Deflation Risks Under Alternative Monetary Policy Rules *

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Abstract

This paper describes a set of projections, using a version of the Global Projection Model, designed to assess how alternative strategic options for monetary policy might affect the looming risk of an international deflation problem. The zero floor to interest rates constrains monetary policy. Confidence intervals, derived from stochastic simulations, indicate the ranges of uncertainty. The results suggest a high probability of a declining price level for a couple of quarters in 2009 under any monetary policy. Suitable policy rules, however, can greatly reduce the risk that this might lead to a deflation problem. Recovery is generally faster if the policy rule contains an element of price level path targeting.

JEL Classification Numbers:

Keywords:

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*The views expressed in this paper are those of the authors and do not necessarily represent those of the Bank of Canada, IMF or IMF policy. We thank James Gordon, Luc Everaert, Kenneth Kang, Charles Kramer, and Emil Stavrev for providing comments on an earlier version of this paper and Olivier Blanchard, Charles Collyns, Jorg Decressen, Hamid Faruqee, and Larry Schembri for encouraging us to do this work. Thanks to Ioan Carabenciov, Huigang Chen, Heesun Kiem, Laura Leon, and Susanna Mursula for invaluable technical assistance. The code for the model simulations used in the final version of this paper can be downloaded from www.douglaslaxton.org.

A. Introduction

Current economic turmoil is raising a growing risk that monetary policy may, for the first time since the Great Depression, have to deal with global deflation. By deflation we mean that current and expected rates of change in the price level, over a horizon of at least a year, are negative. A decline in the headline CPI for a few quarters, resulting for example from a slump in energy prices, under this definition is not deflation, and it does not pose a special problem for monetary policy. However, at the present time, given the overall weakness of the economy, there is some risk of difficult deflation problem, in which the zero interest rate floor (ZIF) blocks the normal remedy of lower interest rates. If nominal interest rates on the safest, most liquid, assets are at zero, the cost of credit to firms and households would be positive, and the real cost of credit (adjusted for the expected deflation) could be high enough to impede economic recovery. This situation, in which conventional monetary policy might not have an effective instrument to stop a deepening spiral, poses a particularly difficult problem.[1]

This paper describes results from an multicountry model—a member of the GPM family—designed to assess the risk of a deflation problem, and to see how different options for monetary policy might affect it. The model has 3 regions: the United States, the euro area, and Japan. An international model is apt because the issues are global. At the ZIF, a monetary action in any one area could still have an expansionary effect through depreciation of the exchange rate—most obviously, an official, unsterilized, purchase of foreign exchange. But this remedy too might be ineffective when all regions face the deflation problem, since currencies cannot simultaneously depreciate against each other.

One strategic option, to reduce the risk of a deflation problem, is to raise the long-run objective for the rate of inflation. Economists (e.g. Summers, 1991) have long recognized that a higher objective would reduce the risk of an encounter with the ZIF. But the consensus view in the major industrialized countries is that this risk would not, in itself, rule out an objective for inflation in the low single digits.

A second option relates to whether, or not, monetary policy should aim at achieving a stable path for the price level. Under a pure inflation target (IT), bygones are bygones: the central bank pursues the same target going forward, regardless of any deviations from target that may have occurred in the past. Under a price-level-path target (PLPT), the central bank would react to past as well as current or expected deviations, so as to stabilize the average rate of inflation over periods of years. In practice, the target path would have a slope corresponding to the target rates for inflation that many central banks announce. Our research compares, for given target rates, pure IT policy rules against policy rules that blend IT and PLPT. Under the latter option, policy would respond to a weighted sum of (a) deviations from IT, and (b) deviations from the associated PLPT. If the latter were credible, it would create increasing expectations of inflation

[1] Smith (2006) provides a survey of international historical evidence. Over the centuries there have been numerous episodes of deflation. Some of these episodes saw good growth and prosperity. Bad outcomes, however, have almost always been associated with the kinds of shocks that we see in 2008—e.g. imploding asset values and financial fragility.

as long as the actual rate of inflation fell below the target rate. During a deflation, the real interest rate would then continue to fall, even at a zero nominal rate. This would potentially reduce the frequency and severity of deflation episodes.[2]

Our model simulations, in which the three economies are subject to empirically-based stochastic shocks, shed light on the extent to which different long-run inflation rates, and the introduction of an element of PLPT into the monetary policy rule, might affect the risk of a deflation problem over the next 3 years. Our work breaks new ground by applying an empirically estimated model, with the zero interest floor constraint, to an actual situation of global deflation risk. Another novel feature is that we derive optimized coefficients for the blended IT-PLPT rule. Previous research has tackled aspects of these issues, but with calibrated model coefficients, or in less difficult contexts than the present international conjuncture.[3]

Section B of the paper discusses some aspects of policy credibility in a deflationary environment. Section C gives a brief description of the model.[4] Section D describes the simulation results. Section E presents some conclusions.

B. Credibility and Policy Rules

In a widely cited statement Woodford (2005) observed: "… not only do expectations about monetary policy matter, but at least under current conditions, very little else matters." This dictum applies to current conditions in late 2008 with a force that Woodford could not have anticipated. To a significant extent, the crisis is a crisis of confidence. Deflation risk largely depends on the public's expectations of future price level developments. Confidence that the central bank will, within the near future, restore the rate of inflation to the desired positive level would solve a deflation problem.

We assume throughout that the policy rules that we test are all credible. That is, at any given moment, the public's long-run expectations of inflation differ from the announced long-run target of the central bank only to the extent that people give some weight to recently experienced rates of inflation.[5] The assumption that the long-run target is credible is crucial, since it provides the system with its nominal anchor. Given the severity of the current situation, however, relevant evidence is lacking on two aspects of this assumption.

[2]On these grounds, Svensson (2001) and Eggertsson and Woodford (2003) advocate a "history dependent" inflation target, in preference to an exclusively forward-looking target.

[3]Examples are Coenen (2003), Coenen and Wieland, 2003, Coenen and others (2004), and Svensson (2001).

[4]Carabenciov and others (2008a and b) provide more detail on the motivation, structure, and properties of the model.

[5]In other projects, GPM has been modified to include an endogenous credibility process, according to which credibility is gained only with the consistent pursuit of a given policy rule over time—see, e.g. Argov and others (2007) and Alichi and others (2008).

First, data on deflation in the modern era is confined to Japan. This experience does not provide much information on how a regime in which policy adheres to a clear inflation objective might cope in a period of falling prices.

Second, no central bank has adopted a PLPT. Since a PLPT implies a time-varying, history-dependent, short-run intermediate inflation target, people might find it more difficult to understand the short- and medium-run targets at a given point in time. If the credibility that the central banks have achieved through the successful pursuit of low inflation targets means anything, however, it should survive a technical change, the essence of which is to make the targets apply to the average rate of inflation over periods that include previous years. Financial market participants have come to pay a lot of attention to monetary policy statements and to analyses of the inflation data. A central bank with a good record for controlling inflation behind it should not find it difficult to persuade at least this audience of the credibility of a PLPT. Going forward, people would find that on average the central bank was achieving the inflation target with a higher degree of accuracy than under a pure IT regime—see Kamenik and others (2008).

Svensson (2001) and Woodford (2003) make two supporting proposals. First, monetary policy would consistently pursue PLPT in response to all cumulative deviations from target, regardless of sign, at all times. Second, the central bank would operate with a high degree of transparency, so that the public has a large set of information with which to evaluate monetary policy. Thus, it would publish the expected short-run rate of inflation, rather than leave it to the public to calculate the time-varying intermediate inflation target consistent with PLPT.

In the model, a credible PLPT component in the policy rule has 2 substantive effects. First, it keeps the policy interest rate below the long-run equilibrium rate not just when current inflation is below target, but also for an additional period to make up for the cumulative negative deviation. Second, during a deepening deflation the expected rate of inflation keeps increasing. The larger is the observed cumulative negative deviation from target, the greater would be the positive future deviations targeted by the central bank. At the zero nominal interest rate floor, this inflation-expectations effect could allow the real interest rate to decline progressively during a deflation, and thereby provide economic stimulus. Expectations thus tend to stabilize inflation directly, through the inflation equation, and indirectly, through the real interest rate.

C. The Model

C.1 Overview

GPM is well suited to analysis of the practical problem at hand. Since the coefficients are estimated, results from the model have more plausibility than those from models with calibrated coefficients, set a priori. Moreover, we employ a Bayesian system estimation technique that takes account of information about coefficients implied by the model as whole. GPM contains a process of expectations formation that contains both backward- and forward-looking elements.

It allows for important nonlinearities, including the zero bound on interest rates. It offers various options for the definition of monetary policy rules, which may be estimated from the data, or determined by an optimization process, or set to represent counterfactual options.

GPM builds from the standard modern monetary policy model, with equations determining:

- the output gap
- the inflation rate (an augmented Phillips curve)
- the exchange rate, and
- the interest rate (a monetary policy rule)

Output is represented by GDP; the output gap is the difference between actual and potential.[6] The inflation rate is the annualized quarterly change in the CPI. The US exchange rate is euro or yen per dollar (an increase corresponding to US dollar appreciation); the real exchange rate adjusts for differential changes in CPIs (an increase implying an increase in the relative price of US goods). It is convenient to express all variables as deviations from long-run equilibrium, i.e. in gap format.

The United States sector includes endogenous credit conditions. We construct an index of bank lending tightness (BLT) in the United States from the Federal Reserve Board's Senior Loan Officer Survey. The index subtracts the percentage of "eased" responses against the percentage of "tightened." A BLT in excess of 50 percent means unusually tight credit conditions; in 2008Q4 (October) the index reached an unprecedented 80 percent.

The policy rule for the short-term interest rate has a general form, which allows for a pure IT rule, or for a weighted blend of IT and PLPT. We estimated empirically the coefficients in the pure IT version. Since the IT-PLPT rule is counterfactual, we use a quadratic policy loss function to derive optimal coefficients for it.

The Bayesian method provides an estimate of the posterior distribution of the system parameters, as well as of the variance-covariance matrix of disturbance terms. We work with the mode of the posterior distribution and condition all the remaining experiments on this point estimate. Unobservable historical variables, such as potential output, are estimated using a linear Kalman filter, conditioned on the posterior mode.

Simulations to construct the confidence intervals in the baseline forecast, and to derive the results for the policy rule experiments, are done with an assumption of unanticipated shocks. In each period, the equilibrium of the economy is established with the assumption that all the future shocks will be zero. In this way, economic agents are repeatedly surprised by shocks as

[6] All variables except interest rates are in natural logarithms. For all intents and purposes, this means that, e.g., the output gap is measured as a proportion of potential GDP.

they occur. The zero-expected-shock assumption means that we neglect the potential behavioral implications of uncertainty about the future.

