.08	0.91
Long rate	0.45	0.09	4.86
Equity returns	3.17	1.78	1.78
Lagged infl. (once)	-194.44	35.89	-5.42
Lagged infl. (twice)	-99.45	35.23	-2.82
Variance of residuals			1.44
Std. error of regression			1.20
R-squared			0.83
Adjusted R-squared			0.83
Durbin-Watson			0.54

Note: Estimated using ordinary least squares.

The regressions explain a significant share of the variability of the ex post real rate in both Japan and the United States, and I use their predictions as an explanatory variable for the output gaps in the two countries.

Specifically, using the same Hodrick-Prescott-filtered output gaps presented earlier in this section, I estimated the following relationship for the two countries, which includes the error term *u*:

$$gap_t = \alpha + (\beta/5)\sum_{k=0}^{4} r_{t-k}^{ex\ ante} + \gamma gap_{t-1} + u_t. \qquad (0.1)$$

The five-quarter average of the ex ante real rate is included to capture the lags in monetary policy, while the lagged output gap helps control for the inertia in that time

series. This expression has two-side dynamics introduced by the forward-looking nature of the ex ante real rate and the backward-looking lagged gap. Both regressions were estimated over the quarterly data available from 1976 to 2000 using two-stage least squares, where the instruments were the same as in the Mishkin regressions plus lagged observations of the output gap.

A feature of this regression is that, when output is at its potential in the long run, the real short rate must equal

$$r^{equilibrium} = -\alpha / \beta, \tag{0.2}$$

which we can take as a measure of the equilibrium real interest rate that prevailed over the entire sample. The results of these regressions are reported in table 4 for Japan and table 5 for the United States, with the implied estimates of the long-run real equilibrium short rate given in panel D of both tables. Those estimates, at 3.30 percent for Japan and 4.34 percent for the United States, are higher than conventional estimates in part because they rely on GDP deflators rather than consumer price indexes. Inflation as measured by GDP deflators has tended to run about 1 percentage lower than as measured by consumer price indexes.

These estimates differ statistically from zero, implying that the real equilibrium short-term interest rate is unlikely to have been negative, on average, over the entire period. But whole-period result does not imply that such a possibility was unlikely for subperiods of the data. In both cases, the coefficient on the lagged gap term is important (both numerically and statistically) in explaining the dynamics of the gap,

which as a consequence suggests that the effects of monetary policy are distributed over time with a considerable lag.

Table 4

Japan
Estimated relationship between the output gap and the ex ante real policy interest rate
1976:Q1 to 2000:Q4

Variable	*Estimate*	*Standard error*	*t-statistic*
Constant	0.35	0.19	1.81
Real rate	-0.11	0.05	-2.02
Lagged gap	0.83	0.06	14.49
Implied equilibriu m real interest rate	3.30	0.69	4.76
Variance of residuals			0.49
Std. error of regression			0.70
R-squared			0.69
Adjusted R-squared			0.68
Durbin-Watson			2.15

Note: Estimated using two-stage least squares with lags of financial quotes, the output gap, and inflation.

In both cases, the ex ante real rate is negatively related to the output gap, and statistically significantly so related. These estimates are crude in that they exclude critical factors shaping aggregate demand, such as a measure of fiscal policy, the terms of trade, activity in important trading partners, and household real net worth. Moreover, the estimation does not explicitly take account of the degrees of freedom used up in the first-stage calculation of Mishkin-style real interest rates, implying that there is a generated-regressor problem. That said, these simple equations afford a

role for monetary policy in influencing activity and are not notably more limited than the estimated relationship of Rudesbuch and Svensson (1999) for instance.

Table 5

United States
Estimated relationship between the output gap and the ex ante real policy interest rate
1976:Q1 to 2000:Q4

Variable	*Estimate*	*Standard Error*	*t-statistic*
Constant	0.33	0.16	2.10
Real rate	-0.08	0.04	-2.11
Lagged gap	0.86	0.05	17.72
Implied equilibriu m real interest rate	4.34	0.99	4.38
Variance of residuals			0.53
Std. error of regression			0.73
R-squared			0.77
Adjusted R-squared			0.77
Durbin-Watson			1.61

Note: Estimated using two-stage least squares with lags of financial quotes, the output gap, and inflation.

