

# Department of Economics

## Working Paper

**The Effectiveness of Central Bank Forward  
Guidance under Inflation and Price-Level Targeting**

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*Working Paper 2016-06*

**College of Business Administration**



# The Effectiveness of Central Bank Forward Guidance under Inflation and Price-Level Targeting

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August 10, 2016

## Abstract

This paper examines the effectiveness of central bank forward guidance under inflation and price-level targeting monetary policies. The results show that the attenuation of the effects of forward guidance can be solved if a central bank switches from inflation targeting to price-level targeting. Output and inflation respond more favorably to forward guidance with price-level targeting than inflation targeting. A monetary policy rule that aggressively reacts to inflation and includes interest rate inertia narrows the performance gap between the two policy regimes. However, forward guidance with price-level targeting is still preferred to forward guidance with inflation targeting after performing multiple robustness checks.

*Keywords:* Forward Guidance, Inflation Targeting, Price-Level Targeting, Monetary Policy.

*JEL classification:* E30, E31, E50, E52, E58, E60.

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# 1 Introduction

The 2007-2009 global financial crisis caused severe adverse effects on economies around the world. Central banks reacted by implementing unconventional monetary policies as their usual policy of lowering overnight interest rates had become exhausted due to the zero lower bound (ZLB). A new tool enacted was forward guidance where the future course of monetary policy is communicated to the public by the central bank. For example, the U.S. Federal Reserve announced guidance on the future path of the short-term interest rate. Another instance regards information about its long-term inflation target. For example, the Federal Reserve communicated in 2012 that “The Committee judges that inflation at the rate of 2 percent . . . is most consistent over the longer run with the Federal Reserve’s statutory mandate.” In this case, forward guidance is in terms of the path of the Federal Reserve’s long-run inflation target. However, even with these additional stimulative measures, U.S. inflation has missed its Federal Reserve target of 2% from the period April 2012 to July 2016. Thus, is there another way to increase the effectiveness of forward guidance?

The debate about whether a central bank should switch from targeting the inflation rate to the price level has been accentuated because of the adverse effects of the Great Recession.<sup>1</sup> Standard central bank practice and macroeconomic models recommend a monetary policy that targets the inflation rate. Targeting the rate of inflation instead of the price level can achieve lower amounts of fluctuations in output and inflation than price-level targeting (see Lebow et al., 1992 and Haldane and Salmon, 1995). However, the period from April 2012 through July 2016 witnessed historic low levels of U.S. inflation as it missed its Federal Reserve target throughout this duration. In contrast, targeting the price-level theorizes stimulative effects to the inflation rate. This monetary policy regime predicts a period of above average inflation after a deflationary episode as the central bank must rapidly raise the price level back to its target path. Since its beneficial predictions for the inflation rate, a natural question that arises is if price-level targeting can increase the positive effects of forward guidance on the economy.

This paper investigates the effectiveness of forward guidance across two monetary policy regimes: inflation and price-level targeting. A standard New Keynesian model is extended to include a monetary policy rule that takes two forms. The first policy responds to deviations of the inflation rate from its target. The alternative is a monetary authority that changes the interest rate due to deviations of the price level from its target. The targeted price level grows at a rate defined by the central bank’s inflation target. Forward guidance is included in the model via the central

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<sup>1</sup>For instance, Evans (2012) describes the positive benefits of price-level targeting when Federal Reserve policy has failed to achieve its dual mandate.

bank communicating about the future course of its inflation target. Anticipated shocks are added to the inflation target. These shocks represent future deviations in the inflation target known to agents and communicated by the monetary authority today.