Variable definitions for country j

$\overline{Y}_{j,t}$: potential output

$i_{j,t}$: nominal interest rate

$R_{j,t}$: real interest rate

$\overline{R}_{j,t}$: equilibrium real interest rate

$\pi_{j,t}$: annualized quarterly inflation

$\pi 4_{j,t}$: year-on-year inflation

$Z_{j,t}$: real exchange rate

$\overline{Z}_{j,t}$: equilibrium real exchange rate

$Z^e_{j,t}$: expected exchange rate of next period

$BLT_{US,t}$: credit tightness

$RPOIL_{US,t}$: log of the real equilibrium price of oil

$RPOIL_{US,t}$: log of the real price of oil

C.2 Behavioral Equations

C.2.1 Output Gap of Country j

$$\begin{aligned} y_{j,t} \quad &= \quad \beta_{j,1} y_{j,t-1} + \beta_{j,2} y_{j,t+1} - \beta_{j,3} r_{j,t-1} + \beta_{j,4} \sum_k \omega_{j,k,4} z_{j,k,t-1} \\ & \quad +\beta_{j,5} \sum_k \omega_{j,k,5} y_{k,t-1+} \theta_j \eta_{j,t} + \varepsilon^y_{j,t} \end{aligned} \tag{1}$$

Equation (1) determines the output gap as a function of

- its own lead and lagged values,
- the real interest rate gap

- bank lending tightening (BLT, US equation only)
- output gaps in its trading partners
- the real exchange rate gap, and
- a disturbance term

The lag from the output gap itself captures both intrinsic delays due to adjustment costs, and the adaptive component of expectations, or habit persistence. The lead corresponds to forward-looking investment and consumption behavior, in anticipation of expected future output and income.

Normal cyclical variations in the availability of credit are accounted for implicitly by the interest rate and other variables in the equation. However, shocks to lending practices will have an independent impact, which is not so captured. Their effect is represented by the term $\eta_{US,t}$ which is defined to be a distributed lag of the non-systematic component of the variable BLT. We measure these shocks as the residuals of a simple estimated equation.

C.2.2 Inflation equation for Country j

$$\begin{aligned}\pi_{j,t} &= \lambda_{j,1}\pi 4_{j,t+4} + (1-\lambda_{j,1})\pi 4_{j,t-1} + \lambda_{j,2}y_{j,t-1} + \lambda_{j,3}\sum_k \omega_{j,k,3}\Delta Z_{j,k,t} \\ &\quad + \upsilon_{j,1}\pi^{RPOIL}_{j,t} + \upsilon_{j,2}\pi^{RPOIL}_{j,t-1} - \varepsilon^{\pi}_{j,t} \qquad (2)\end{aligned}$$

The augmented Phillips curve, equation (2), has inflation as a function of

- inflation expectations—a weighted average of past and model-consistent future rates
- the lagged output gap
- the change in the real exchange rate
- the current and lagged increase in the real price of oil, and
- a disturbance term

The model-consistent aspect relates to price setting based on predictions of future inflation. When monetary policy adheres to a stable policy rule, expectations eventually converge on the inflation path targeted by the central bank.

A variant of the policy rule, described below, introduces a price-level factor, to keep the average inflation rate overtime on target. To offset the cumulative effect of current deviations from target, the central bank would aim to achieve deviations in the opposite direction for a while. This affects the dynamics of inflation. While inflation would eventually return to the target rate, medium-term expectations would vary inversely with just-experienced inflation gaps. For the case in point, following a succession of undershoots, people would expect a relatively high rate of inflation in the quarters immediately ahead. This countercyclical property adds a stabilizing factor to the actual inflation rate. The greater the weight on the forward-looking component ($\lambda_{j,1}$), the more rapid is the convergence to the policy target. The backward-looking component, in contrast, reflects adaptive behavior, which slows the adjustment.

The coefficient on the lagged output gap embodies the familiar short-run output-inflation trade-off. This is the crucial link between the real sector of the economy and the price level.

The coefficients on the changes in the real exchange rate and in the real price of oil reflect the pass-through to the CPI of changes to import and oil prices.

C.2.3 Policy interest rate equation for Country j

$$\begin{aligned} i_{j,t} &= \gamma_{j,1} i_{j,t-1} + \left(1-\gamma_{j,1}\right)\left[\bar{r}_{j,t} + \pi4_{j,t+3}\right] + \gamma_{j,2}[\pi4_{j,t+3} - \pi_j^*] \\ &\quad + \gamma_{j,3}[p_{j,t+8} - p_{j,t+8}^*] + \gamma_{j,3} y_{j,t} + \varepsilon_{j,t}^i \end{aligned} \tag{3}$$

This Taylor-type rule determines a key, policy-determined, short-term interest rate (Federal Funds rate for the United States, 30-day interbank rates for the euro area and Japan). The own lag provides smoothed policy responses, in line with the incremental movements typical of central bank decisions.[7]

In a steady state, with inflation on target, and the price level on track, the central bank sets the actual nominal interest rate, $i_{j,t}$ at the long-run equilibrium level (equal to the equilibrium real rate plus the rate of inflation). Otherwise, it opens a corrective interest rate gap. There are both IT and PLPT components to the rule in equation (3):

- the coefficient $\gamma_{j,2}$ on the expected Y-o-Y inflation rate 3 quarters ahead, which is positive, has the central bank cut the real interest rate when expected inflation is below the target rate;
- and the coefficient $\gamma_{j,3}$ reflects the extent to which policy reacts to cumulative deviations from target—in the case of pure IT, $\gamma_{j,3}$ is zero.

Apart from the inflation and price-level-path deviation factors, the policy rule responds as well to output gaps, which can have important effects on the path of future inflation and reducing

[7] Woodford (2003) provides a theoretical rationale for the smoothed interest rate response. In essence, smoothing increases the impact of changes in short-term rates on longer-term rates, because it gives the changes some persistence.

variability in the real economy. A disturbance term allows for interest rate actions (possible policy errors) not indicated by the equation. The equation is constrained to respect the zero lower bound to the interest rate.

To investigate alternative options for monetary policy, we vary the policy rule across 2 dimensions. First, we set the target rate at three alternatives—2, or 2.5, or 3 percent—common to all regions. Second, we compare the estimated pure IT rule (with the $\gamma_{j,3}$ weight set to zero), against a combined IT-PLPT rule, the coefficients of which are derived by minimizing a quadratic loss function.[8] The latter assumes an aversion to output gaps, deviations of inflation from target, and variability of the interest rate.

C.2.4 Estimated of parameters for IT policy rule

The estimation technique for the coefficients of the IT rule involves a full-model estimation procedure, which takes account of all the simultaneity in the system. The estimated coefficients differ somewhat from country to country. To estimate the coefficients of the rule, we need to calculate the deviations to which policy responds. Although none of the 3 central banks in the model announces an official target, in practice their inflation objectives are reasonably transparent and allow market participants to make plausible assumptions based on their statements and behavior.

For the United States, we assume an objective for the rate of increase of the CPI of 2.5 percent. This is derived from recent Federal Open Market Committee medium-term forecasts for the rate of increase of the deflator of consumer expenditure, which lie between 1.8 and 2 percent. This would yield a forecast for the CPI about half a percentage point higher.[9] For the euro area, considering the official statement that "The ECB aims at inflation rates of below, but close to, 2% over the medium term," we assume a long-run objective of 1.9 percent.[10] The Bank of Japan is guided by the Board Members' "understanding of medium- to long-term price stability," which is currently defined as CPI inflation ranging between 0 and 2 percent with most Policy Board members' median figures at around 1 percent.[11]

Table 1 contains the estimated values for an IT rule. The smoothing coefficient for Japan is relatively high, indicating slow adjustment of the policy interest rate, while the coefficient on the output gap is low, suggesting more tolerance for output gap persistence. The IT re-

[8] The optimization was done with a linear approximation to the nonlinear model.

[9] Minutes of the Federal Open Market Committee, June 2008, Table 1, Economic Projections of Federal Reserve Governors and Reserve Bank Presidents. For the differences between the consumption deflator and the CPI see McCully and others (2007). Bernanke (2005), Yellen (2006), and Mishkin (2008) provide insiders' views on the Fed's comfort zone" for inflation.

[10] The quotation is from the ECB website, http://www.ecb.int/mopo/html/index.en.html. In an ECB Working Paper, Christoffel and others (2008), citing the same statement, also adopt a 1.9 percent target.

[11] Hara, Kimura and Okina (2008) refer to the need for the Bank of Japan to take "insurance against deflation." See also a speech by Deputy Governor Muto entitled "The Battle Against Deflation," New York, 2003.

action function for the euro area has a larger coefficient on expected inflation than in either the United States or Japan. The estimated coefficients on the output gap are significantly lower than in reaction functions that include contemporaneous measures of inflation instead of model-consistent forecasts of inflation, as the latter already includes information about the contemporaneous output gap.

Table 1
Estimated short-run coefficients
IT policy rule

	US	euro area	Japan
Rate Smoothing ($\gamma_{j,1}$)	0.73	0.70	0.80
Expected Inflation (1-$\gamma_{j,1}$+$\gamma_{j,2}$)	0.52	0.68	0.43
Output gap ($\gamma_{j,4}$)	0.06	0.06	0.03

C.2.5 Optimization of parameters for IT-PLPT rule

Because the PLPT regime has not been observed in history, we generate optimal parameters for the IT-PLPT policy rule. These minimize the loss function, given the estimated variance-covariance matrix of disturbance terms, and given the estimated structural parameters as well as estimated policy rule parameters for other countries. For each country, the loss function (L) takes the form:

$$L = w_{\Delta i}\, Var\left(\Delta i\right) + w_{\pi 4}\, Var\left(\pi 4 - \pi^{*}\right) + w_{y}\, Var\left(y\right), \tag{4}$$

where $Var\left(\Delta i\right)$, $Var\left(\pi 4\right)$ and $Var\left(y\right)$ are unconditional (long run) variances of the Q-o-Q change in the policy interest rate, the Y-o-Y inflation deviation, and the output gap. The weights in the loss function are calibrated as $w_{\Delta i} = 0.5$, $w_{\pi 4} = 1$ and $w_{y} = 1.$

We use the unconstrained OSR algorithm in Dynare (Sims's CSMINWEL optimization algorithm). This repeatedly evaluates the loss function, in four steps. First, the derivatives of the equations are evaluated for the specific parameters of the optimized policy rule. Second, the Blanchard-Kahn algorithm is invoked to obtain a reduced form of the model. Third, the unconditional variance-covariance matrix of the endogenous variables is derived, using the reduced form, and the given variance-covariance matrix of the structural disturbance terms. And fourth, the loss function is evaluated from the disturbance term variance-covariance matrix.

Table 2			
Optimal short-run coefficients Combined IT-PLPT policy rule			
	US	euro area	Japan
Rate smoothing ($\gamma_{j,1}$)	0.70	0.52	0.93
Expected Inflation (1-$\gamma_{j,1}$+$\gamma_{j,2}$)	0.26	0.29	0.20
PLPT gap ($\gamma_{j,3}$)	0.60	0.38	0.07
Output gap ($\gamma_{j,4}$)	0.50	1.08	0.19

Table 2 displays the optimal coefficients for the blended IT-PLPT rules. Japan is again quite different from the United States or the euro area. The interest rate smoothing coefficient is much higher than for the United States and, especially, Europe, while the coefficients on the PLPT and output gaps are much smaller. In contrast, the estimates for the United States put a high weight on the PLPT gap, and for the euro area on the output gap. In all 3 regions, the greater weights on the output gap in comparison to the pure IT rule provide an additional mechanism that will help reduce output variability.

