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Price Level Targeting and Risk Management*

Roberto Billi

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Price Level Targeting and Risk Management*

Roberto M. Billi[†]

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Abstract

Many argue that, in the presence of a lower bound on nominal interest rates, central banks should use a risk management approach for setting policy, which implies committing to a more expansionary policy to deal with uncertainty about the economic recovery. Using a standard model for monetary policy analysis, I study the effects of an uncertain future for both price level targeting and nominal GDP level targeting. The results clarify that, during lower bound episodes, the extent to which policy can overcome uncertainty depends crucially on the choice of policy framework.

Keywords: nominal level targets, optimal discretionary policy, zero lower bound

JEL: E31, E52, E58

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1 Introduction

Most would agree that, to reduce the risk of particularly adverse outcomes for the economy, central banks should use a risk management approach for setting policy. Such an approach implies committing to a more expansionary policy to deal with uncertainty about the strength of the economic recovery in the presence of a zero lower bound (ZLB) on nominal interest rates.¹ In fact, during ZLB episodes, if the economic recovery turns out to be stronger than anticipated, the central bank can remove policy accommodation, but in an unanticipated downturn the scope for further policy stimulus is limited.

Using a standard model for monetary policy analysis, this article studies the effects of an uncertain future for both price level targeting and nominal GDP level targeting during ZLB episodes.² Recently in Billi (2015) I have shown that, if the central bank faces persistent supply and demand shocks, nominal GDP level targeting may lead to large falls in nominal GDP, because such a policy framework implies renouncing to a certain extent to stabilizing the price level. However, strict price level targeting induces greater policy inertia and thus improves the tradeoffs faced by the central bank. By introducing risk management considerations into the analysis, this article clarifies that, during ZLB episodes, the extent to which policy can overcome uncertainty depends crucially on the choice of policy framework.

In the analysis, I consider two scenarios regarding the evolution of the economy. In one, despite shocks hitting the economy, the future state of the economy is assumed to be known in advance with certainty (perfect foresight). In the other, the economy is buffeted by unforeseen shocks and thus the future is not known (uncertain future). The scenarios are compared in a small New Keynesian model, calibrated to recent U.S. data. In the model, the central bank operates under optimal discretion and faces a ZLB constraint. The policy frameworks are then ranked in terms of economic performance, based on the model's social welfare function. In the model, adverse demand shocks and the ZLB cause a tradeoff between current and future

¹This article follows the practice of referring to a zero lower bound for nominal interest rates, but the recent experience with negative nominal rates in Europe suggests the effective lower bound is below zero.

²To view some recent proposals for nominal GDP level targeting, see for example Frankel (2013), Hatzius and Stehn (2011), Sumner (2011), and Woodford (2012). See Billi (2015) for further references.

output, because it is desirable in a ZLB episode to promise to induce an economic expansion after the ZLB episode.³

Relative to the existing ZLB literature, the article shows that under nominal GDP level targeting the existence of unforeseen shocks substantially worsens the tradeoff between current and future output, as a consequence the extent to which monetary policy overcomes uncertainty is rather limited. At the same time, however, strict price level targeting is more effective in dealing with uncertainty. This conclusion only partially explains the result in Billi (2015), because nominal GDP level targeting worsens the aforementioned tradeoff even absent uncertainty. Following Adam and Billi (2007) and Nakov (2008), a recent paper by Evans, Fisher, Gourio and Krane (2015) studies how uncertainty delays the liftoff from the ZLB in an inflation targeting framework, absent a nominal level target.⁴

Section 2 describes the model. Section 3 explains the policy frameworks. Section 4 explains the scenarios regarding the uncertainty. Section 5 presents the policy evaluation. And Section 6 concludes. The Appendix contains technical details on the model solution.

2 The model

I apply a version of the small New Keynesian model of Woodford (2010). The behavior of the private sector is summarized by two structural equations, log-linearized around zero inflation.