The key difference between inflation and price-level targeting monetary policies regards history dependence. Under the former regime, history dependence is inherently absent. For instance, historical inflationary shocks do not play a role in inflation targeting policy. If an adverse shock produced a decline in inflation and the price level, a monetary authority that targets the inflation rate would only be concerned with bringing inflation back to its target level. Since it lets bygones be bygones, the drop in the price level does not concern an inflation targeting central bank. In contrast, a price-level targeting regime is inherently history dependent. It reacts to the low price level caused by the prior adverse shocks by bringing the price level back to its higher target. This action creates a period of above average inflation.<sup>2</sup>

The results show that the attenuation of the effects of forward guidance can be solved if a central bank switches from inflation to price-level targeting monetary policy. These outcomes are shown during a period of severe economic decline. The monetary authority responds to this recession by implementing forward guidance in the form of a constant level for the future path of its inflation target.<sup>3</sup> The values of output and inflation are higher under forward guidance with price-level targeting than forward guidance with inflation targeting. The results also favor forward guidance under the former than latter monetary policy when utilizing a loss function based on variances of inflation, output, and the interest rate. The values of this loss function are higher under forward guidance with inflation targeting than forward guidance with price-level targeting.

The reasons for the favorable effects of forward guidance under price-level targeting than inflation targeting are twofold. The first regards the inherent history dependence feature of the former monetary policy regime. A price-level targeting central bank reacts to the drop in inflation and the price level by using policy to rapidly bring the latter macroeconomic variable back to its target. This action results in periods of above average inflation. The second reason concerns how the expectations of agents react to forward guidance statements given by the monetary authority. In response to central bank forward guidance, agents' expectations of output and inflation are more favorable under price-level than inflation targeting. Under the former monetary policy, agents expect higher future inflation as the central bank will target a higher price level than otherwise would exist. The increases in inflation expectations lead to higher levels of output expectations.

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<sup>2</sup>In the model presented in this paper, I also assume interest rate inertia to both inflation and price-level targeting regimes. This feature adds a degree of common history dependence to both policies. However, price-level targeting still has the inherent history dependence as discussed in this paragraph.

<sup>3</sup>This is akin to the FOMC stating its long-run objective for inflation of 2%.

These combined effects result in larger levels of current output and inflation.

The favorable results under forward guidance with price-level targeting hold across different policy scenarios. The first investigates whether the performance gap between the two policy regimes with forward guidance can be reduced if there is a more aggressive monetary policy. A central bank that responds more to deviations of the inflation rate from its target than it did before can narrow this gap between forward guidance with inflation targeting and forward guidance with price-level targeting. Introducing interest rate inertia also alleviates the disparity. By including a lagged interest rate in both inflation and price-level targeting monetary policy rules, the differences are reduced as the first policy regime has a level of history dependence closer to the second policy regime. However, forward guidance still has more favorable outcomes under price-level than inflation targeting.

The model's main results are also robust to different degrees of price stickiness and forward guidance horizons. When lowering the level of price stickiness in the model, the levels of output and inflation are still higher under forward guidance with price-level targeting than forward guidance with inflation targeting. When varying the length of the forward guidance horizon, output and inflation respond to forward guidance more favorably under price-level than inflation targeting.

Overall, the results indicate a primary takeaway: a central bank that switches from inflation to price-level targeting can produce more favorable responses of macroeconomic variables to forward guidance. For instance, output and inflation are higher under forward guidance with price-level targeting than inflation targeting. These results are also confirmed under alternative scenarios.

## 1.1 Previous Literature

The current paper contributes to previous research on the effectiveness of central bank forward guidance. Eggertsson and Woodford (2003) explain how central bank communication about the future course of policy (e.g. the path of interest rates) is pertinent for successful monetary policy. Swanson and Williams (2014) empirically show that medium- and longer-term interest rates are influenced by forward guidance communication. De Graeve, Ilbas, and Wouters (2014) find that the effectiveness of forward guidance depends on the rationale for implementing this policy. For instance, if the central bank communicates that the reason for lower than normal interest rates in the future is a forecasted downturn in the economy, the effectiveness of forward guidance will increase. In addition, Carlstrom, Fuerst, Paustian (2012) and Del Negro, Giannoni, and Patterson (2012) show that standard macroeconomic models predict extreme responses of the variables to forward guidance. McKay, Nakamura, and Steinsson (2015) explain that these predictions vary

depending on the assumption of complete markets. Cole (2015) and Cole (2016) state that the unusually large responses and the effectiveness of this unconventional monetary policy tool may be due to the manner in which expectations are modeled. Furthermore, the current paper augments these studies by examining the effectiveness of forward guidance when the central bank implements price-level targeting.