The long-run estimate of the equilibrium real short-term rate seems to suggest the zero bound to nominal interest rate would pose no particular concern, but persistent forces that would move the equilibrium rate away from its long-run level may be at work in the short run. One way of capturing that possibility is to incorporate a run of systematic error terms (the *u*'s) in calculating intermediate-term measures of the equilibrium real rate. To be specific, I calculated a backward-looking two-year moving average of the errors from the estimated output-gap

relationship, attributed those errors to changes in the constant term, and then asked what real short-term interest rate, if sustained, would have held the output gap at zero.[18] That is, the equation

$$r_t^{\,temporary\ \ equilibrium} = -(\alpha + \sum_{k=0}^{8} u_{t-k}) / \beta, \qquad (0.3)$$

allows scope for time variation in the equilibrium rate interest rate. Of course, this may allow too much time variation, in that changes in the forces of productivity and thrift, and their reflection in the equilibrium real rate, are likely to evolve more slowly than captured in this two-year moving average.

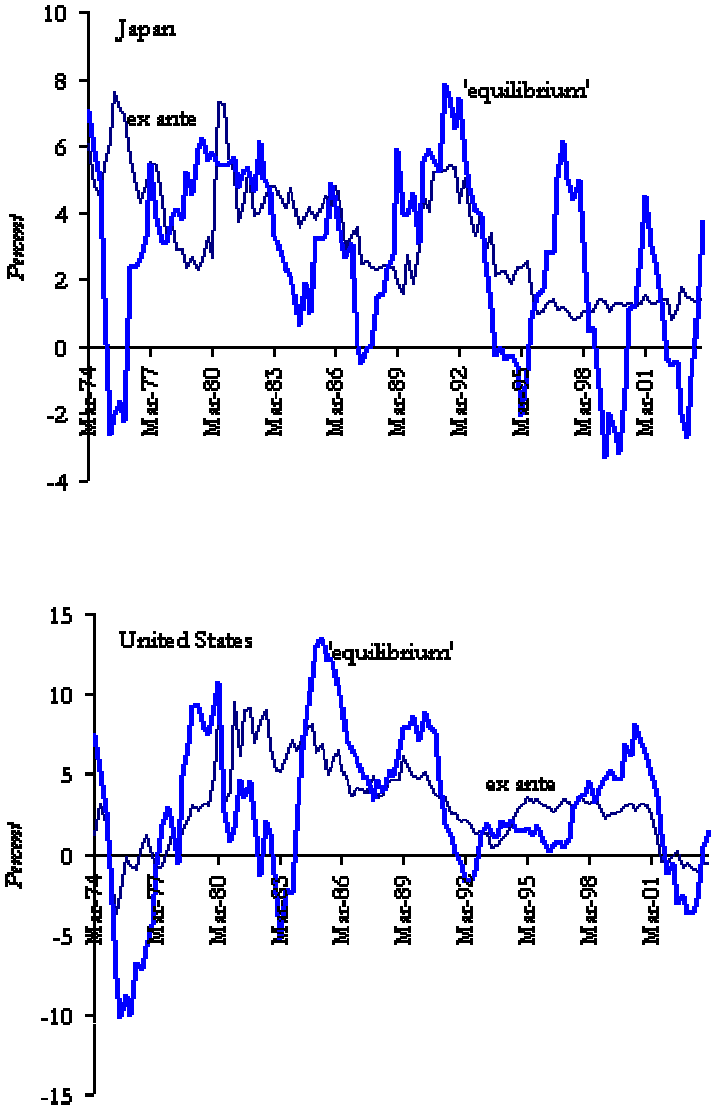
The estimates of the equilibrium real policy rate, along with the Mishkin-style ex ante rate, are presented in figure 7, with those for Japan plotted in the upper panel and those for the United States plotted in the lower panel. As is evident, the real short-rate consistent with the full employment of resources moves through a wide range—perhaps an unbelievably wide range—and is not infrequently below zero. Moreover policymakers seem often to chase after a moving target, in that the equilibrium rate moves up before changes in policy. For both Japan and the United States, the source of the pickup in inflation in the 1970s seems to have been an actual real rate that was originally allowed to drift below its equilibrium and was subsequently raised insufficiently to catch up to a rising equilibrium. Similarly, the disinflation of the 1980s was associated with a significant stretch of policy stringency,

[18] See Laubach and Williams (2001) for a discussion of a more satisfactory method of estimating the equilibrium real federal funds rate.

at least as measured by the excess of the ex ante real rate over its estimated equilibrium.