On the demand side of the model economy, the Euler equation describes the representative household's expenditure decisions,

$$y_t = E_t y_{t+1} - \varphi (i_t - r - E_t \pi_{t+1} - v_t), \quad (1)$$

where y_t is output measured as the log deviation from trend. π_t is the inflation rate, the log change of prices, $p_t - p_{t-1}$. And $i_t \geq 0$ is the nominal interest rate, while $r > 0$ is the steady-state real interest rate. $\varphi > 0$ is the interest elasticity of real aggregate demand,

³In the analysis, even though supply shocks do not lead to hitting the ZLB, supply shocks can buffet the economy during ZLB episodes. See Billi (2015) for a discussion.

⁴The paper also provides evidence, based on Federal Reserve communications, that risk management considerations have been influential for setting monetary policy.

capturing intertemporal substitution in household spending. The demand shock v_t represents other spending, for example, government spending. Though a positive demand shock can be countered by raising the nominal interest rate, a large adverse shock that leads to hitting the ZLB results in an economic downturn.

On the supply side of the economy, the Phillips curve describes the optimal price-setting behavior of firms, under staggered price changes à la Calvo,

$$\pi_t = \beta E_t \pi_{t+1} + \kappa x_t + u_t, \quad (2)$$

where $\beta \in (0, 1)$ is the discount factor of the representative household.⁵ The slope parameter $\kappa > 0$ is a function of the structure of the economy.⁶ $x_t \equiv y_t - y_t^n$ is the output gap. y_t^n is the natural rate of output, the output deviation from trend that would prevail in the absence of any price rigidities, which represents a *technology shock*. And u_t is a cost-push shock, or a *mark-up shock* resulting from variation over time in the degree of monopolistic competition between firms, which causes an inflation-output tradeoff for monetary policy.

Each of the three types of shocks (y_t^n, u_t, v_t) follows an AR(1) stochastic processes, with first-order autocorrelation parameters $\rho_j \in (-1, 1)$ for $j = y, u, v$. And $\sigma_{\varepsilon j} \varepsilon_{jt}$ are the innovations that buffet the economy, which are independent across time and cross-sectionally, and normally distributed with mean zero and standard deviations $\sigma_{\varepsilon j} \geq 0$.

Finally, the policy frameworks to be considered are evaluated based on the model's social welfare function approximated around zero inflation, as derived in Woodford (2010),

$$E_0 \sum_{t=0}^{\infty} \beta^t [\pi_t^2 + \lambda (x_t - x^*)^2], \quad (3)$$

where $\lambda = \kappa/\theta$ is the weight assigned to stabilizing the output gap relative to inflation. x^* is the target level of the output gap, which stems from monopolistic competition and distortion in the steady state. Output subsidies are assumed to offset the monopolistic distortion so

⁵ β is determined as $1/(1+r)$.

⁶In this model $\kappa = (1-\alpha)(1-\alpha\beta)\alpha^{-1}(\varphi^{-1}+\omega)(1+\omega\theta)^{-1}$, where $\omega > 0$ denotes the elasticity of a firm's real marginal cost. $\theta > 1$ is the price elasticity of demand substitution with firms in monopolistic competition. And $\alpha \in (0, 1)$ is the share of firms keeping prices fixed each period.

the steady state is efficient, $x^* = 0$. Thus, in the analysis there is no inflation bias but a stabilization bias due to discretionary policy.

3 The policy frameworks

Under optimal discretion, the central bank has an objective function and re-optimizes its policy decision in each period. In this analysis, two monetary policy frameworks are considered, and in each framework the private sector and central bank operate with the same information.

Strict price level targeting. First, the objective function is $\min_{i_t \geq 0} E_t \sum_{j=0}^{\infty} \beta^j p_{t+j}^2$, where p_t is the price level, which is equal to $p_{t-1} + \pi_t$. By focusing on price stability, the policymaker transfers the entire burden of shocks onto output. This approach involves inertia in the setting of policy, because the current policy decision depends on the past price level.