C.2.6 Exchange rate

$$4\left(Z^e_{j,t+1} - Z_{j,t}\right) = \left(R_{j,t} - R_{us,t}\right) - \left(\overline{R}_{j,t} - \overline{R}_{us,t}\right) + \varepsilon^{Z^e-Z}_{j,t} \tag{5}$$

This embodies a modified uncovered interest parity condition. But whereas simple uncovered interest parity would imply equality of all exchange-rate adjusted short-term interest rates, equation (5) allows cross-country differences in equilibrium real interest rates ($\overline{R}_{j,t} - \overline{R}_{us,t}$), even in the long-run equilibrium. That is, each currency has a risk premium, which may be positive or negative, or zero. The model also has an expectations process for the real exchange rate that has lagged and model-consistent (forward-looking) components—see Carabenciov and others (2008).

C.2.7 Variance and covariance of disturbances

Shocks to the variables are not independent. The present version of GPM contains 3 cross-equation correlations, between:

- potential output and inflation disturbances—negative covariance representing supply shocks—e.g. a positive shock to potential output reduces the current inflation rate;
- potential output growth and output gap disturbances—positive covariance representing the expected income effect of a change in growth, which has an immediate effect on spending and output, implying excess demand in the short run;

- and potential output growth and BLT disturbances in the United States—a negative covariance representing asset market/output market interactions—e.g. higher growth of potential eases bank credit (because higher growth implies higher asset values and returns);in the short run an anticipatory increase in spending would produce a positive output gap.

C.3 Underlying Equilibrium Values and Stochastic Processes

Underlying real equilibrium values, which determine the long-run paths of real variables, are not directly observable, but within the context of the model, the Bayesian technique allows us to estimate these values, given the stochastic process for each variable.

C.3.1 Potential output

Potential output follows a stochastic trend with disturbances which may affect its level permanently, and its growth rate over a finite period. In addition, increases in the international price of oil have a negative effect on potential output. Disturbances may affect the level of potential output, but its growth rate over time will eventually return to its steady-state growth rate.

C.3.2 Real equilibrium interest rate and exchange rate

Shocks may cause both short- and long-run changes in the equilibrium values of the interest rate and the exchange rate. The equilibrium real exchange rate follows a random walk.

C.3.3 Oil price

The log of the real equilibrium price of oil (in inflation-adjusted US dollars), is modeled as a stochastic trend where the current price gradually adjusts to a long-term equilibrium that contains a unit root. In model simulations, the nominal price of oil in the United States rises with the US inflation rate, and in other countries by the rate of exchange against the US dollar. Changes in the price of oil will have two effects in the model. First, permanent increases in the real price of oil will result in a permanent decline in potential output. Second, higher oil prices will raise inflation and require an increase in real interest rates that will result in weaker demand conditions.

D. Model Results for Different Policy Options

D.1 Baseline Forecast

We derive projections, for the 3 economic regions, over 12 quarters starting 2008Q3. Initial conditions for the variables of most interest for present purposes are shown in Table 3.

Table 3						
Initial conditions 2008Q3 (percent)						
	Interest rate					
	nominal	**real***	**long-run equilibrium**	**CPI inflation**	**Output gap**	**BLT**
US	2.00	-0.03	1.75	5.3	-1.4	70.6
euro area	5.00	3.37	1.95	3.9	0.5	na
Japan	0.80	-0.35	0.67	2.0	-0.7	na
* Nominal rate minus model-derived expected inflation						

The starting point matters. The United States (the only country for which we have included a BLT variable) has extremely tight credit conditions, without historical precedent, and a significant output gap, which is already putting downward pressure on inflation.[12] In effect, the Fed starts from a position in which it confronts extremely severe financial conditions in its efforts to stabilize the US economy.[13] At the same time, a slightly negative real interest rate, as calculated with model-generated inflation expectations, provides some counter to the deflationary forces. Japan too has a negative initial real interest rate, but this provides less stimulus than in the United States, because the estimated real long-run equilibrium rate is lower. In contrast, the initial short-term interest rate in the euro area is above the long-run equilibrium rate.

Confidence intervals are a key aspect of risk analysis; here, they embody all the exogenous random factors of the model. We derive them from 3072 drawings, over the whole projection period, from the estimated probability distributions of the set of stochastic terms. Because of the numerous interacting variables, to obtain reliable representations of the distributions of stochastic shocks efficiently, we use Latin hypercube sampling.

The baseline path is constructed by blending judgment about the near-term outlook with the medium-term dynamics of the model. This judgment is incorporated in non-zero add factors at the beginning of the forecast, which die out over time. To construct the confidence bands we draw shocks from their historically estimated distributions and add them to the baseline path.

[12]Both the Bank of Japan and ECB have surveys of Bank Lending Standards, but at this point explicit measures of BLT have not been factored into the analysis.

[13]See Carabenciov and others (2008a) for a discussion of the much less severe financial conditions of the early 1990s.

The figures show 2 confidence intervals, representing the 75 and 95 percentiles. The middle line designates the 0.5 quantile, i.e. the median of the distribution. In Figures 1-4 this represents our baseline forecast, which uses the historically based assumptions about CPI inflation targets (2.5 percent for the United States, 1.9 percent for the euro area, and 1 percent for Japan).

Our baseline is weaker than the recent forecasts reported by Consensus Economics, and by the IMF November WEO—but given the latest data, it may well be overoptimistic. It has a sharp fall in real GDP growth in 2008Q4, followed by further declines over the next few quarters. Moderate growth resumes in the second half of 2009.

In the US baseline, GDP declines 1.3 per cent, 2009-over-2008; and the output gap widens to over 4 percent (Figure 1). Headline inflation drops sharply, largely because of the sharp fall in oil prices from the 2008 peak, becoming negative in the middle quarters of 2009. As the economy recovers, the US price level rises steadily, so that by 2010 it is again at new highs.

The baseline for the euro area and Japan is somewhat stronger than that for the United States. The output gaps do not widen so much (Figures 2 and 3). Headline inflation essentially remains positive: only just so in Japan, but around 1 percent in the euro area. In consequence, the price level in these 2 regions rises fairly steadily throughout the piece.

Of the 3 regions, the euro area seems least likely to encounter the interest floor. The baseline policy rates in the United States and Japan, although below 1 percent throughout 2009, do not quite touch zero.

Figure 4 gives an overall picture of the 3 economies taken together (G-3). The baseline forecast has an international recession (negative GDP growth) for most of 2009. Recovery is assisted by the steep drop in the oil price—but the band of uncertainty for this price is very wide. As the baseline oil price flattens out, the forecast level of the headline CPI declines only temporarily.

Expectations of price changes in this baseline remain positive, as they are influenced by lagged and (model-consistent) future rates of inflation, and give a low weight to the short-lived fall in the headline CPI. Our baseline forecast, in which monetary policy follows the empirically estimated policy rule, therefore avoids the worst type of deflation spiral. However, the estimated confidence intervals suggest that the risk of a zero-constrained interest rate is not negligible. Thus, according to our analysis, it is the margin of uncertainty in the outlook, more than the weak median forecast that makes potential deflation an immediate policy concern.

The baseline price level for the 3 regions taken together (G-3) dips in 2009, in large part because of the fall in the price of energy, and then rises steadily, as the oil price stabilizes. By 2011, the baseline G-3 price level is above its previous, 2008, peak. Moreover, the confidence bands indicate that the probability that the price level might fall below its 2009 trough becomes increasingly remote as time advances.

D.2 Overview of The Policy Option Experiments

We use stochastic simulations to assess how well the variants on the baseline policy rule cope with this situation. For each economic area, we present figures for the output gap, the policy-determined interest rate, and for Y-o-Y inflation.

Figure 5 summarizes the results from the perspective of the cumulative output gap (column 1), the price gap (the cumulative sum of inflation target deviations, column 2), and the frequency of encounters with the zero interest floor over the next 12 quarters. ("ZIF Hits", column 3). There are several notable features.

First, consider the model predictions for the pure IT rules (bars with light shading). The higher target rates of inflation uniformly result in less frequent encounters with the zero interest floor, but only moderately better cumulative outcomes for output and inflation. For Japan, if anything, targeting accuracy goes down as the target is increased from 1 to 3 percent.

Second, consider the blended IT-PLPT policy rules (dark shading). Relative to pure IT, these lead, perhaps obviously given their design, to much smaller cumulative price level gaps. Output performance, as gauged by the size of the negative gaps, also improves—and by a large margin. For example, the cumulative gap for the United States increases from -8.7 to -4.7 percent, for the euro area from -5.1 to -1.8 percent, and for Japan from -3.7 to -1.9 percent, in the case with an inflation target of 2.5 percent .The frequency of zero interest rate occurrences goes up with the addition of the PLPT, reflecting more aggressive and more prolonged easing, as compared to pure IT.

Finally, it is important to note that attempts to simulate a common target rate of inflation of 1 percent broke down. The failure to converge on a solution path suggests that in the model a target rate this low, for all countries together, given the conditions underlying the baseline path, would result in dynamic instability, i.e. an intractable deflation problem.

Subsections D.4.3-D.4.5 discuss the policy rule options, by economic region, respectively: the United States (Figures 6-8); euro area (figures 9-11); and Japan (figures 12-14). Each figure shows the time path for one of the 3 variables. Within each figure, there are 2 columns: the first shows results for a pure IT rule; the second for an optimal blend of IT and PLPT. There are 3 rows for alternative levels of the inflation target: 2 percent; 2.5 percent; and 3 percent.

D.3 United States

Pure IT rule

According to the model, at all levels for the inflation target, the US output gap troughs at about -5 percent in 2009Q4, as in the baseline (first column, Figure 6). In 2010 and 2011, output rebounds at almost the same rates for both targets, such the gap is close to zero by 2011Q2. This would represent a fairly typical cyclical recovery.

The 3 percent target results in a median forecast rate of inflation somewhat less than 1 percent higher, throughout the simulation period, than the 2 percent target (Figure 7). The confidence intervals show a lower, but still considerable, probability of some deflation in 2009 and 2010.

The projections suggest a high risk that the Federal Funds rate would hit the zero floor if the Fed pursued a 2 percent CPI target, as the median forecast itself reaches zero (Figure 8). Even with a 2.5 or 3 percent inflation target, the risk would not be not negligible.

IT-PLPT rule

Introducing an element of PLPT into US monetary policy would substantially reduce the projected output and inflation gaps, regardless of the slope of the target path. In combination with a 3 percent inflation target, it almost eliminates any risk of deflation (second column, Figure 7).

The median projections show an apparent overshooting of the long-run equilibrium. Thus, the output gap turns positive in the second half of 2010, and inflation exceeds target in 2011. The overshooting is greater for the higher inflation target. Thus, by 2011Q2, the inflation rate is about 2 $\frac{1}{2}$ percent with a 2 percent target, but almost 4 percent with a 3 percent target. This is exactly the pattern one would expect, since, by 2011 a central bank giving weight to PLPT would aim to undo the undershooting of the previous 2 years.