Figure 7

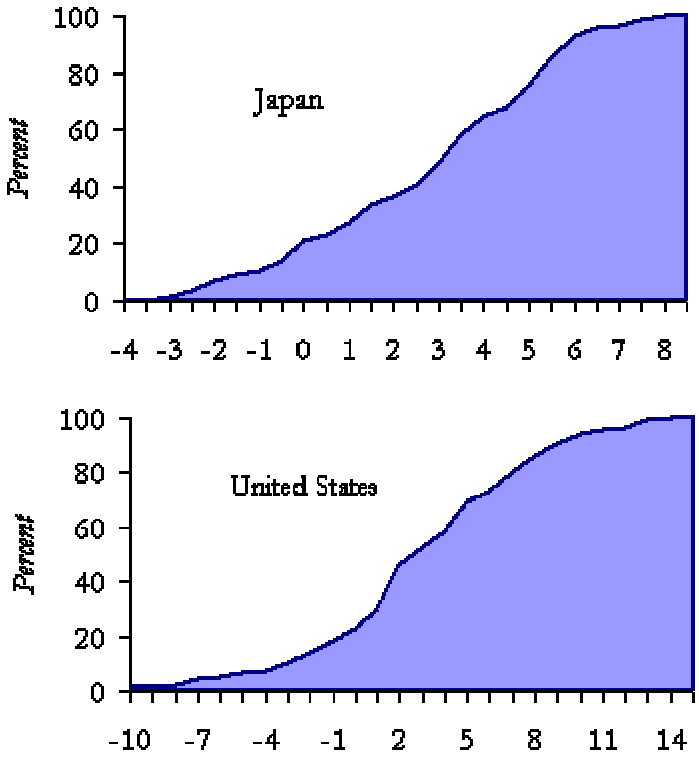
Estimated ex ante and 'equilibrium' real policy interest rates



With regard to the insurance value of some inflation, the more evocative representation of the data is to sort the observations for both countries by the level of the estimated equilibrium real interest rate, as in the cumulative distributions plotted in figure 8. In particular, in about one in five of the quarters since 1976 the estimated equilibrium real rate was in negative territory. Thus, strict price stability—a measured inflation rate of zero—would have bound the central bank from providing interest-rate stimulus sufficient to eliminate the output gap on many occasions.

Figure 8

Cumulative distribution of estimates of the 'equilibrium' real policy interest rate



Estimated 'equilibrium' real policy rate

From a risk-management perspective, the region to the left of zero can be reduced by allowing some positive inflation, acknowledging that some efficiency losses may occur as households economize on money balances, resources are used up changing price tags, and tax distortions loom larger. However, the need to avoid that region depends critically on policymakers' assessment of their ability to prevent such outcomes and the efficacy of its tools should the nominal short rate become pinned to zero.

5. What are the Tools of Policy in a Period of Low Inflation?

Japan's experience at and the United State's close brush with the zero lower bound to nominal interest rates have elicited considerable attention from the economics profession. Some contributions have rigorously framed the problem in a general equilibrium setting, for example, Woodford's description of the rate of time preference dipping for a time into negative territory (Woodford, 2003). Some models have emphasized the importance of shaping expectations about the future path of the policy rate, either by committing to a permanent expansion in the monetary base (as in Auerbach and Obstfeld, 2004) or by being explicit about future interest rate action (as in Eggertsson and Woodford, 2003). And in some examples, other policy levers provide the needed impetus, whether fiscal policy (Eggertsson, 2003) or the external sector (Svensson, 2001). Less work has been done thus far on empirical aspects of the zero bound, with the exception of Nagayasu's explication of the behavior of the term structure of interest rates during the zero interest rate period (Nagayasu, 2004) and Shirakawa's examination of balance sheet adjustment during that episode

(Shirakawa, 2001). The purpose of this section is not to review the options of policymaking in extremis (as is done in Bernanke, 2002, or Bernanke and Reinhart, 2004) but rather to point out two lessons of more general practicality to a central bank that is operating in a low-inflation environment.

The first lesson is that policymakers operating at a nominal interest rate above the zero bound should appreciate that their actions can make becoming pinned at the zero bound less likely. In particular, two strategies for action exist if there is significant potential for an adverse shock. Policymakers can "save their ammunition" by waiting until the shock materializes before acting, or they can move preemptively before expected shock. Simulation work in a large-scale econometric model (such as Reifschnieder and Williams, 2000) indicates that it is better to have the economy on the strongest possible footing when the shock hits by easing before, even accepting the fact that policy would be mispositioned should the shock not materialize. Unless the act of easing has an independent effect from the level of the rate (which might occur, say, if policy action if timed with the release of adverse news bolstered confidence), moving preemptively works better.

There are tradeoffs, of course, in that erring toward the side of ease when rates are low would create an inflation bias, but the earlier discussion suggests that an inflation goal of zero maybe too low. And a systematic tendency to err toward an easier policy when adverse shocks bulk large and nominal interest rates are low can be offset by a willingness to unwind that accommodation quickly once the situation clears.

