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CONTROLLING INFLATION AFTER BRETTON WOODS: AN ANALYSIS BASED ON POLICY OBJECTIVES

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ABSTRACT

This paper reviews the inflation experience in the post-Bretton Woods era in the context of alternative central bank objectives. It summarizes research on inflation-targeting issues, especially those associated with stabilizing the price level. Generally, inflation-targeting schemes do not provide a nominal anchor unless the central bank is focusing strictly on the inflation target and ignoring unemployment and the business cycle. Research summarized in this article suggests that the most important step a central bank can take to improve policy is to decide on a long-term path for the price level. Being explicit about the desired path for the price level not only reduces inflation variability at all horizons, but also gives the policymaker more flexibility to pursue output stabilization goals.

KEYWORDS: Inflation Targeting, Monetary Policy Objectives

JEL CLASSIFICATION: E42, E52

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Controlling Inflation after Bretton Woods: An Analysis Based on Policy Objectives

I. INTRODUCTION

The Czech Republic and other economies in transition are facing the same problem that Western democracies faced in 1973 when the international monetary system based on a modified gold standard collapsed. These countries are now learning how to develop and maintain an efficient paper money standard, to find a way to anchor the purchasing power of their currency. When the Bretton Woods System came apart, the West went through a long cycle of rising, then falling, inflation. Was this a one-time learning experience? Will the transition economies learn from the mistakes of the United States and other Western countries? Have Western countries learned how to prevent such cycles from recurring?

These are questions without clear answers, despite an abundance of research on changes in monetary regimes and specific monetary policy rules. The main problem is that most of this research does not address the issue of the nominal anchor directly. This article summarizes research on the degree of price stability implied by alternative monetary policy regimes.

The best option for a small open economy like the Czech Republic may be to tie its monetary policy to a larger trading partner. Certainly, the idea of fixing the Czech koruna to the European euro is one possibility. But exchange rate rules are not considered here. Rather, this article examines issues that arise when a country adopts an independent monetary policy. Using a common framework, the article compares actual outcomes to those that might be expected under alternative assumptions about central bank objectives.

Section II reviews the inflation experience in the post-Bretton Woods era. Section III summarizes our research on issues in inflation targeting, especially those associated with stabilizing the price level.[1] Section IV investigates the improvement in price stability that can be achieved by adding a long-term price-level objective to an inflation-targeting regime. Section V presents results from our model calibrated to time series data for selected countries and periods. Section VI concludes.

II. THE INFLATION EXPERIENCE IN SELECTED COUNTRIES

Since the end of Bretton Woods, most discussion about price stability has been in terms of inflation, not the price level. Figure 1a shows the inflation rates for five countries are key currency countries or had relatively high inflation after March 1973. As Figure 1a shows, inflation rates were relatively low and close together before Bretton Woods ended. By March 1973, all of the countries, except Germany, began to experience higher and more variable inflation. While there were a variety of monetary policy experiments in these countries, all adopted some form of monetary targeting. Of these five, only Germany continues to advocate monetary targeting as a framework for achieving and maintaining price stability. (Interestingly, Bernanke et al. (1999), who advocate inflation targeting, list Germany as a country that implicitly targets inflation even though it announces targets for the monetary aggregate, M3, and has never adopted short-run targets for inflation. Also, Clarida and Gertler (1999) describe German policy more as an inflation-targeting regime than as a monetary targeting policy.)

[1] This article draws heavily on research by Dittmar, Gavin, and Kydland (1999a and 1999b) as well as work by Dittmar and Gavin (1999).

Monetary targeting was most prevalent from 1973 through 1985, the period when inflation was highest and most volatile. While common behavioral patterns are evident in Figure 1a, the country detail is not. Figures 1b through 1e show the inflation rates of Japan, the United States, the United Kingdom and Italy in combination with the inflation rate for Germany, which had the lowest inflation rate for the full 40-year period.

The countries are ordered by their success in getting control over inflation. Although Japan and the United States had the same average inflation throughout the 40-year period, Japan is placed first because Japanese monetary authorities were several years ahead of the United States in getting control over the inflation. Initially, Japan reacted to the quadrupling of the world oil price in 1973 by allowing the inflation rate to soar above 20 percent per year. Japanese inflation remained in double digits throughout 1973 and 1974. By 1977, inflation began to come down. Since 1980, Japan's average inflation rate has been lower than Germany's (see Figure 1b).

The U.S. government adopted wage and price controls in conjunction with an expansionary monetary policy in the early 1970s. In 1973, inflationary pressures associated with rising world oil prices brought an end to price controls and a rapid acceleration of inflation (see Figure 1c). Monetarists in academia and at the St. Louis Federal Reserve Bank argued for stricter monetary targeting—keeping money growth closer to the target in the short run and achieving the average target growth rate over a longer horizon (eliminating the year-end drift in the base of the target). Such stricter monetary targeting implied less emphasis on keeping output at its full-employment potential and smoothing short-term interest rates.

The U.S. Congress passed a resolution in 1975 advising the Federal Reserve to set targets for monetary and credit aggregates. In 1978, it passed a law requiring the Federal Reserve to set annual targets for money and credit. Although it appeared that the Federal Reserve had gained control over inflation in 1975-1976, both monetary growth and inflation surged upward with the 1979 oil price shock.

On October 6, 1979, the Federal Reserve System announced the beginning of a new resolve to reduce inflation by restricting the growth of the monetary aggregates. New procedures were adopted that set weekly targets for a monetary reserve aggregate rather than an interest rate. The policy led to high and volatile *ex post* real interest rates, but no significant decline in monetary growth. Despite the failure of monetary aggregates to slow, inflation (as measured by the CPI) fell sharply from a 15 percent annual rate in the first quarter of 1980 to less than 2 percent in the last quarter of 1982.

The pattern of inflation in the United Kingdom was much the same as in the United States, but the average rate was somewhat higher (see Figure 1d). In Italy, the CPI inflation rate remained in double digits until 1985 (see Figure 1e). By then, all five countries appear to have gained more control over inflation. The period following 1984 appears to be one of relatively stable inflation, more like the period under the Bretton Woods Agreement.

The unweighted average CPI inflation rate in these five countries for this 40-year period was 5.4 percent, and the standard deviation of quarterly inflation was 5.1 percent at an annual rate. In the period following the breakdown of the Bretton Woods agreement, average inflation rose to 9.8 percent and the average standard deviation rose one-half percentage point to 5.6 percent. Since the end of 1984, the average inflation rate has dropped dramatically to 3.3 percent, somewhat below the average during the period of Bretton Woods. The average standard deviation of inflation also has been much lower at 2.6 percent.