Nominal GDP level targeting. Second, the objective function is $\min_{i_t \geq 0} E_t \sum_{j=0}^{\infty} \beta^j n_{t+j}^2$, where n_t is the (detrended) level of nominal GDP, the log sum of prices and output, $p_t + y_t$. Because this approach requires the burden of shocks to be shared by prices and output, the policymaker acts less in accordance with a precommitment to price stability.

4 The uncertainty

In equilibrium, the policymaker chooses a policy based on a response function $\mathbf{y}(\mathbf{s}_t)$ and a state vector \mathbf{s}_t . The expectations function is $\mathbf{E}_t \mathbf{y}_{t+1} = \int \mathbf{y}(\mathbf{s}_{t+1}) f(\varepsilon_{t+1}) d(\varepsilon_{t+1})$ with $\sigma_\varepsilon \geq \mathbf{0}$, where $f(\cdot)$ is a probability density function of the future innovations that buffet the economy.⁷ In this analysis, two scenario about the future innovations are considered.

Perfect foresight. In the first scenario, despite shocks hitting the economy, the future state of the economy is assumed to be known in advance with certainty, $\sigma_\varepsilon = \mathbf{0}$. The ZLB constraint then affects the setting of policy only when it actually binds.⁸

⁷An equilibrium is then given by $\mathbf{y}(\mathbf{s}_t)$ and $\mathbf{E}_t \mathbf{y}_{t+1}$ that satisfy the optimal policy problem's equilibrium conditions, derived in Appendix A.1.

⁸Thus, $\mathbf{E}_t \mathbf{y}_{t+1}$ simplifies to $\mathbf{y}(\mathbf{s}_{t+1})$. The model can then be solved with standard numerical methods.

Uncertain future. Instead the second scenario takes into account the existence of uncertainty about the future state of the economy, $\sigma_\varepsilon > 0$. In such a case, when the ZLB threatens, the mere possibility of hitting the ZLB causes expectations of a future downturn in the economy, as shown by Adam and Billi (2007) and Nakov (2008).⁹

5 Policy evaluation

After calibrating the model, I assess the effects of an uncertain future for the performance of the two targeting frameworks.

5.1 Calibration

The small model economy is calibrated to U.S. data for recent decades following Billi (2015). Regarding the structural parameters, β is set to 0.99, to imply a steady-state interest rate of 4 percent annual. φ is set to 6.25.¹⁰ The implied parameters κ and λ are equal to 0.024 and 0.003, respectively. Regarding the calibration of the shocks, $\rho_{y,u,v}$ are set to 0.8. $\sigma_{y,v}$ are set to 0.8 percent quarterly, while σ_u is set to 0.05 percent quarterly. In Billi (2015) the ranking of the two targeting frameworks is shown to be robust to a wide range of alternate calibrations.

5.2 The effects of an uncertain future

Using the calibrated model, figure 1 shows the expected liftoff of the nominal interest rate after an adverse demand shock.¹¹ The top panel shows the response under strict price level targeting, both with perfect foresight and an uncertain future, as well as the difference between the two scenarios. In both scenarios, given the size of the shock, the central bank cuts the nominal rate all the way to the ZLB. However, with an uncertain future the nominal rate stays for a longer time below its equilibrium value, which implies greater policy stimulus.

⁹To solve the model with unforeseen shocks, I employ the same numerical procedure as in Billi (2015).

¹⁰ α is set to 0.66, so the duration between price changes $1/(1 - \alpha)$ is 3 quarters. θ is set to 7.66, so the markup over marginal costs $\theta/(\theta - 1)$ is 15 percent. And ω is set to 0.47.

¹¹The shock size is three standard deviations. The expected paths are obtained by averaging across 10,000 stochastic simulations.

The bottom panel shows the response under nominal GDP level targeting, with uncertainty resulting in a more expansionary policy. But comparing to the top panel, nominal GDP level targeting entails an earlier liftoff from the ZLB and less policy stimulus.¹² The figure thus suggests that nominal GDP level targeting is less effective in dealing with uncertainty.