The second general lesson to take away from the work on the zero bound is that the short-term nominal interest rate under the direct control of policymakers has little direct effect on behavior. Rather, it is the current value of the short-term rate and its expected future course that gets embedded into capital values and that thereby affects spending decisions. Even if the nominal short-term rate is low, a central bank can provide impetus to the economy if it can convince investors that the rate may hold at that level for longer than previously expected or that it may go even lower. For such assurance to be credible, a policymaker's description of its outlook and public understanding of the policymaker's objectives must combine to indicate a subdued path of short-term rates for, to coin a phrase, a considerable period.

That this lesson is nothing new is an understatement. In 1936, John Maynard Keynes explained in *The General Theory* that

> …the rate of interest is a highly conventional, rather than a highly psychological, phenomenon. For its actual value is largely governed by the prevailing view as to what its value is expected to be. (Keynes, 1936, pp. 203)

Lord Keynes went on to draw out the policy implication.

> Such comfort as we can fairly take from more encouraging reflections must be drawn from the hope that, precisely because the convention is not rooted in secure knowledge, it will not be always unduly resistant to a modest measure of persistence and consistency of purpose by the monetary authority. (Keynes, 1936, p. 204)

Work in the field since then has increasingly viewed expectations about the future course of interest rates as centrally connected to investors' outlook for the economy, rather than as a *deus ex machina* convention. But these insights offer the possibility

that, by conveying its view of the economic outlook to the public, perhaps with a modest measure of "persistence and consistency of purpose," a monetary authority can induce helpful adjustments in capital values (in a manner described rigorously by Woodford, 2003).

An interesting observation in that regard can be gotten by examining the volatility of private-sector interest rates along the term structure in Japan and the United States. Table 6 records the absolute weekly change in one-month deposit rates and swap yields at the two-, three-, five-, and ten-year maturity from 1990 to mid-year 2004. As is evident, yields at the front end of the term structure—at the one-month maturity—have been equally variable in both countries, at about a mean absolute change of 5 basis points per month. But volatilities have stepped up markedly moving out the yield curve in the United States in a manner not observed in Japan. At the ten-year horizon, swap yields in the United States have been almost twice as volatile as those in Japan. In the sense of Keynes and Woodford, U.S. markets appear to have been getting signals that vary more significantly as to the appropriate allocation of capital than do Japanese markets.

Table 6

Changes in selected nominal interest rates

Mean absolute weekly change, basis points

January 1, 1990 to May 21, 2004

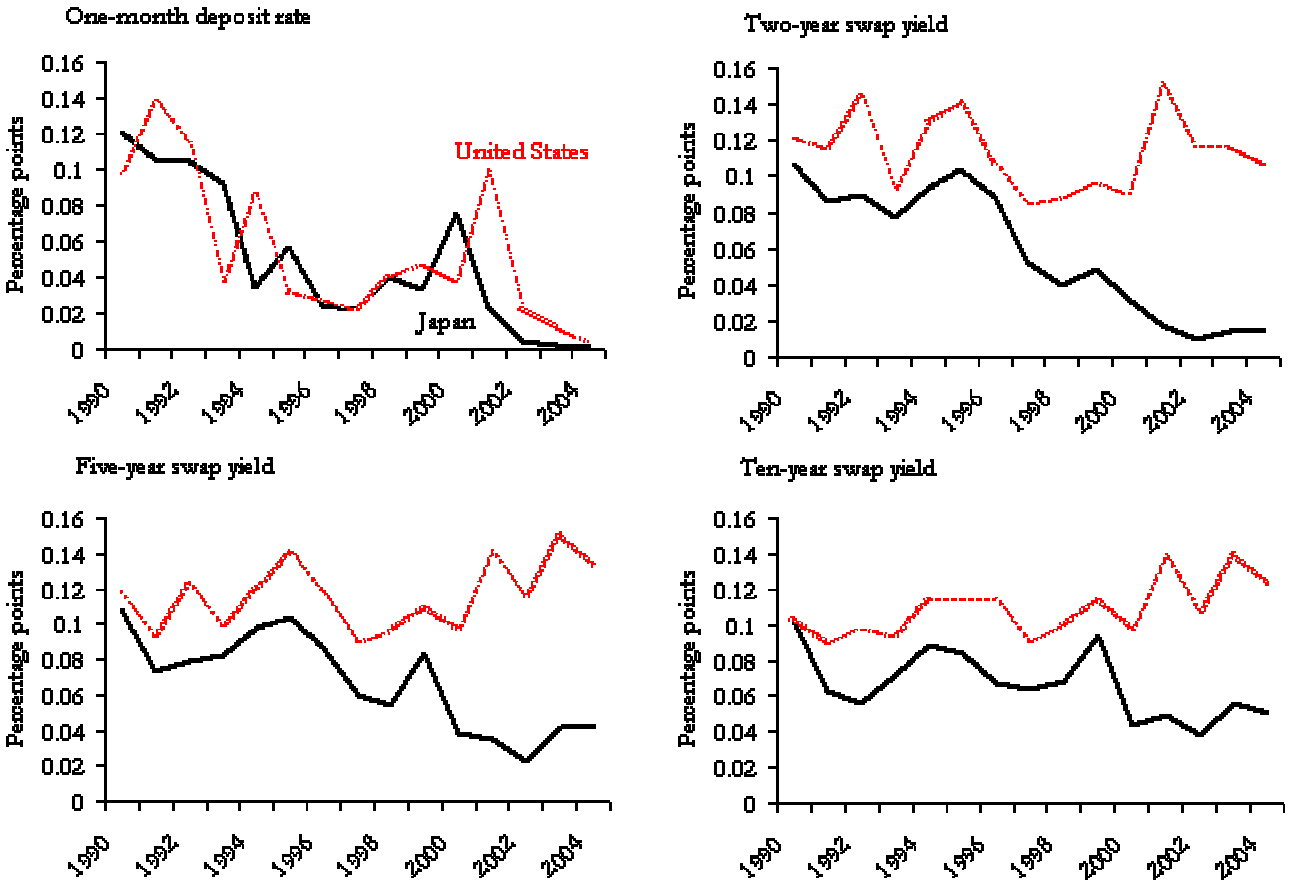
Obligation	Japan	United States
One-month deposit	5.2	5.7
Two-year swaps	6.0	11.4
Three-year swaps	6.8	11.6
Five-year swaps	6.8	11.6
Ten-year swaps	6.7	10.9