The frequency of encounters with the zero floor is higher with the IT-PLPT policy rule than with the simple IT rule. This reflects the more aggressive and prolonged easing when inflation remains below target on a cumulative basis. Thus, in this comparison, increased frequency of the floor does not indicate increased severity of the deflation problem, but a policy that makes more use of the room to maneuver.

D.4 Euro area

Pure IT rule

The model projects a milder downturn in the euro area than in the United States, but a more sluggish recovery. With a 2 percent inflation target, the median forecast for the euro area has the output gap troughing in 2009Q3, at about -2 $\frac{1}{2}$ percent (first column, Figure 9). By 2011Q2, a gap of almost -1 percent still persists. Increasing the target inflation rate to 2.5 or 3 percent produces only a small narrowing in the output gap.

Inflation again increases as the target rate is increased, but less than one-for-one (Figure 10). With the 2 percent target, this produces a high probability of some price level declines; the 3 percent target would a distinctly lower this probability.

With a 2 percent inflation target, the probability of hitting the zero interest rate floor would be quite high 2009-2010 (Figure 11). But with the 2.5 and, especially, the 3 percent targets, this risk looks low.

IT-PLPT rule

As for the United States, an element of PLPT reduces the risk that the price level would fall. In 2009, the median projected output gap does not widen so much, and inflation does not drop so much (second column, Figures 6 and 7). Moreover the median gaps narrow more quickly.

For the euro area simulations, PLPT results in less overshooting than in the United States. One reason for this difference is that the simulated downturn in 2009 is less severe in Europe, such that the ECB has less ground to make up.

D.5 Japan

Pure IT rule

The projection for the Japanese output gap is stable across the inflation target levels (first column, Figure 11). For all cases, the median gap narrows rapidly in 2010, and is eliminated by 2011Q2.

Japan might be able to target inflation more accurately than the other regions (Figure 12). For all 3 target levels, the median projection has inflation approaching target by the end of the simulation period. This may reflect that the data used to estimate the parameters of the model contain a lengthy Japanese experience with very low inflation.

The confidence bands for inflation in Japan, however, are somewhat wider than those for the United States and the euro area. As a result, the simulations show similar risks of declining prices to those for Europe.

The risk of hitting the zero interest floor looks similar to that of the euro area (Figure 13). Again, the probability that the interest rate will touch zero is inversely correlated with the level of the target rate of inflation.

IT-PLPT rule

With either inflation target, the model suggests that the introduction of a price level path to the policy rule would result in a fairly speedy transition to equilibrium in 2010, and some mild overshooting in 2011 to make up for undershooting 2008-2009 (second column, figure 12). This is in spite of an encounter with the zero floor in 2009 (second column, figure 13).

E. Conclusions

In all three regions, for all policy rules, the projections for 2009 show the same pattern: a sharp widening of the negative output gap; and a steep drop in inflation. The risk of deflation, however, in the sense that current price level and the expected future price level are both falling, for a period of at least a year, looks quite low. The strength of the subsequent recovery, and the path back to target inflation, differ to a significant extent across the policy options that we investigate.

Under a pure IT rule, according to our model simulations, the probability of deflation problem over the next couple of years would be high with a uniform long-run inflation target of 2 percent, but considerably lower with a target of 3 percent. This does not mean that 3 percent would necessarily be better, because it may well involve increased distortions and inequities, and questions about its coherence with the goal of price stability. These issues are beyond the scope of the present inquiry.

Adding an element of PLPT to the policy rule mitigates deflation risk in the model simulations. It is not surprising that the simulations show smaller cumulative inflation deviations from target, since this is what a PLPT is designed to do. Less intuitive—but in line with the theoretical contribution of Svensson (1999)—is that the simulated cumulative output gaps too are substantially smaller under a blended IT-PLPT rule than under a pure IT rule.

Our results indicate that starting with a pure 2 percent IT, the macroeconomic gains from introducing an element of PLPT would be larger than those from raising the IT to 3 percent. If increasing the inflation target, or introducing an element of price-level targeting, would help reduce the risk of deflation, the two together would be a fairly potent combination.

A crucial assumption in our argument is that the alternative policy rules are credible. There is a lot of evidence over the past 2 decades to suggest that public expectations have indeed anchored on the low rates of inflation that central banks have aimed to achieve. This supports the idea that a rule with a PLPT element would also be credible, especially as one would observe more accurate inflation control over spans of years. However, the model could be improved by the inclusion of an endogenous process for the required credibility building.[14] To this end, future research might focus more on the formation of expectations in periods of falling prices.[15]

Another avenue for future work concerns the role of fiscal policy. It may be possible to develop fiscal policy rules which would become active as monetary policy loses effectiveness because of the zero interest floor. Given the scale of the budgetary initiatives currently underway, this would be a high priority item on the research agenda.

[14] Endogenous credibility processes have been incorporated into GPM-type models for economies with inflation problems, e.g. Argov and others (2007).

[15] See Smith (2006) for a considerable research agenda on other issues related to deflation.

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Figure 1: Confidence Intervals for Baseline Model: United States