The inflation rates shown in Figure 1a were associated with widely varying behavior of price levels. Figure 2 shows the Consumer Price Index (CPI), normalized to one in January 1957, for each of our five countries. Italy had the highest average inflation (7.8 percent at an annual rate) throughout the last 40 years, more than 2 percentage points above the average. The lowest average inflation was in Germany where the inflation rate averaged 3.2 percent during the full period, more than 2 percentage points below the average. The broad range of experience in Figure 2 is shown to provide a benchmark for considering the magnitude of uncertainty about the price level implied by alternative monetary policy regimes.

III. INFLATION TARGETING AND PRICE-LEVEL STABILITY

Would a price-level objective destabilize the economy? The idea of inflation targeting is appealing both to those who think that having a target for inflation focuses policymakers' attention on the inflation objective, as well as to those who want rule-like policy, but believe that the central bank can still achieve multiple objectives. The problem with inflation targeting is that it does not tie down the price level. It does not provide a nominal anchor. If a nominal anchor is the goal, why not target the price level directly? Fisher (1994), Cecchetti (1998) and Kiley (1998) offer intuitive explanations—based on analysis of a single price shock—about why attempting to achieve a price-level objective would increase the variability of inflation and output. Milton Friedman (1968) made perhaps the most influential objection to price-level targeting in his December 1967 presidential address to the American Economic Association. In recommending how monetary policy should be conducted, he explains why he would not target a price level:

> "Of the three guides listed, the price level is clearly the most important in its own right. Other things the same, it would be much the best of the alternatives—as so many distinguished economists have urged in the past. But other things are not the same. The link between the policy actions of the authority and the price level, while unquestionably present, is more indirect than the link between the policy actions of the authority and any of the several monetary totals. Moreover, monetary action takes a longer time to affect the price level than to affect the monetary totals and both the time lag and the magnitude of the effect vary with circumstances. As a result, we cannot predict at all accurately just what effect a particular monetary action will have on the price level and, equally important, just when it will have that effect. Attempting to control directly the price level is therefore likely to make monetary policy itself a source of economic disturbance because of false stops and starts. Perhaps, as our understanding of monetary phenomena advances, the situation will change. But at the present state of our understanding, the long way around seems the surer way to our objective. Accordingly, I believe that a monetary total is the best currently available immediate guide or criterion for monetary policy—and I believe that it matters much less which particular total is chosen than that one be chosen." (Page 15)

This was written before the Rational Expectations revolution had taken hold. Our understanding of monetary phenomena has advanced since then. We now know that the immediate effect of a monetary policy action on anything will vary with circumstances. The way to evaluate policy strategies is not to look at the effect of a single action, but rather to examine the implications of alternative rules in dynamic model economies.

This section summarizes research that uses a dynamic framework popularized by Lars Svensson (1997, 1999). Svensson (1999) showed that, for the case with a Neoclassical aggregate supply function and a persistent output gap, a price-level targeting regime would result in less short-run inflation variability than an inflation targeting regime. Using a simplified version of Svensson's model, Dittmar et al. (1999a) then derived inflation-output variability tradeoffs (Taylor Curves) for inflation targeting and price-level targeting regimes.

This simple policy model has two components. One is a central bank objective function,

$$L = \sum_{t=0}^{\infty} \beta^t \left(\lambda\, y_t^{\,2} + (\pi_t - \pi^*)^2 \right), \tag{1}$$

where y_t is the deviation of output from the target level (which we assume is the underlying trend in real output) and (π_t - π^*) is the deviation of inflation from the central bank's inflation target. The central bank discounts future variability in the output gap and inflation by the factor β. The parameter, λ, relates the central bank's preference for output stability to its preference for inflation stability.

The other component is a short-run aggregate supply curve with persistence in the output gap:

$$y_t = \rho\, y_{t-1} + \alpha(\pi_t - \pi_t^e) + \varepsilon_t . \tag{2}$$

The introduction of a lagged output gap in this equation is important in comparing inflation and price-level targeting. Conceptually, the lag will be introduced any time some friction prevents instantaneous and complete adjustment of output to unexpected changes in the price level. This friction could be induced by incomplete information, wage contracts, menu costs, transaction costs, incomplete markets, capital adjustment costs, etc. Dittmar and Gavin (1999) show that the introduction of lagged output tends to make the Neoclassical aggregate supply function look more like the New Keynesian supply functions described in Roberts (1995).

With this aggregate supply curve and rational expectations, that is, $\pi_t^e = E_{t-1}\pi_t$, the central bank's optimization problem implies a tradeoff between output and inflation variability.[2] Minimizing this loss function—subject to the aggregate supply curve—leads to a rule for inflation that is contingent on the size of the output gap.

$$\pi_t^A = \pi^* - \frac{\alpha\lambda\rho}{1-\beta\rho^2}\, y_{t-1} - \frac{\alpha\lambda}{1-\beta\rho^2+\alpha^2\lambda}\,\varepsilon_t, \tag{3}$$

where the superscript *A* indicates that the variable is determined by the inflation-targeting rule.[3] The inflation rate in each period is set equal to the inflation target, with countercyclical adjustments proportional to the lagged output gap and the current technology shock. Note that this stylized model assumes that the central bank can control the inflation rate directly. Thus, we cannot address questions involving the slippage between changes in central bank instruments and its effect on inflation uncertainty. The issue of how a central bank controls inflation is irrelevant in comparing inflation and price-level targeting. One step ahead, the control problem is identical. An appendix in Svensson (1997) shows that introducing money with a control error in the inflation equation would not change his results.[4]

If the central bank cares about deviations of the price level rather than the inflation rate, the natural logarithm of the price level, *p*, will replace the inflation rate in the loss function. For price-level targeting, we reformulate the objective function as

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[2] Taylor (1979) showed that, in macroeconomic models with Rational Expectations, there was no tradeoff between the mean growth rate of inflation and the level of output, but there was a tradeoff between the second moments.

[3] See the appendix in Dittmar et al. (1999a) for solution details. Note that the central bank is assumed to take expectations as given. There is no attempt to manipulate the public's expectations.

[4] We could follow the example of Clarida et al. (1999) and use a two-step procedure to derive interest rate rules. First, they solve a model like ours for the desired output. Then, in a second stage, they substitute the decision rule for output into an IS relation to find the interest rate rule. We do not think that this would affect any of our conclusions about the relative desirability of inflation vs. price-level targeting.

$$(4) \qquad L^B = \sum_{t=0}^{\infty} \beta^t \left(\lambda\, y_t^{\;2} + (p_t - p_t^*)^2 \right).$$

The target path for the price level may be constant or may be rising at a constant rate. The superscript B indicates that the loss function is for the case where the central bank has a price-level objective.