Source: Bloomberg

These longer-period averages are representative of finer slices of the data, as is clear in figure 9, which plots measures of the volatility of rates each year since 1990. Short rates, year-by-year, have been equally variable in the United States and in Japan. But this has decidedly not been the case further out the yield curve. One wonders if a policy tool—encouraging changes in the longer-run outlook—has either been left unexploited or for institutional reasons has been less available for use in Japan than in the United States.

Figure 9

Average absolute weekly change in selected private rates



Source: Bloomberg

Acting preemptively and shaping expectations about the economy are tools that are available to central banks at all times, and they may be particularly important when nonlinearities are feared to be adverse. But policy need not be constrained when events turn adverse and these two tools prove inadequate to the task. In particular, when the funds rate is zero, a central bank can over-supply reserves at that interest rate floor, a tactic that is described by Auerbach and Obstfeld (2004). In effect, a zero nominal funds rate is a classic example of the Brunner-Meltzer (1973) problem, in that the nominal rate is not informative about the stance of policy when it is attained at a depressed demand for reserves. Increasing the quantity of reserves at that point--that is, oversupplying reserves--may have an effect. In point of fact, our understanding of the monetary transmission mechanism is sufficiently imprecise not to rule out a quantity channel that might work through the size of banks' balance sheets or through banks' willingness to lend.

If oversupplying reserves has no obviously discernible effect, the central bank can attack the term structure of interest rates more directly. In particular, if asset prices adjust insufficiently to stimulate spending, then open market purchases of longer-term Treasuries, in sizable quantities if necessary, can move term premiums lower. Of course, such a promise to put a ceiling on parts of the yield curve would be reinforced if it were associated with a credible promise to keep the short rate along a path consistent with those long-term rates.

No doubt, all of these policy mechanisms are uncertain. Such uncertainty about containing deflation implies that the best policy is to deal with deflation by

strenuously avoiding it through preemptive action. Perhaps the most important message from Lord Keynes, filtered through what has been learned in the three-quarters century since he wrote, is that

> …a monetary policy which strikes public opinion as being experimental in character or easily liable to change may fail in its objective of greatly reducing the long-term rate of interest… (Keynes, 1936, p. 203)

Improvisation indicates a commendable flexibility of action, but is an unfortunate trait in an entity relied upon to provide a predictable backdrop against which investors price long-lived assets. Before a central bank puts even slim odds on policy alternatives at the zero bound to nominal interest rates, it should use its conventional interest rate stimulus as aggressively as possible and should explain the alternative—and ultimately effective—sources of stimulus once the zero bound takes hold.

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