Prior studies have shown the positive benefits of a price-level targeting central bank. Woodford (2003) describes that a history dependent central bank can improve the power of monetary policy when agents are forward looking. Svensson (1999) shows that this monetary policy regime can reduce fluctuations in the inflation rate relative to an inflation targeting central bank. Giamponi (2014) explains that price-level targeting outperforms inflation when judging by welfare. Evans (2012), Billi (2008), Wolman (2005), and Eggertsson and Woodford (2003) argue that a price-level targeting monetary policy can alleviate adverse effects of an economy at the ZLB. If there is an adverse shock that drops the price level, Gaspar, Smets, and Vestin (2007) describe that agents will forecast a policy that raises the price level in the future. This expected increase raises inflation expectations and lowers real interest rates. Consequently, the decrease in the real interest rate stimulates the economy. In addition, price-level targeting has been studied when relaxing the rational expectations hypothesis. Williams (2010) investigates this monetary policy under adaptive learning and at the ZLB. Honkapohja and Mitra (2015b) examine the performance of inflation, price level, and nominal GDP targeting policies under a New Keynesian model with adaptive learning.<sup>4</sup> They introduce forward guidance on the targeted price level or nominal GDP. The addition of forward guidance to either price level or nominal GDP targeting can help the economy avoid a liquidity trap. Furthermore, the current paper adds to this literature by examining how the effectiveness of forward guidance increases when a central bank switches from inflation to price-level targeting. Forward guidance is also applied to both inflation and price-level targeting and regards the future path of the inflation target.

The rest of the paper is organized as follows. Section two presents the New Keynesian model with forward guidance under both inflation and price-level targeting. Section three shows the results of the model with forward guidance under both types of monetary policy regimes. Section four investigates the disparity between the responses of the macroeconomic variables to forward guidance with inflation targeting and forward guidance with price-level targeting. Specifically, it examines the model's outcomes under an aggressive monetary policy and with or without interest rate inertia. Section five contains robustness exercises in which the degree of price stickiness and

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<sup>4</sup>Honkapohja and Mitra (2015a) also perform a similar analysis without nominal GDP targeting.

the length of the forward guidance horizon vary. Section six concludes.

## 2 Model

The economy's aggregate dynamics are described by the benchmark New Keynesian model analyzed in Woodford (2003). The model is derived from microfoundations and contains three sectors: households, firms, and a monetary authority. The log-linearized equations modeling the first two are given by

$$x_t = E_t x_{t+1} - \sigma(i_t - E_t \pi_{t+1}) + r_t^n \quad (1)$$

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

Equation (1) represents aggregate demand in the economy.  $x_t$  denotes the output gap, which is the difference between current output from its potential.<sup>5</sup> The output gap is a function of expected one-period ahead output gap ( $E_t x_{t+1}$ ), the nominal interest rate ( $i_t$ ), expected one-period ahead inflation ( $E_t \pi_{t+1}$ ), and the natural real rate interest shock ( $r_t^n$ ).  $\sigma > 0$  measures the intertemporal elasticity of substitution of consumption across periods.  $\beta$  is the household's discount rate and is assumed bound between 0 and 1 (i.e.  $0 \leq \beta \leq 1$ ). In addition, firms operate in a monopolistically competitive environment in which they use labor from households to produce their goods. Following Calvo (1983), a fraction  $0 < 1 - \alpha < 1$  of producers are able to reoptimize each period with respect to their price. The remaining  $\alpha$  of firms set prices according to the previous period's price level. The resulting equation representing the supply side of the economy and the New Keynesian Phillips curve is given by (2). It relates inflation to expected one-period ahead inflation, output gap, and a cost-push shock ( $\mu_t$ ). The parameter  $\kappa \equiv \frac{(1-\alpha)}{\alpha} \frac{(1-\alpha\beta)}{(1+\omega\theta)} (\omega + \sigma^{-1}) > 0$  with  $\theta > 1$  representing the elasticity of substitution across differentiated goods.  $\omega$  is the elasticity of a firm's real marginal cost with respect to increasing its output. In addition, the price level is defined by