The central bank's rule for achieving the target path is given by

$$(5) \qquad p_t^B = p_t^* - \frac{\alpha\lambda\rho}{1-\beta\rho^2}\; y_{t-1} - \frac{\alpha\lambda}{1-\beta\rho^2+\alpha^2\lambda}\; \varepsilon_t,$$

implying the following rule for the inflation rate:

$$(6) \qquad \pi_t^B = p_t^B - p_{t-1} = \pi^* - \frac{\alpha\lambda\rho}{1-\beta\rho^2}(y_{t-1} - y_{t-2}) - \frac{\alpha\lambda}{1-\beta\rho^2+\alpha^2\lambda}(\varepsilon_t - \varepsilon_{t-1}).$$

The price-level target, p_t^*, is given by $p_t^* = \pi^* + p_{t-1}^*$. With the price-level target, the central bank's reaction function (6) has three elements on the right-hand side. The first is the steady-state inflation embodied in the target path for the price level. The second and third are proportional, countercyclical adjustments to the change in the output gap from period *t*-2 to period *t*-1 and the change in the technology shock from period *t*-1 to period *t*, respectively.

As Svensson (1999) explains, the relative variance of inflation under inflation and price-level targeting rules depends on whether the output gap itself is more or less variable than its rate of change. If the output gap is highly persistent (ρ >0.5), the output gap itself will be more variable than its rate of change and the inflation rate will be more variable under an inflation-targeting regime. The answer to the question opening this section is no, stabilizing the price level should not destabilize short-run inflation or the real economy. In the commonly used aggregate supply framework, the price-level target actually results in less short-run volatility, not more. The better performance expected under price-level targeting can be seen in the Taylor curves for inflation and price-level targeting in Figure 3. There we used the Neoclassical aggregate supply function with ρ calibrated to persistence in the different countries (always greater than 0.5). We return to this figure in Section V.

Kiley (1998) objected to the use of the Neoclassical aggregate supply curve and suggested that one based on New Keynesian theories would be more realistic and less likely to favor the price-level target. Dittmar and Gavin (1999) modified this framework to incorporate a New Keynesian aggregate supply function. They derived results showing that price-level targeting is preferred over inflation targeting in the New Keynesian case for all values of the central bank's preference parameter, λ, and all values of ρ.

It is important to derive the dynamic properties of economies when comparing alternative regimes. Our results are derived in model economies with forward-looking expectations. This is a critical choice. Simulations of econometric models typically find that targeting the price level is a bad idea. Economists have attributed this result to the presence of nominal rigidities such as wage contracts or price adjustment costs. Yet in these econometric experiments, it is also true that inflation expectations are almost always backward-looking. For example, Haldane and Salmon (1995) use a small econometric model with adaptive inflation expectations to examine whether monetary policy targets for price stability should be expressed in levels or rates of change. They find that price-level targeting results in higher short-run variability for both inflation and output growth. These results are typical of econometric model simulations with backward-looking expectations.[5]

Two notable examples use econometric models modified to include forward-looking behavior in the financial sectors. Black, Macklem, and Rose (1997) look at rules that combine a long-term price-level objective with a short-term inflation-targeting rule. The presence of an error-correction term guarantees the eventual return of the price level to its long-run target path. For values of the error correction parameter between 0.1 and 0.125, they derive a Taylor Curve that is better than with the inflation rule alone. Using a policy model estimated at the Board of Governors of the Federal Reserve System, Williams (1999) finds "interestingly, targeting the price level rather than the inflation rate generates little additional cost in terms of output and inflation variability. Under price-level targeting, the expectations channel helps stabilize inflation, thereby eliminating much of the output stabilization costs that would otherwise be associated with reversing deviations of the price level from its target." Williams confirms the view that price-level targeting fares so badly in econometric simulations because this is exactly the type of exercise for which the Lucas Critique is likely to be most relevant. The policy rules that were most efficient in reducing inflation and output variability when the model assumes forward-looking expectations turn out to be the worst when fixed adaptive expectations are assumed. And vice-versa, policies that are efficient when expectations are assumed to be adaptive do poorly when expectations are forward looking.

Does Inflation Targeting Anchor the Price Level? Adoption of a long-run price-level objective would probably enhance the short-run stabilization options facing central

[5] See Haldane and Salmon (1995) for further references.

banks. But the reality is that central banks are adopting inflation targets, not price-level targets. The question that arises is how much slippage of the nominal anchor is allowed under an inflation-targeting regime—and how much would we have to change current policies to eliminate some of the slippage? Dittmar et al. (1999b) address this question by conducting 40-year experiments using the models presented above. They find that the price level and inflation inherently uncertain in current proposals to target inflation. The degree of price-level uncertainty depends largely on how aggressively the central bank tries to stabilize the real economy.

To calculate the price-level uncertainty expected under inflation-targeting regimes, we ran the model repeatedly under alternative assumptions about the model parameters. In the computational experiments, ρ was set equal to 0.9 and α equal to 0.5. We assume that the interest rate is 4 percent at an annual rate, so the quarterly discount factor is approximately 0.99. The standard deviation of the random error in the aggregate supply function (2) is assumed to be 0.75 percent at a quarterly rate. The two most important parameters in this model are the degree of persistence in the output gap, ρ, and the central bank's relative preference for output stabilization, λ. The values for ρ and the standard deviation of the random error in the aggregate supply function are chosen to approximate estimates for the U.S. economy.

The experiment is run here using four alternative values of λ: 0.5, 0.33, 0.25, and 0.1.[6] The upper panel in Table 1 reports standard errors for deviations of the average inflation rates from the central bank's target. The model was run for 160 periods (corresponding to quarters). There were 100 replications in each experiment. Each experiment was started with the same random number seed, so that the same series of random errors was used in each column of the table. There were 100 prices saved for each period. Trimming 16-2/3 percent off each tail of the distribution of prices in each period produced the data in the table. Because the samples were relatively small, the distributions were not perfectly symmetric. The standard deviations reported are the averages of the absolute deviations associated with the upper and lower tails. The average inflation rates were calculated from the beginning to the reported horizon. The standard deviation of the price level from its expected path for the reported horizons is shown in the bottom panel of Table 1.