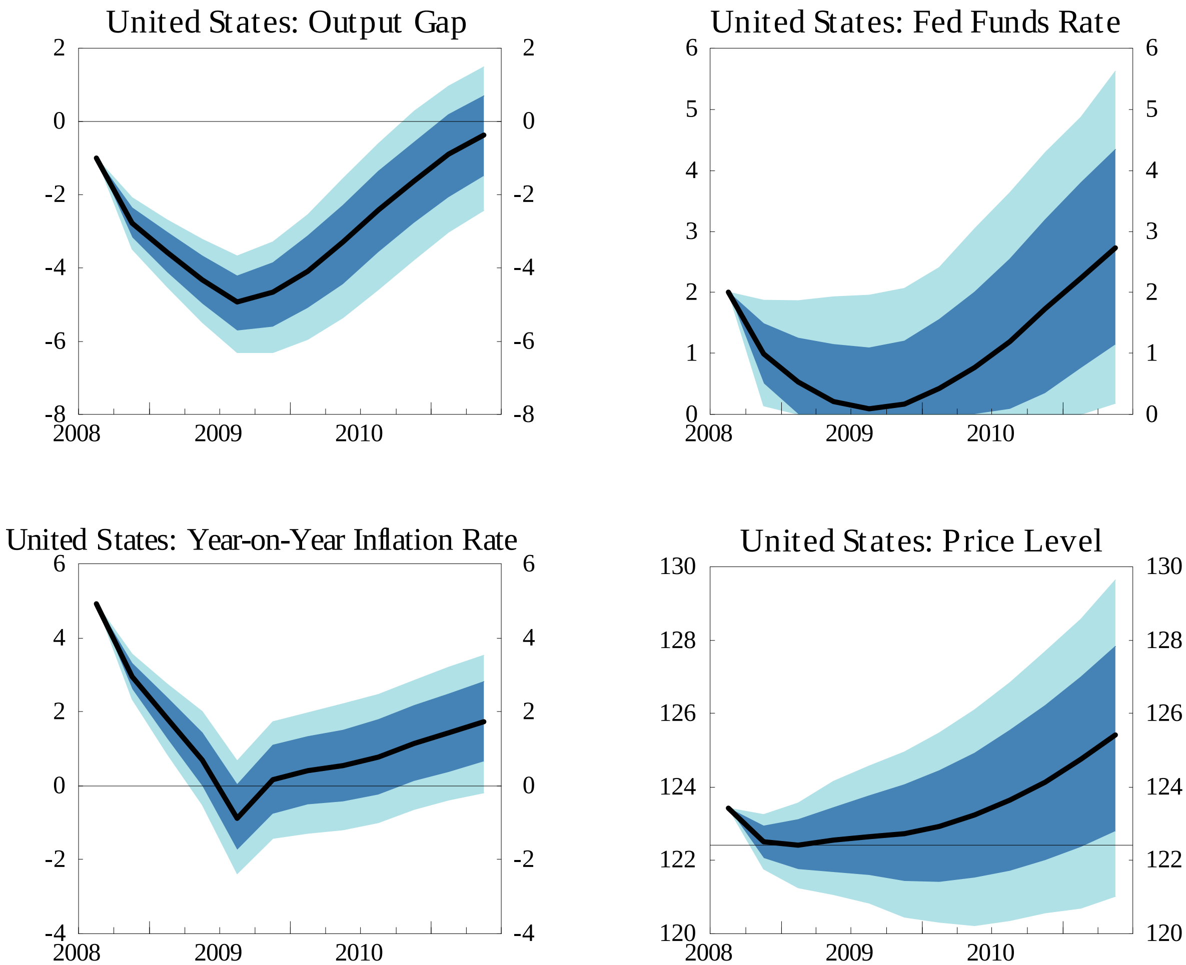

Figure 2: Confidence Intervals for Baseline Model: Euro Area

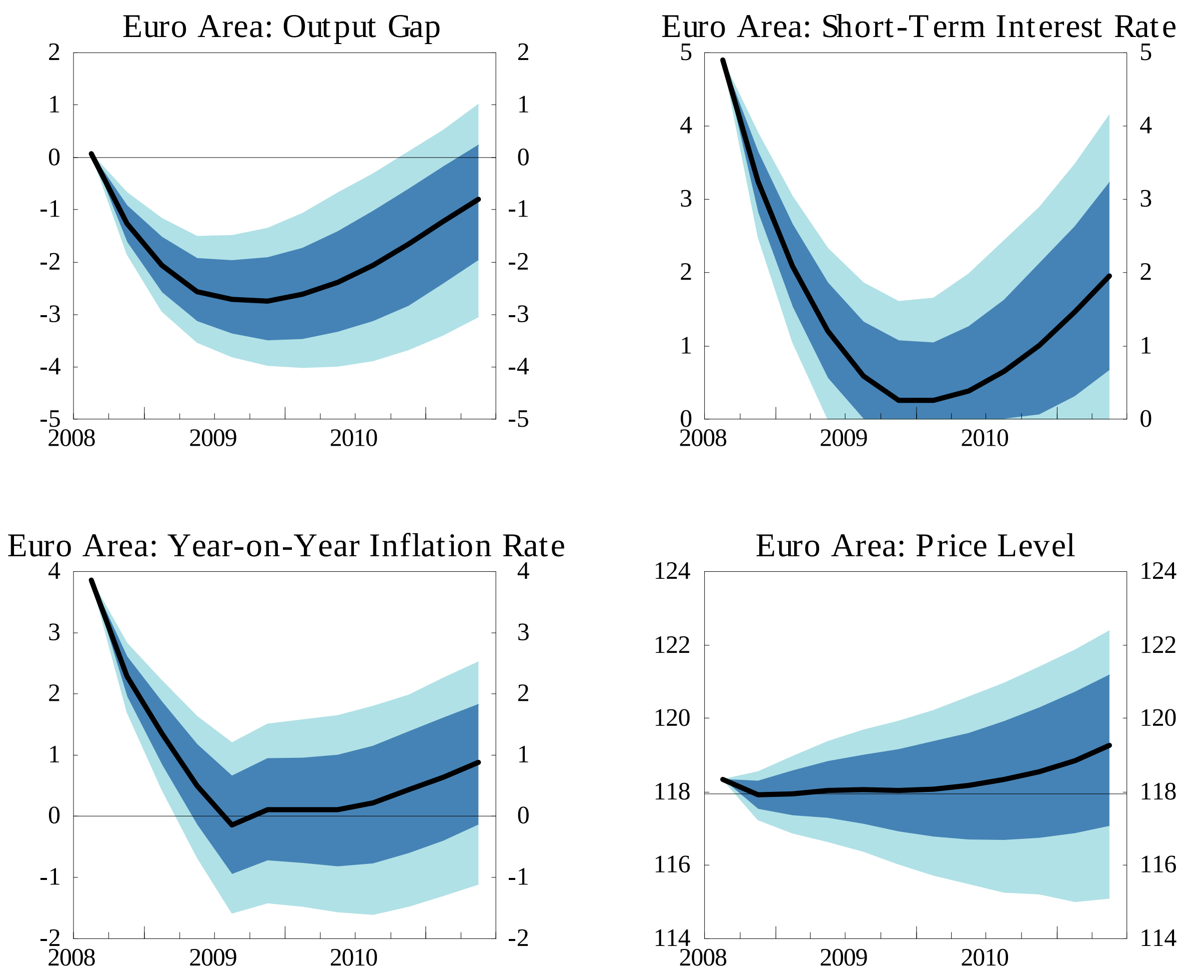

Figure 3: Confidence Intervals for Baseline Model: Japan

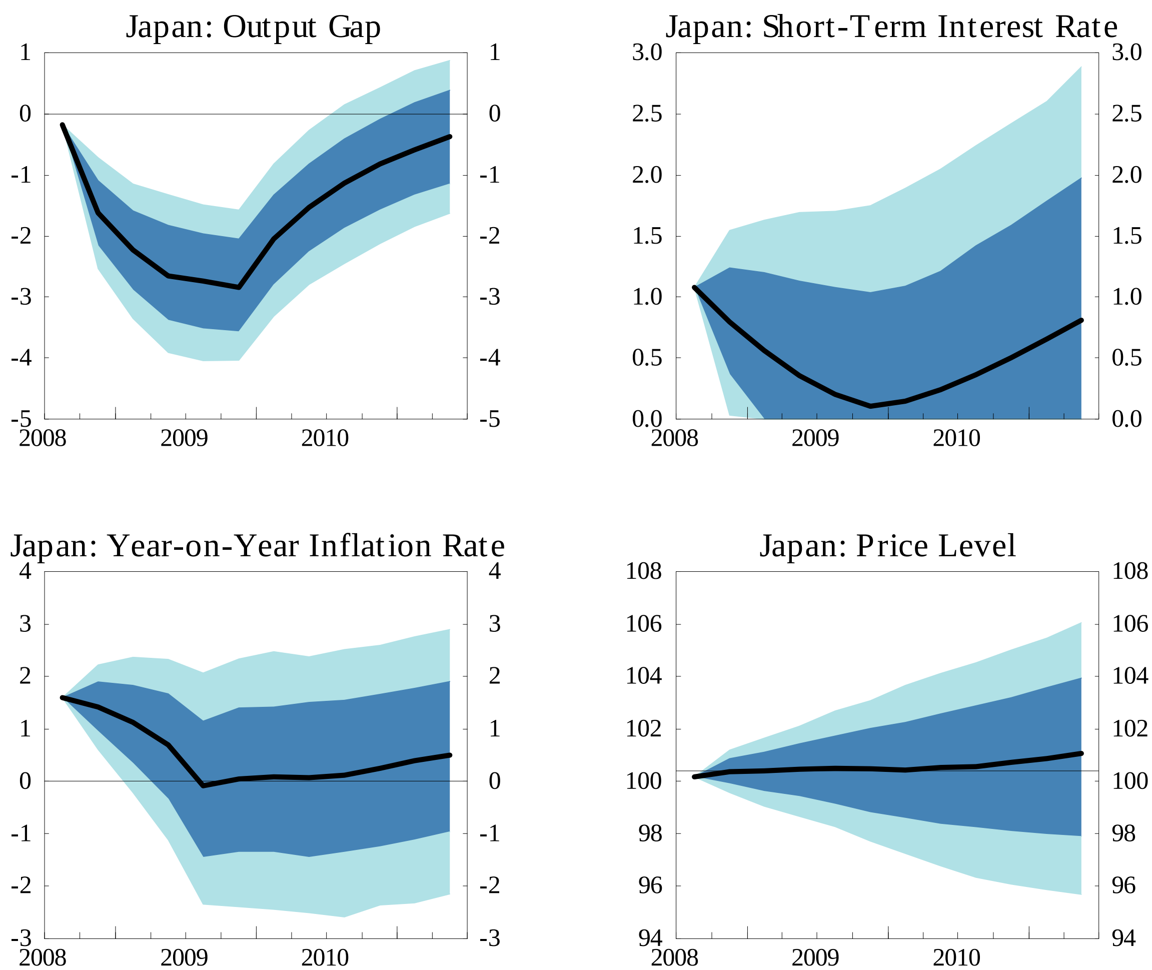

Figure 4: Confidence Intervals for Baseline Model: G3 and Oil Price