[Figure 1 about here]

To illustrate the effectiveness of policy, figure 2 shows the expected path of the nominal GDP level following the adverse demand shock. As the top panel shows, under strict price level targeting, nominal GDP on impact falls below trend but later rises above trend, both with perfect foresight and an uncertain future. But with an uncertain future, the recession is deeper and the expansion is stronger. The reason for this stronger expansion is the greater policy stimulus, which improves the tradeoff between current and future output. However, as the bottom panel shows, under nominal GDP level targeting, uncertainty results in a notably deeper recession and slower recovery.

[Figure 2 about here]

Next, to rank the two targeting frameworks, table 1 summarizes their overall performance. The table reports the expected frequency and duration of ZLB episodes, as well as the welfare loss due to business cycles.¹³ The top panel shows the results with perfect foresight, while the middle panel shows the outcome with an uncertain future, and the bottom panel shows the difference between the two scenarios. In both scenarios, nominal GDP level targeting leads to more costly fluctuations in prices and output, especially with an uncertain future. In fact, although uncertainty raises the welfare costs of business cycles, the welfare costs rises more under nominal GDP level targeting. In sum, strict price level targeting overcomes uncertainty to a greater extent than nominal GDP level targeting.

¹²As a consequence, ZLB episodes are less frequent and shorter under nominal GDP level targeting. With an uncertain future, the frequency of ZLB episodes is 8 percent of the time under nominal GDP level targeting, but rises to 15 percent under strict price level targeting; at the same time, the expected duration of a ZLB episode rises from 1.8 to 3.4 quarters (table 1).

¹³To calculate the welfare loss, first the value of objective function (3) is obtained by averaging across 10,000 stochastic simulations each 1,000 periods long after a burn-in period. This value is then converted into a permanent consumption loss, as explained in Billi (2015).

[Table 1 about here]

6 Conclusion

In this article, I study the effects of an uncertain future for both price level targeting and nominal GDP level targeting in the presence of a ZLB constraint. The analysis clarifies that, during ZLB episodes, the extent to which monetary policy can overcome uncertainty depends crucially on the choice of policy framework. In particular, the existence of unforeseen shocks worsens the tradeoff, between current and future output, faced by the central bank. However, strict price level targeting induces greater policy inertia and therefore is more effective in dealing with uncertainty. Still, the analysis is conducted in a stylized model that does not include, for example, the effects of positive trend inflation, nor balance sheet policies and fiscal spending, which involve additional tradeoffs for monetary policy. Incorporating such features into the analysis seems an interesting task for future research.

A Appendix

A.1 Equilibrium conditions

To derive the equilibrium conditions, the optimal policy problem can be written as

$$\begin{aligned} V(\mathbf{s}_t) = \max & \left[- (p_{t-1} + \pi_t + I y_t)^2 + \beta E_t V(\mathbf{s}_{t+1}) \right] \\ & \text{subject to (1), (2) and } i_t \geq 0 \\ & \text{and } \mathbf{E}_t \mathbf{y}_{t+1} \text{ given,} \end{aligned}$$

where I represents an indicator function, which for any \mathbf{s}_t is equal to 1 under nominal GDP level targeting and to 0 under strict price level targeting. Write the period Lagrangian

$$\begin{aligned}
L_t = & -(p_{t-1} + \pi_t + Iy_t)^2 + \beta E_t V(\mathbf{s}_{t+1}) \\
& + m_{1t} [\pi_t - \beta E_t \pi_{t+1} - \kappa(y_t - y_t^n) - u_t] \\
& + m_{2t} [-y_t + E_t y_{t+1} - \varphi(i_t - r - E_t \pi_{t+1} - v_t)] \\
& \text{and } \mathbf{E}_t \mathbf{y}_{t+1} \text{ given}
\end{aligned}$$

The Kuhn-Tucker conditions are

$$\partial L_t / \partial \pi_t = -2(p_{t-1} + \pi_t + Iy_t) + m_{1t} = 0 \quad (4)$$

$$\partial L_t / \partial y_t = -2(p_{t-1} + \pi_t + Iy_t) - \kappa m_{1t} - m_{2t} = 0 \quad (5)$$

$$\partial L_t / \partial i_t \cdot i_t = -\varphi m_{2t} \cdot i_t = 0, \quad m_{2t} \geq 0, \quad i_t \geq 0 \quad (6)$$