The two most important results are: 1) inflation targeting does not pin down the price level, and 2) the weight the central bank puts on output stabilization really matters. With $\lambda = 0.5$, the standard deviation of the inflation rate is 3.2 percent at a five year horizon. If the central bank targets inflation at 2 percent, we would expect the actual five-year-ahead inflation rate to be greater than 5 percent or less than –1 percent one-third of the time. In calculating the inflation risk associated with a 20-year investment, we would expect the average inflation rate to be greater than 4 percent or less than zero percent one-third of the time. If the inflation target were the 40-year average of the five countries shown in Figure 1, 5.4 percent plus and minus one standard deviation of the average inflation expected over 40 years nearly includes the 7.75 percent inflation of Italy and the 3.2 percent inflation in Germany. The bottom panel shows that with $\lambda = 0.33$, there is still an enormous range of uncertainty about the price level at a 40-year horizon (±57.4 percent).

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[6] Cecchetti et al. (1999) estimate the value of our preference parameter, λ, for a number of European

McCallum (1997) compares the log of the price level that follows a pure random walk to a preset target path. He assumes that the random walk has an unpredictable component at the quarterly frequency that is approximately equal to the standard deviation of one-step-ahead forecast errors for the United States throughout 1954-91 (0.0045 percent at a quarterly rate). With this pure random walk assumption, the 20-year-ahead price level has a standard deviation of only 4 percent. Compare this to the 32 percent standard deviation for the 20-year-ahead price level that is implied by the typical inflation targeting rule when the value of λ is as high as 1/3. Even setting λ as low as 0.1 results in three times more uncertainty about the price level than is implied by the standard deviation in the case of the random walk. So the answer to the second question of this section is no, the typical proposal to target inflation does not provide a nominal anchor.

IV. MONETARY POLICY WITH A PRICE-LEVEL OBJECTIVE

Dittmar et al. (1999b) also show that if central banks want to both stabilize business cycle fluctuations and achieve price stability, they may find it useful to adopt a long-term objective for the price level. One way to do this is to follow Black, Macklem, and Rose (1997) and write down an inflation-targeting rule with an error-correction term for the deviation of the actual price level from the long-term path implied by the inflation target. Another way is to suppose that there is a policymaking committee that includes a mixture of policymaker types, A and B. Type A policymaker's loss function is given by

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countries and conclude that it is often found to be around 0.33.

L^A and type B policymaker has a loss function, L^B. The monetary policy rule can be rewritten approximately as a combination of the two rules:[7]

(7) $$\pi_t = \delta \pi_t^A + (1-\delta)\pi_t^B .$$

When δ= 1, policymakers all want to target inflation and the central bank follows the rule given in equation 3. When δ= 0, nobody wants to target inflation, and the central bank follows a price-level rule. When δ falls between 0 and 1, there are policymakers of both types on the committee and the central bank follows a combination rule that is equal to the an inflation-targeting rule with an error-correction term on the deviation of the price level from a target path. To show this, we substitute equations 3 and 5 into 7 to get

(8) $$\pi_t = \pi^* - \frac{\alpha\lambda\rho}{1-\beta\rho^2} y_{t-1} - \frac{\alpha\lambda}{1-\beta\rho^2+\alpha^2\lambda}\varepsilon_t + (1-\delta)(p_{t-1}^* - p_{t-1}).$$

Equation 8 has the same form as equation 3 except for the addition of the error correction term. This general form of the model is used to examine the effects of changing the relative weight on the alternative rules.

Table 2 presents the results of running the inflation-targeting experiment for our combination rule. Here, we assumed the value of 1/3 for the central bank's preference parameter, λ. The first column of Table 2 merely repeats the second column of Table 1, where there was no price-level targeting involved. Here the 20-year-ahead inflation rate had a standard deviation of 1.6 percent around the target. Putting just a small, 0.01, weight on the price-level deviation reduces the standard deviations by 25 percent. Putting one-tenth of the weight on the price-level deviations reduces the standard deviations by 75 percent. As the table shows, even when the error-correction parameter

[7] The exact solution for the combined model is more complicated because people take account of both objective functions when solving the model.

is as large as 0.1, the uncertainty about the price level at relevant horizons is still almost twice as great as McCallum's random-walk example.

V. MONETARY POLICY IN SELECTED COUNTRIES

In this section, we compute the Taylor Curves implied by calibrations based on data from the five countries selected earlier. The Taylor Curves show a frontier of minimum combinations of standard deviations for inflation and the output gap that would be achievable according to our simple model. We do not look at counterfactual experiments or examine the expected consequence of the combination policies. Doing so would require more rigorous empirical research than is presented here. The effects of monetary policy operate through expectations about how policy will be conducted in the future. In the best of circumstances, these expectation channels are difficult to identify in empirical work. Complicating this task is the evolution of macroeconomic theory and shifting priorities among policymakers and the general population that occurred during the post-Bretton Woods period.

Simulations of the model result in a strong and stable relationship between output and inflation. In the model, the central bank can control output at short horizons. This assumption is probably not true, but is implied by most of the models, both theoretical and empirical, that are used by central bank economists and their private-sector counterparts. Aggregate supply relations are not identified in any of the five countries.[8] In this section, we simply assume that the aggregate supply parameter, α, is equal to 0.5. The value of the coefficient on expected inflation in the velocity function, θ, is assumed

[8] The macro data on GDP, the monetary aggregates, and the CPI used in this paper were series published by *International Financial Statistics* for each of the countries.

to equal 0.4. Dittmar and Gavin (2000) show that the results are not sensitive to a reasonable range of values for α and θ. Also, the location of the Taylor Curves for monetary targeting were relatively insensitive to assumptions about the amount of persistence in the velocity error.

The output gap was calculated by regressing the logarithm of real GDP for each of the five countries on a quadratic time trend. The standard deviations of the output gap and inflation are reported for each period in the bottom panel of Table 3. They are also shown as points in each of the panels of Figure 3, which shows the Taylor Curves for the individual countries. The quarterly standard deviation of inflation here is based on the change in the logarithm of the GDP deflator (Table 1 reports CPI statistics).

The policy model developed above is calibrated to the five countries: Germany, Japan, the United States, the United Kingdom, and Italy. We estimate values for the first-order autocorrelation in the output gap. The equation used to estimate ρ is given as

$$\Delta y_t = c + \rho\, y_{t-1} + \sum_{t=1}^{5} \phi_i\, \Delta y_{t-i} + e_t .$$

The properties of the distribution for this estimate were discussed in Dickey and Fuller (1981). The equations used to estimate the autocorrelation parameters also yield estimates of the variance of output shock for each country. The standard error of the output shock used in the calibrations is calculated as the standard deviation of the sum of two last terms in the equation, $\sum_{i=1}^{5} \phi_i\, \Delta x_{t-i} + e_t$. This was done because cyclical components in output are not adequately captured by our simple model.