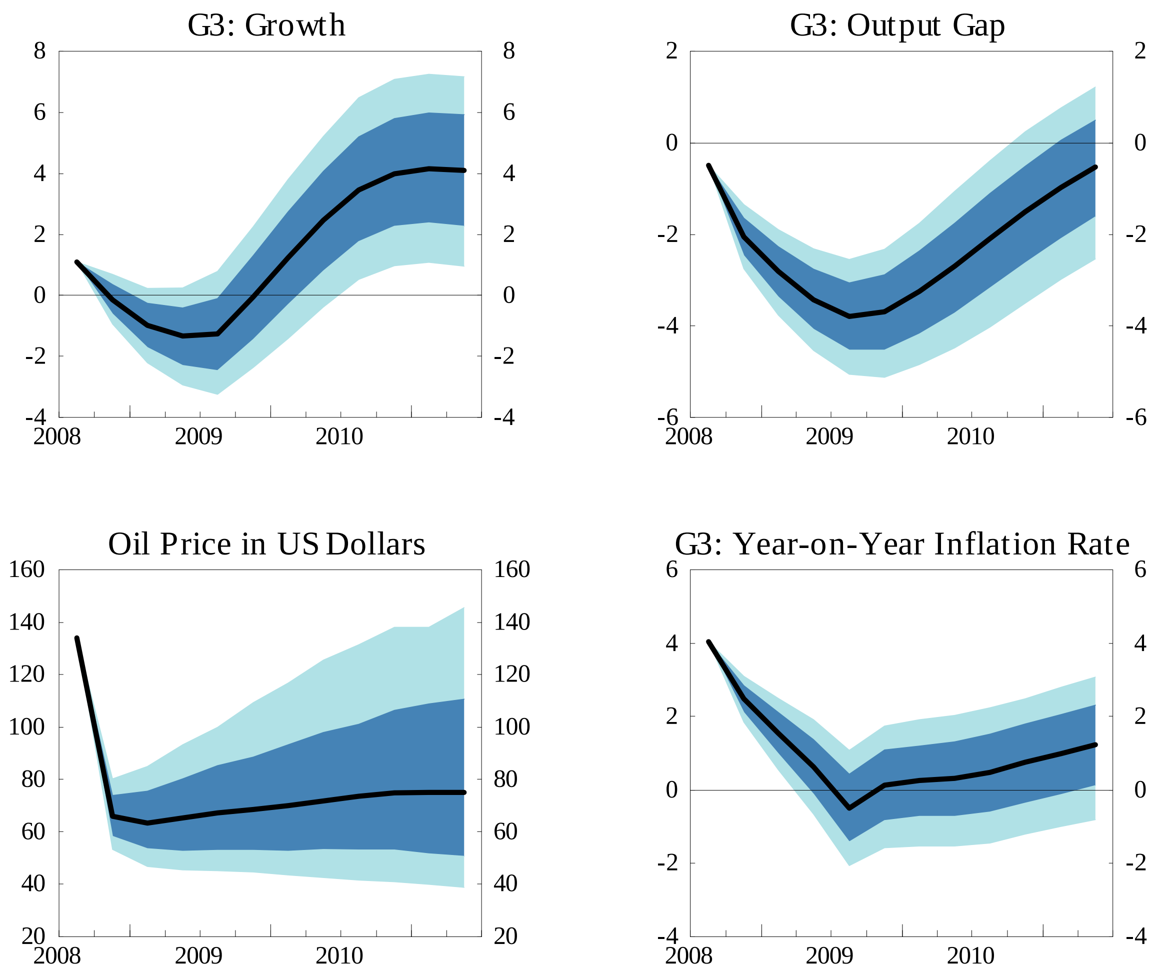

Figure 5: Summary Results for 3-year Simulation Period

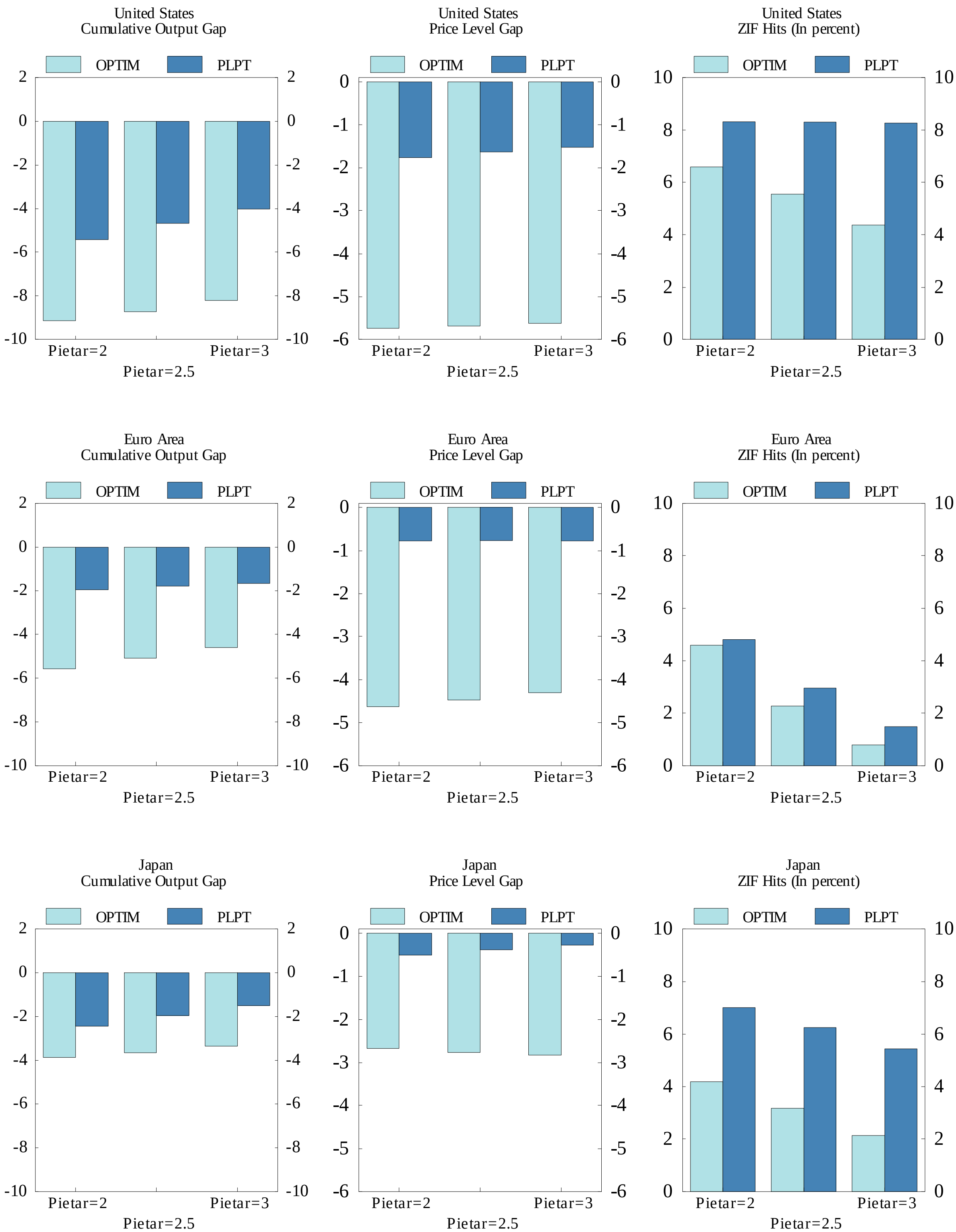

Figure 6: United States: Output Gap

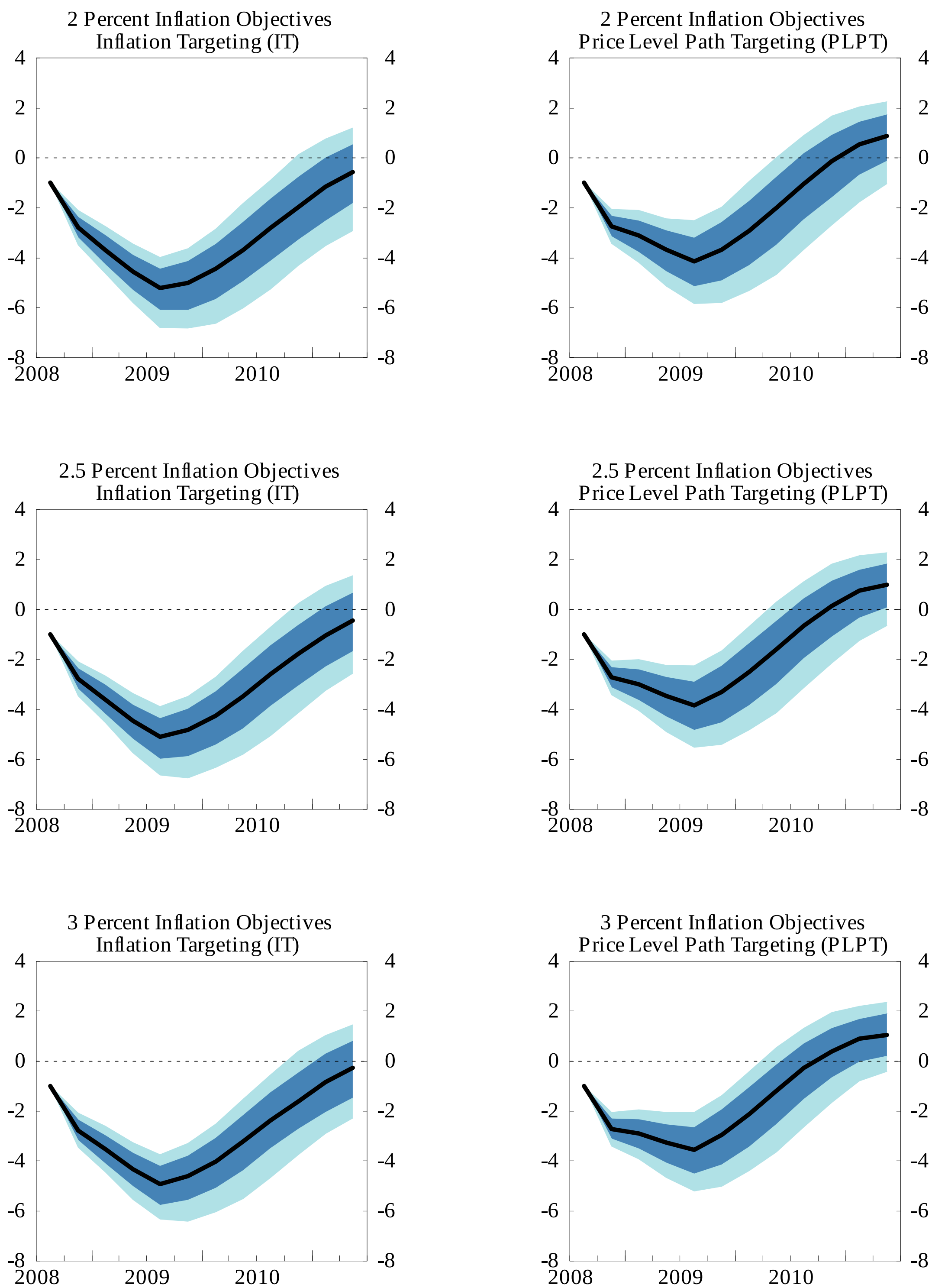

Figure 7: United States: Year-on-Year InflationRate