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Table 1: Uncertain future and economic performance

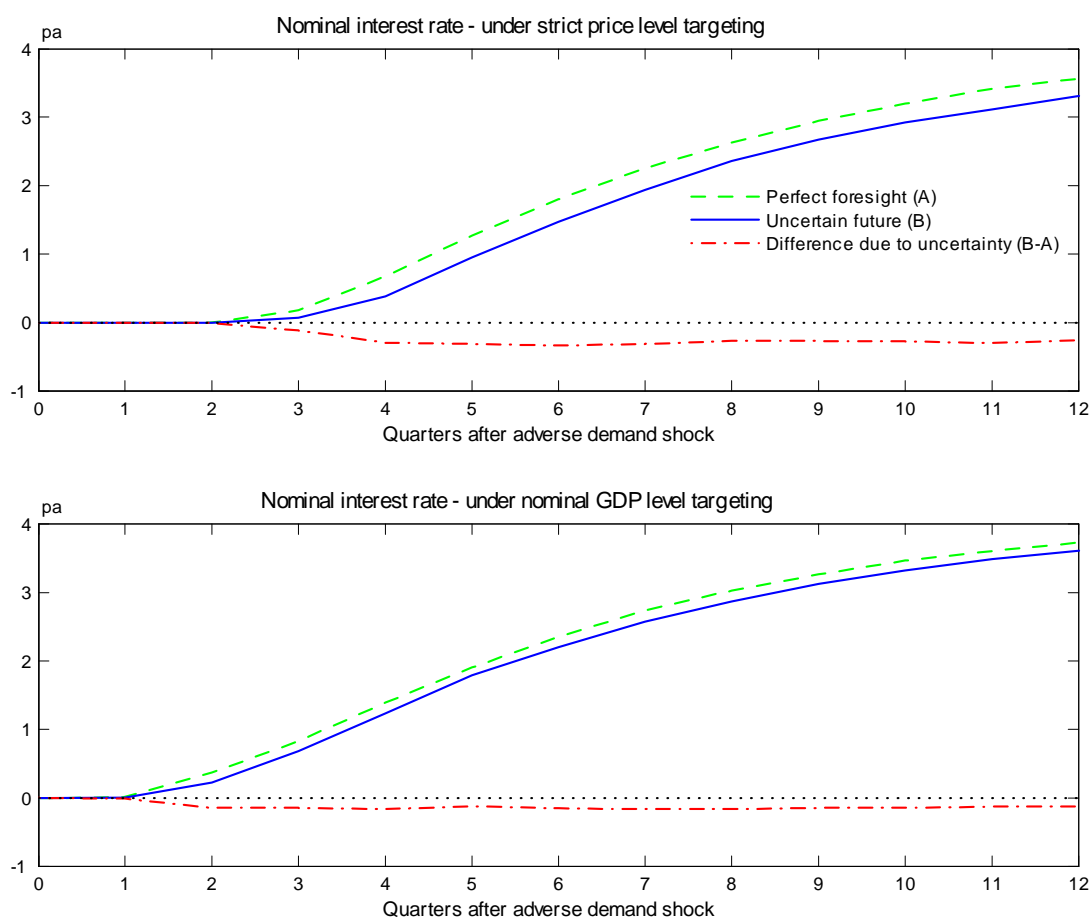
| | ZLB episodes | | Welfare loss ^c | | |
|--------------------------------------|--------------------|-----------------------|---------------------------|-----|------|
| | freq. ^a | duration ^b | π | x | Tot. |
| Perfect foresight (A): | | | | | |
| Strict price level targeting | 9 | 2.8 | 0 | 7 | 7 |
| Nominal GDP level targeting | 5 | 1.7 | 7 | 4 | 11 |
| Uncertain future (B): | | | | | |
| Strict price level targeting | 15 | 3.4 | 1 | 9 | 10 |
| Nominal GDP level targeting | 8 | 1.8 | 13 | 11 | 24 |
| Difference due to uncertainty (B-A): | | | | | |
| Strict price level targeting | 6 | 0.6 | 1 | 2 | 3 |
| Nominal GDP level targeting | 3 | 0.1 | 6 | 7 | 13 |