The post-Bretton Woods period is split in two parts, 1973:Q2 to 1984:Q4 and 1985:Q1 to 1998:Q4. In the earlier period policy seemed to be more erratic with rising inflation in all countries but Germany. In the latter period, these countries all found a way to stabilize inflation. Table 3 shows the estimates of the autoregressive parameters calculated for the output gap for each period. The table also reports the statistics used to calibrate the models that generate the Taylor Curves in Figure 3.

For Germany, only the first-period results are reported because the data available did not adequately adjust for the effect of the unification on GDP and the monetary aggregates. The values used to calibrate the Taylor Curves for Germany (see first panel in Figure 3) are shown in the first column of Table 3. The standard deviation of the output shock was in the low end, equal to Italy's and somewhat greater than Japan's, but less than estimates for the United States and United Kingdom. However, the estimate of the persistence in the output gap was the lowest for all countries in either period. Since we are using Svensson's Neoclassical supply function, the relatively low persistence of the output gap means that the Taylor Curve for price-level targeting is not so far below the one for inflation targeting. The location of the actual value of the output variance, 2.3 percent, is above the highest value suggested by the Taylor Curves generated from inflation-targeting and price-level targeting regimes.

Japan is a very interesting case because it is the only one in which the Taylor Curves shift rightward in the second period. The scales in the panels of Figure 3 are all the same so that the curves can be more easily compared. Note, however, that the comparisons across time for each country are more relevant than the comparisons between countries. The reason is simply that measurement methods may be so different that cross-country comparisons are suspect. In the Japan's case, the standard deviation of the output shock is only slightly lower in the second period, while the persistence of the output gap is much closer to unity.

In the United States, the standard deviation of the output gap declined by about two-thirds from the earlier to the latter period. Although there was a substantial increase in the persistence, there was still a large downward (leftward) shift in the Taylor Curves in the second period. The Taylor Curves for the United Kingdom in the earlier period look similar to the curves for Japan in the second period. In the United Kingdom, the standard deviations of both shocks fell by about half, and there was little change in the autocorrelation estimate for output. Italy is an interesting case because it has a relatively low standard deviation of the shock to the output gap, but has the highest persistence, so the Taylor Curves are not much different than those for the United Kingdom. The big leftward shift in the United Kingdom was associated with a lower error variance, while in Italy, it was a combination of a lower variance and a lower estimate of the persistence in output.

One common aspect of all of our countries is that the inflation variances are all smaller in the second period, even in Japan, where the output variance is 50 percent larger than in the earlier period. In almost every case (the exceptions are Japan and Italy in the earlier period), the actual values for the standard deviations of the output gap lie above the maximum value for the standard deviation of output found on the Taylor Curves for inflation and price-level targeting. One explanation for this is that the model is too optimistic about the central bank's ability to control output. Perhaps the output variance is given by nature (or some other aspect of economic policy), and all monetary policymakers can do is stabilize the inflation rate. Indeed, some analysts have argued that the main service provided by explicit inflation targeting is to give central banks the political cover to ignore the output gap. The Taylor Curves shown in Figure 3 were calculated from pure policies. In future work, we intend to consider combination policies like those considered in the previous section.

VI. CONCLUSION

Our research shows that commonly proposed rules for targeting inflation generate an enormous amount of uncertainty over the long run. Inflation-targeting schemes do not provide a nominal anchor unless the central bank is focusing strictly on the inflation target and ignoring unemployment and the business cycle. Inflation has been unexpectedly stable in the 1990s. This may be partly because central banks have used inflation targeting as cover to ignore the real side. But, with the exception of Japan, it is also true that output fluctuations in these countries have been smaller in the 1990s than they were on average for most of the last half century.

The international monetary arrangements agreed to at Bretton Woods in 1946 reflected policymakers' confidence that they could build a system of fiat money standards that would provide price stability. For a variety of reasons, the system failed. The most important lesson that the Czech Republic, and all of us, can take from this experience is to focus on the inflation objective. Central banks focusing more sharply on inflation objectives have delivered lower and more stable inflation.

Research summarized in this article suggests that the most important step a central bank can take to improve focus on the inflation objective is to decide on a long-term path for the price level. Being explicit about the desired path for the price level not only reduces inflation variability at all horizons, but also gives the policymaker more flexibility to pursue output stabilization goals.

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Table 1: Uncertainty about the Price Level and Inflation With Inflation Targeting

	Standard Deviation of Average Inflation Deviation from Target			
Years	$\lambda = .5$	$\lambda = 1/3$	$\lambda = .25$	$\lambda = .1$
1	2.1%	1.6%	1.3%	0.6%
2	3.1%	2.4%	1.9%	0.9%
5	3.2%	2.4%	2.0%	0.9%
10	2.7%	2.0%	1.7%	0.8%
20	2.1%	1.6%	1.3%	0.6%
40	1.9%	1.4%	1.2%	0.5%

	Standard Deviation of Price-Level Deviation from Target			
Years	$\lambda = .5$	$\lambda = 1/3$	$\lambda = .25$	$\lambda = .1$
1	2.1%	1.6%	1.3%	0.6%
2	6.2%	4.8%	3.9%	1.8%
5	16.0%	12.2%	9.9%	4.6%
10	26.6%	20.4%	16.5%	7.7%
20	42.0%	32.2%	26.0%	12.2%
40	74.9%	57.4%	46.5%	21.7%

Table 2: Uncertainty about the Price Level and Inflation With Inflation Targeting and a Long-Term Price Objective (λ = 1/3)

	Standard Deviation of Average Inflation Deviation from Target			
Years	$\delta = 1$	$\delta = 0.99$	$\delta = 0.95$	$\delta = 0.9$
1	1.6%	1.1%	1.0%	1.0%
2	2.4%	1.9%	1.8%	1.6%
5	2.4%	2.2%	1.6%	1.2%
10	2.0%	1.7%	1.1%	0.8%
20	1.6%	1.2%	0.6%	0.4%
40	1.4%	0.8%	0.3%	0.2%

	Standard Deviation of Price-Level Deviation from Target			
Years	$\delta = 1$	$\delta = 0.99$	$\delta = 0.95$	$\delta = 0.9$
1	1.6%	1.1%	1.0%	1.0%
2	4.8%	3.9%	3.5%	3.3%
5	12.2%	11.0%	8.2%	6.1%
10	20.4%	17.1%	11.5%	7.9%
20	32.2%	24.8%	12.6%	7.5%
40	57.4%	30.5%	13.1%	8.0%