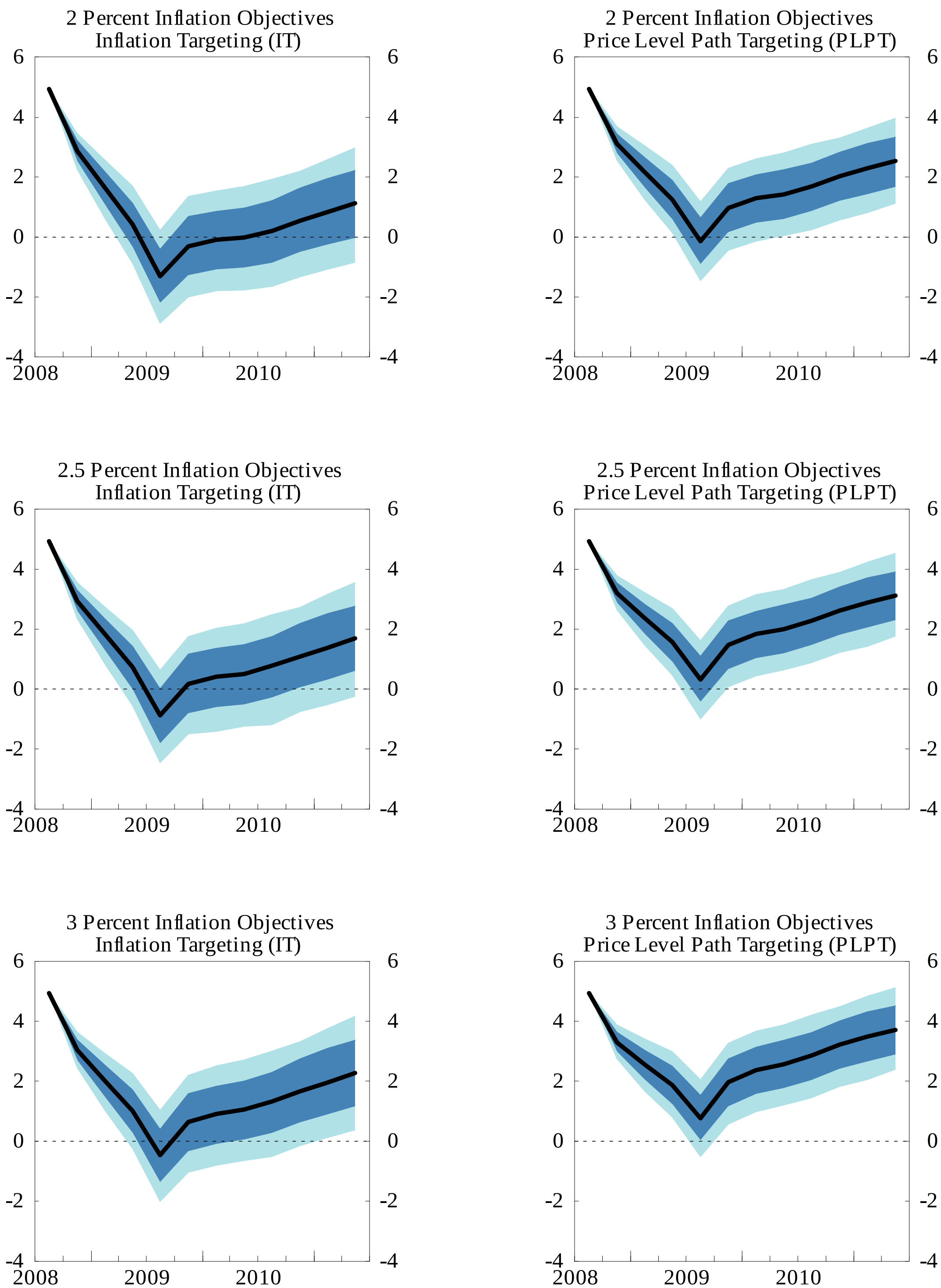

Figure 8: United States: Fed Funds Rate

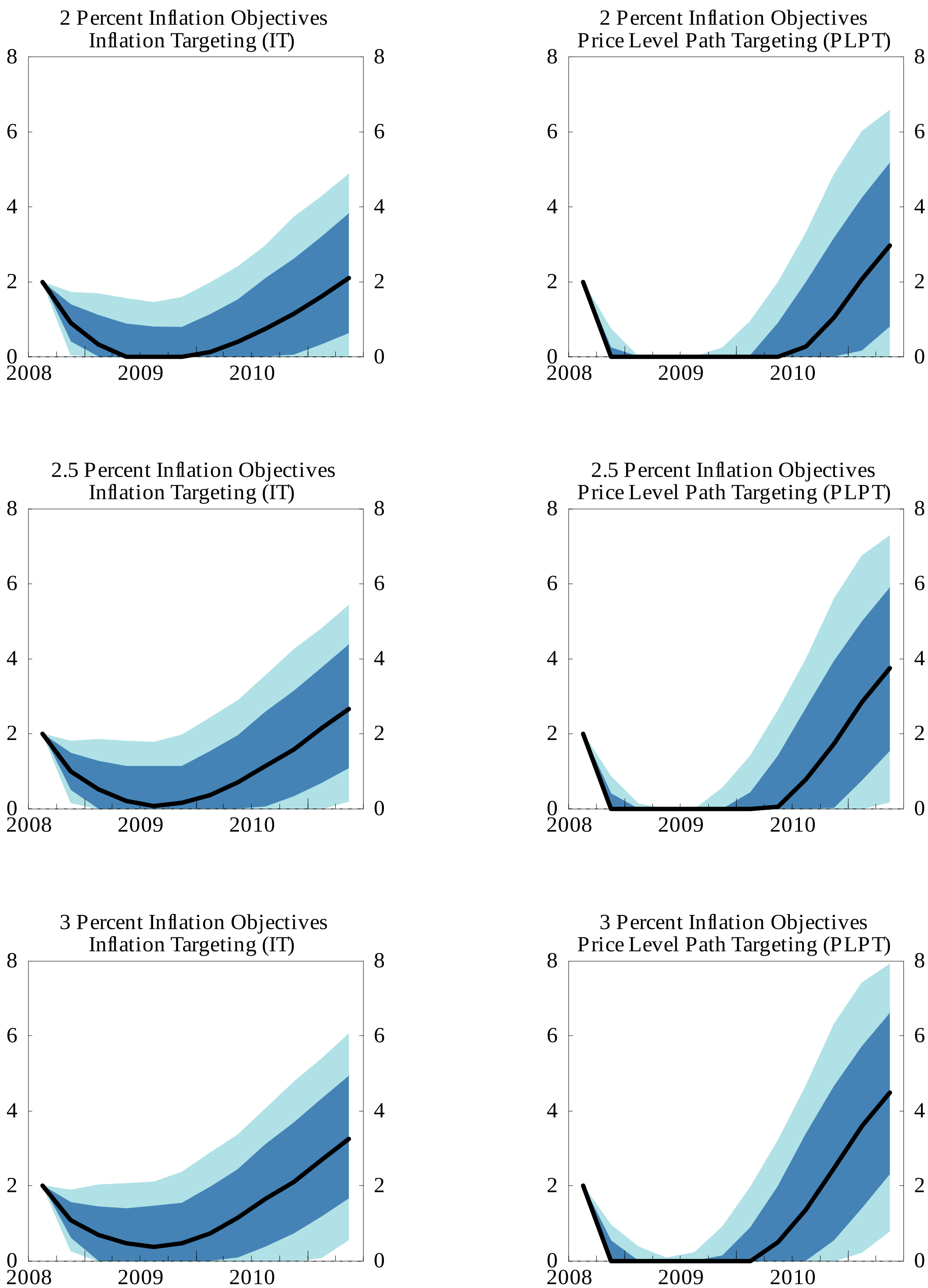

Figure 9: Euro Area: Output Gap

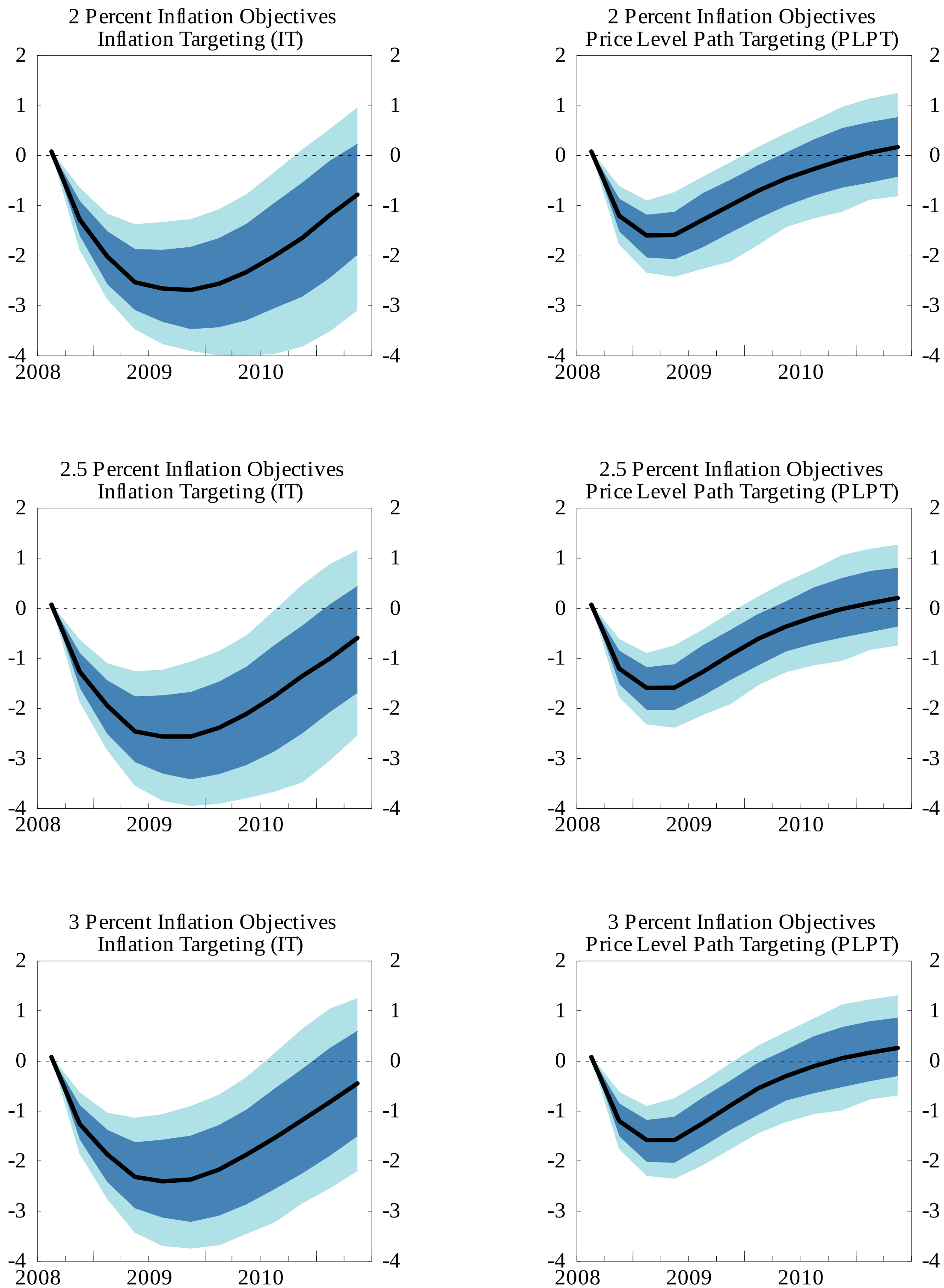

Figure 10: Euro Area: Year-on-Year Inflation Rate

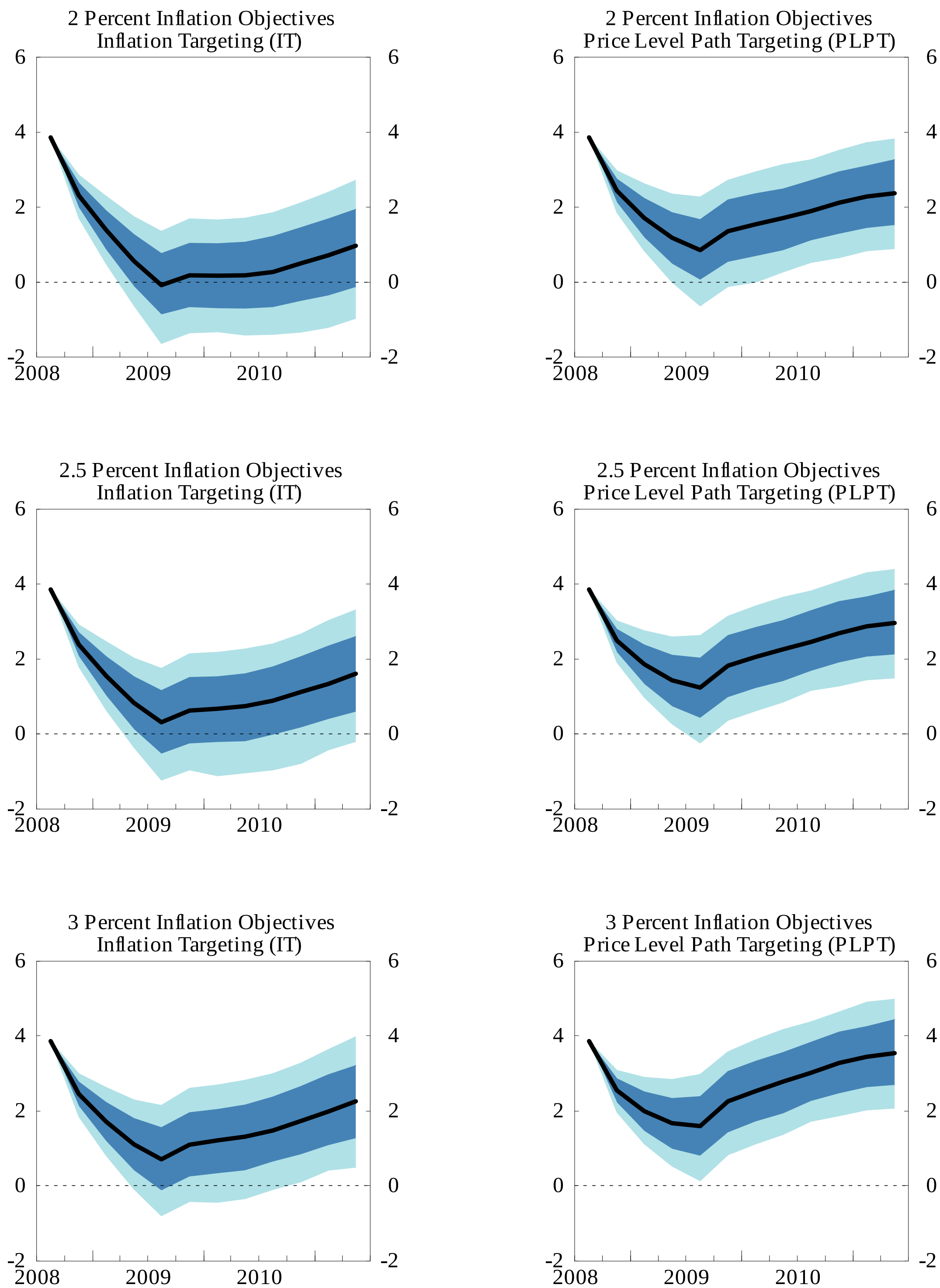