a. Expected percent of time at the ZLB

b. Expected number of consecutive quarters at the ZLB

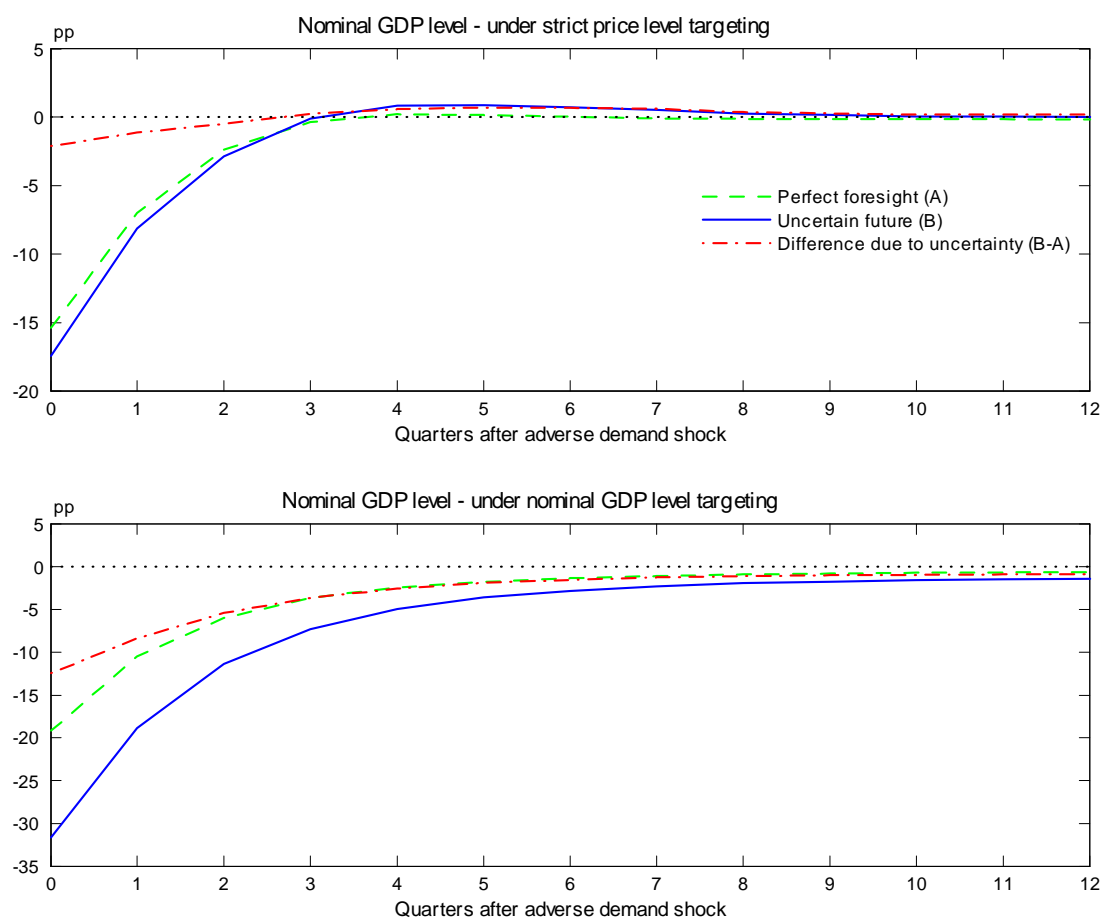
c. Permanent consumption loss (basis points)

Figure 1: Delayed policy rate liftoff in the presence of an uncertain future



Note: Expected paths after a -3 standard deviation v_t shock

Figure 2: Uncertain future and economic stability during ZLB episodes



Note: Expected paths after a -3 standard deviation v_t shock

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