Table 3: Statistics Used in Calibrations of Taylor Curves

Standard Deviations of Inflation (at quarterly rates) and the Output Gap

1973:2 to 1984:4	Germany	Japan	United States	United Kingdom	Italy 1976:3 to 1984:4
Output Gap	2.3%	2.0%	2.9%	2.9%	2.3%
Inflation	1.4%	1.3%	0.6%	1.8%	1.1%
1985:1 to 1998:4					1985:1 to 1998:2
Output Gap		3.1%	1.8%	2.7%	1.5%
Inflation		1.0%	0.3%	0.7%	0.5%

First Order Autocorrelations (estimates of ρ)

1973:2 to 1984:4					1976:3 to 1984:4
Output Gap	0.76	0.88	0.81	0.89	0.95
1985:1 to 1998:4					1985:1 to 1998:2
Output Gap		0.94	0.92	0.90	0.87

Standard Deviation of Output and Velocity Shocks (at quarterly rates)

1973:2 to 1984:4	Germany	Japan	United States	United Kingdom	Italy 1976:3 to 1984:4
Output Gap	1.47%	1.01%	1.44%	1.36%	0.87%
					1985:1 to 1998:2
1985:1 to 1998:4					
Output Gap		0.98%	0.53%	0.74%	0.65%

Figure 1a: CPI Inflation for Select Countries

Monthly data, year-over-year growth

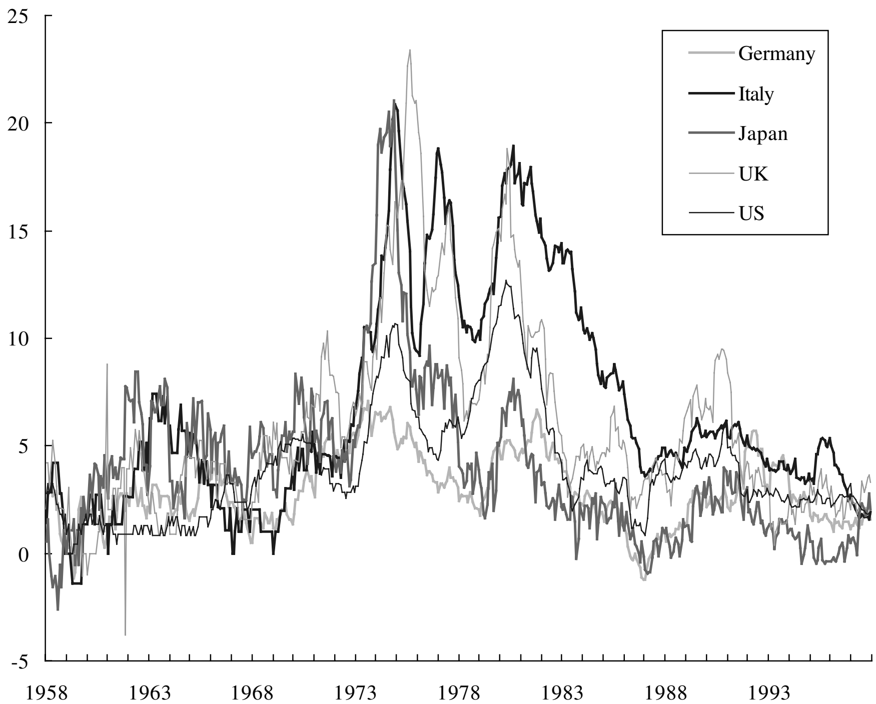

Figure 1b: CPI Inflation for Germany and Japan

Monthly data, year-over-year growth

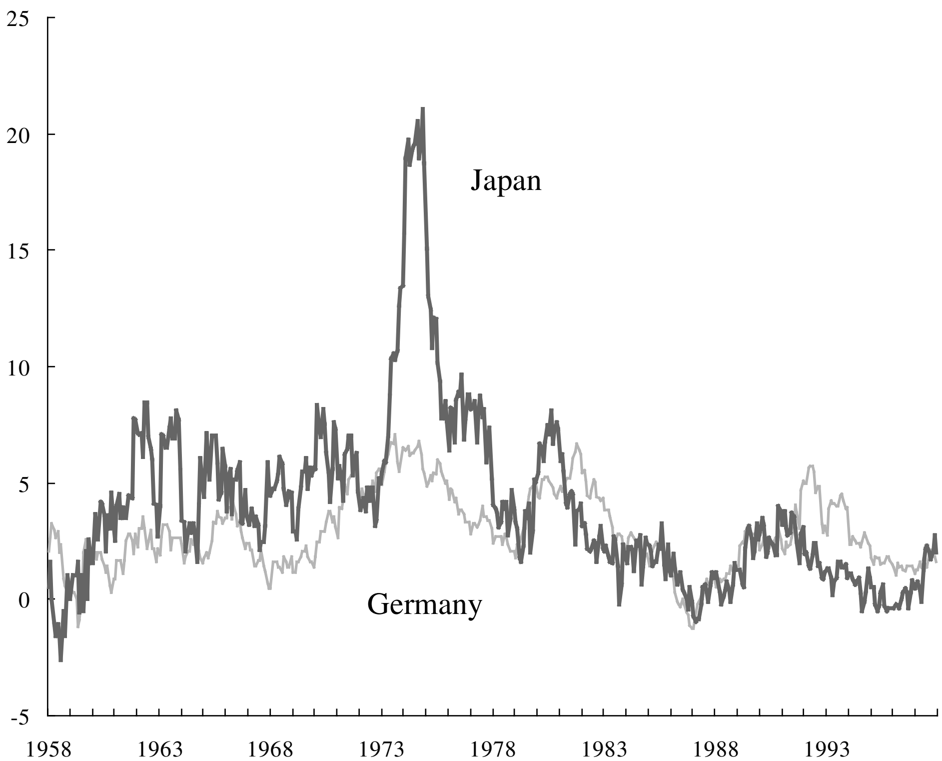

Figure 1c: CPI Inflation for Germany and the United States