Figure 11: Euro Area: Short-Term Interest Rate

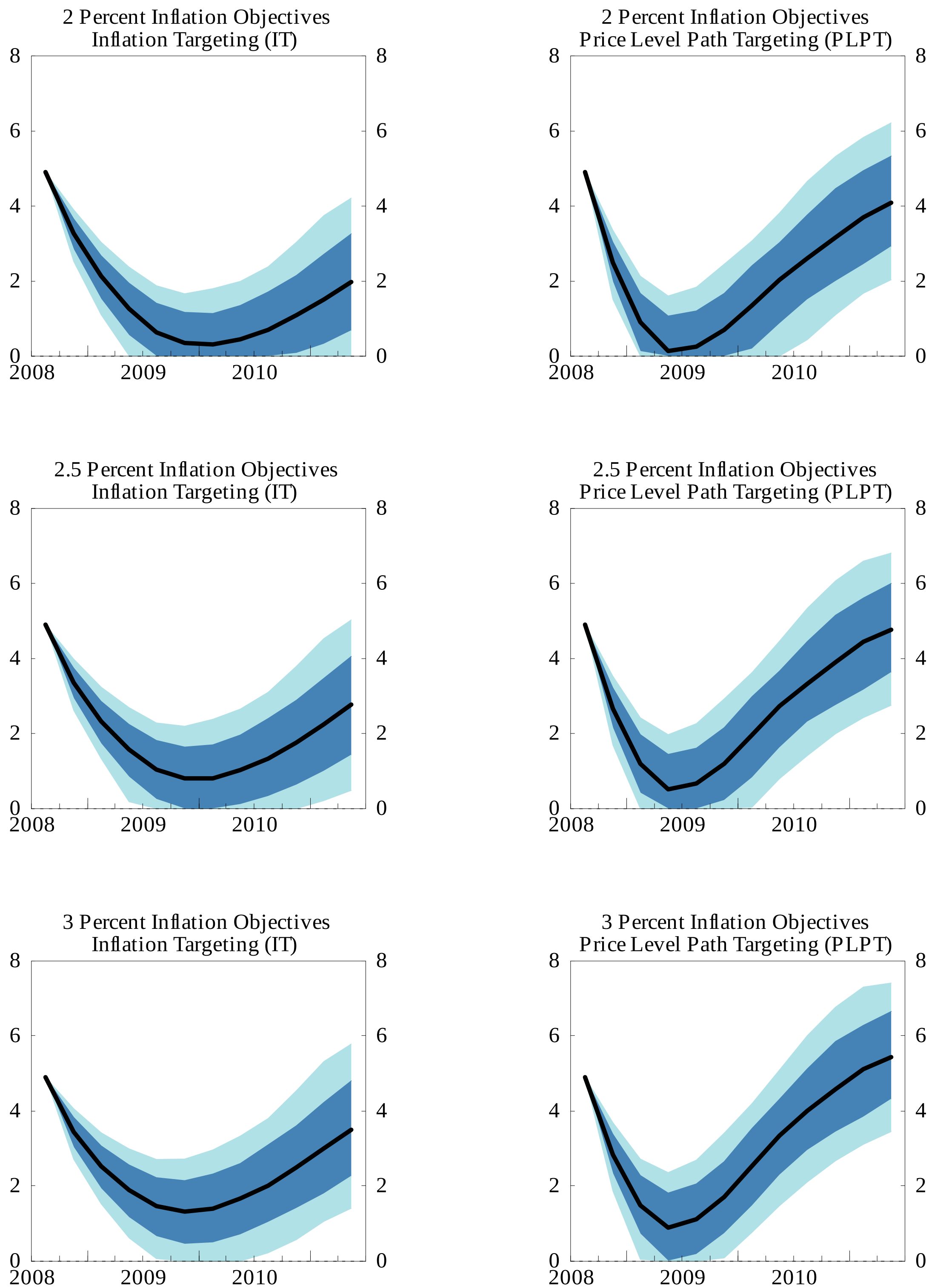

Figure 12: Japan: Output Gap

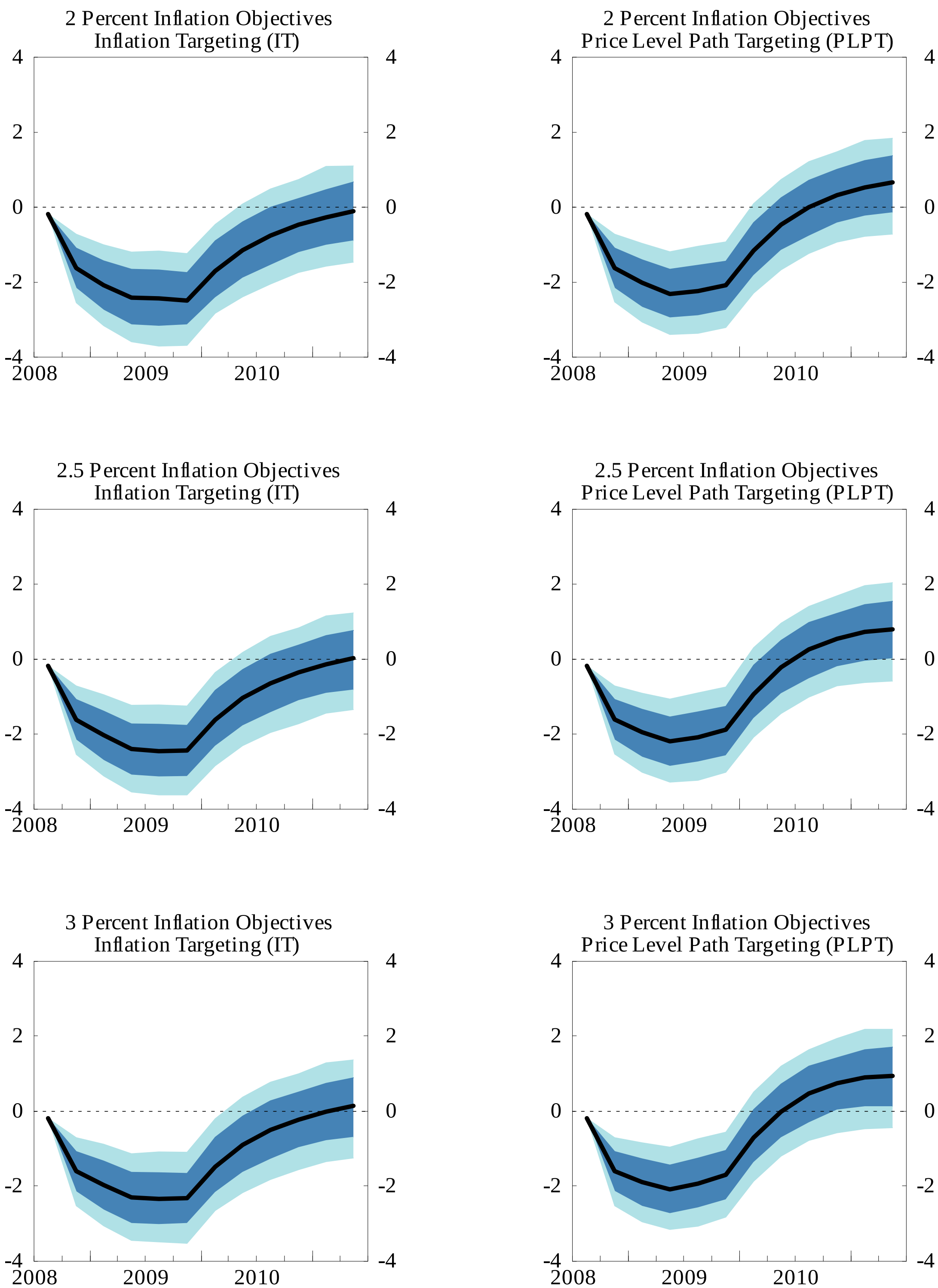

Figure 13: Japan Year-on-Year Inflation Rate

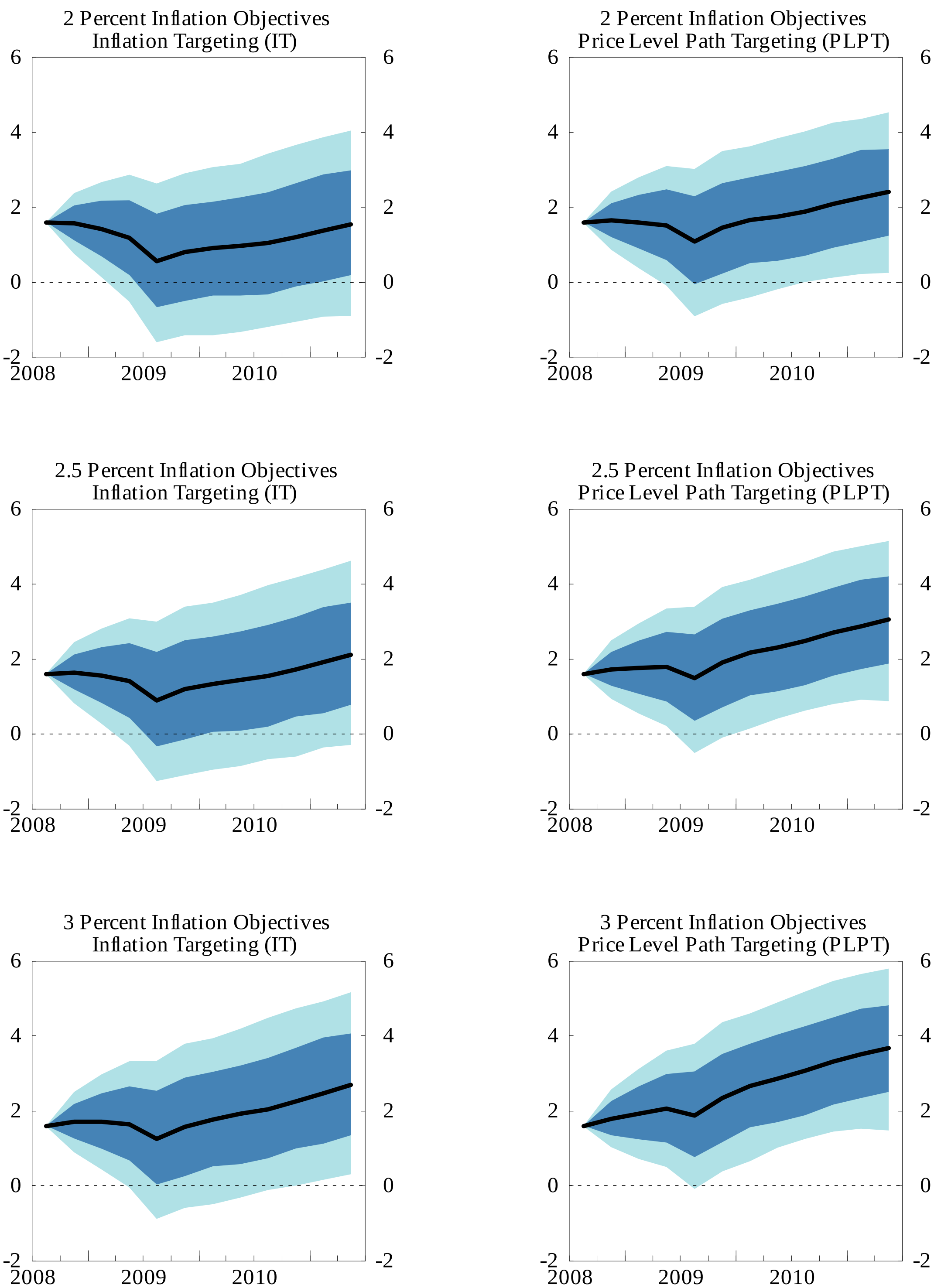

Figure 14: Japan: Short-Term Interest Rate