Monthly data, year-over-year growth

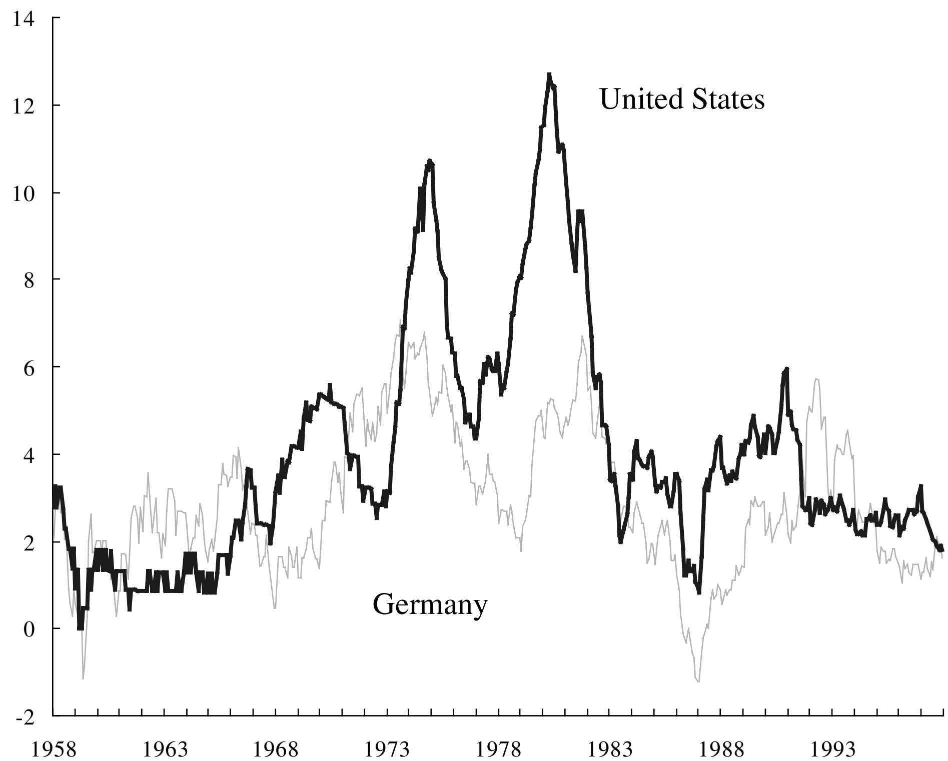

Figure 1d: CPI Inflation for Germany and the United Kingdom

Monthly data, year-over-year growth

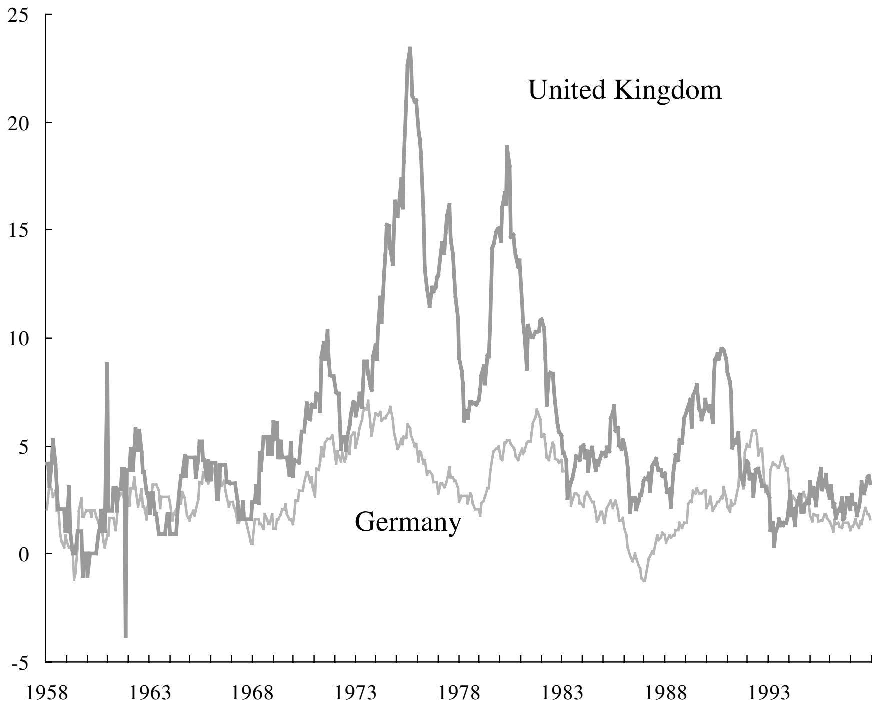

Figure 1e: CPI Inflation for Germany and Italy

Monthly data, year-over-year growth

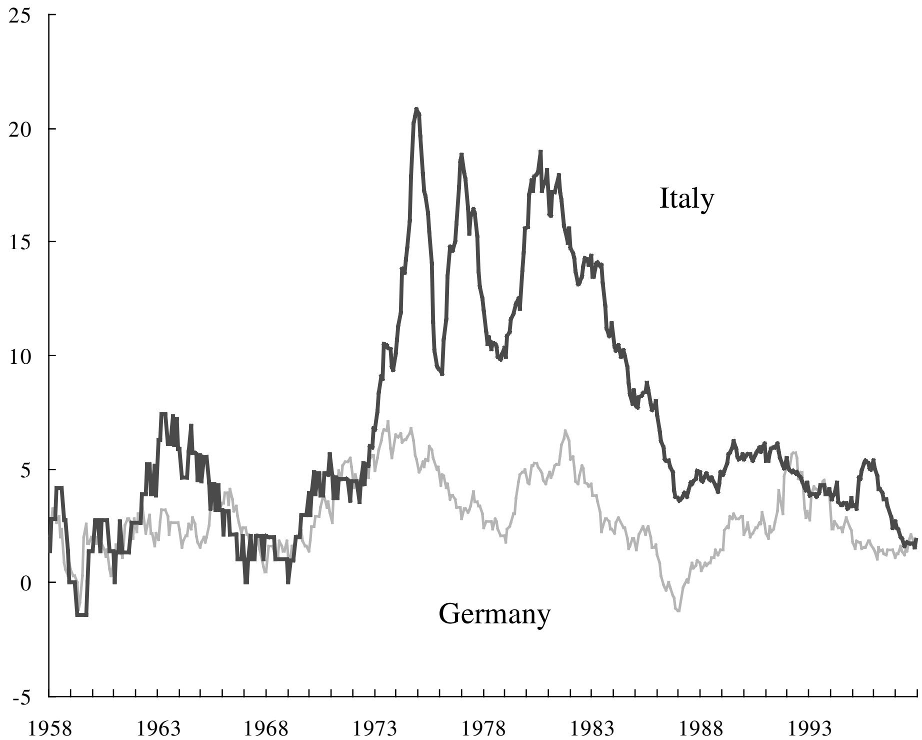

Figure 2: The CPI for Select Countries

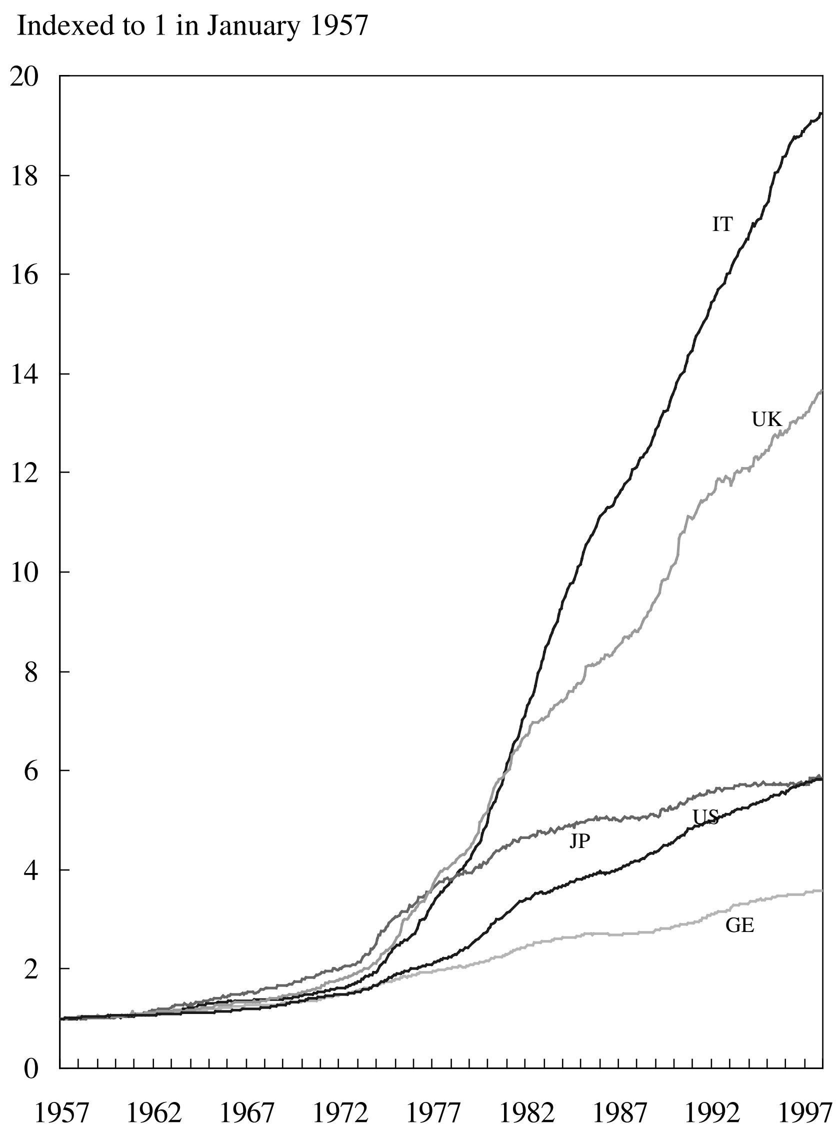

Figure 3

Taylor Curves for Selected Countries

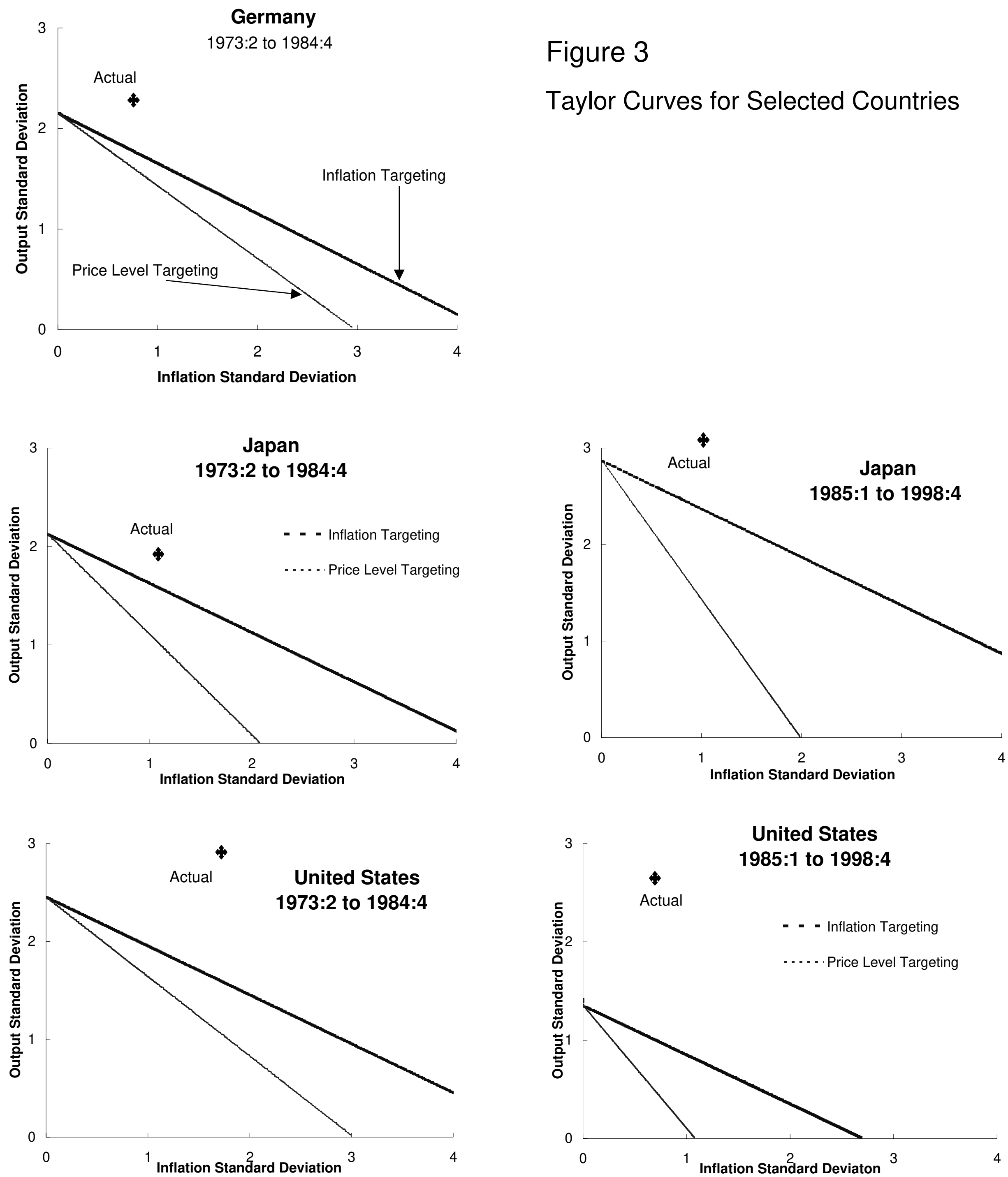

Figure 3 Continued

Taylor Curves for Selected Countries