$$p_t = \pi_t + p_{t-1} \quad (3)$$

The structural disturbances are assumed to follow AR(1) processes given by

$$r_t^n = \rho_n r_{t-1}^n + \varepsilon_t^n \quad (4)$$

$$\mu_t = \rho_\mu \mu_{t-1} + \varepsilon_t^\mu \quad (5)$$

$\varepsilon_t^n$  and  $\varepsilon_t^\mu$  are assumed to be *i.i.d.* and drawn from a Normal distribution, that is,  $\varepsilon_t^n \stackrel{iid}{\sim} N(0, \sigma_n^2)$  and  $\varepsilon_t^\mu \stackrel{iid}{\sim} N(0, \sigma_\mu^2)$ .

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<sup>5</sup>Potential output is defined as output under flexible prices.

## 2.1 Monetary Authority

The model is closed by describing the central bank. The monetary authority is assumed to follow a policy rule by either targeting the inflation rate or the price level. The central bank issues forward guidance on the inflation target. This act is akin to the the Federal Reserve communicating to the public that its long-run inflation target is 2%. For instance, the Federal Reserve declared in January 2012 that “The Committee judges that inflation at the rate of 2 percent . . . is most consistent over the longer run with the Federal Reserve’s statutory mandate.” The next two subsections describe central bank monetary policy rules under forward guidance with inflation targeting and forward guidance with price-level targeting.

### 2.1.1 Inflation Targeting with Forward Guidance

When targeting the inflation rate of the economy, the central bank follows a rule similar to Taylor (1993). It is assumed to adjust the nominal interest rate to changes in itself, output gap, inflation from its target, and an unanticipated monetary policy shock. Accordingly, the monetary policy rule is given by

$$i_t = \rho i_{t-1} + (1 - \rho)[\chi_\pi(\pi_t - \pi_t^*) + \chi_x x_t] + \varepsilon_t^{MP} \quad (6)$$

where  $\varepsilon_t^{MP}$  is *i.i.d.* and drawn from a Normal distribution, that is,  $\varepsilon_t^{MP} \stackrel{iid}{\sim} N(0, \sigma_{MP}^2)$ . Following Del Negro, Giannoni, and Schorfheide (2014), Milani and Treadwell (2012), and Milani (2009), the inflation target  $\pi_t^*$  is assumed to be time varying and is given by

$$\pi_t^* = \rho_{\pi^*} \pi_{t-1}^* + \varepsilon_t^{\pi^*} \quad (7)$$

In addition, the monetary authority communicates to the public guidance on the future course of the inflation target  $\pi_t^*$ . To model this central bank forward guidance, equation (7) is augmented in the following way:

$$\pi_t^* = \rho_{\pi^*} \pi_{t-1}^* + \varepsilon_t^{\pi^*} + \sum_{l=1}^L \varepsilon_{t,t-l}^{FG} \quad (8)$$

The central bank adjusts its inflation target to changes in the previous period’s target, an unanticipated inflation target shock, and forward guidance shocks.<sup>6</sup> I assume that  $\varepsilon_t^{\pi^*} \stackrel{iid}{\sim} N(0, \sigma_{\pi^*}^2)$ . Forward guidance is included in the model via anticipated or forward guidance shocks contained in the last term in equation (8). Each forward guidance shock ( $\varepsilon_{t,t-l}^{FG}$ ) is *i.i.d.* and represents communication by the central bank in period  $t - l$  that the inflation target will change  $l$  periods later (i.e. in

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<sup>6</sup>Milani and Treadwell (2012) model the time-varying inflation target in a similar fashion to (8), but their focus is on policy news and not forward guidance.



period  $t$ ).<sup>7</sup> If the monetary authority has been communicating forward guidance for  $1, 2, \dots, L$  periods ahead, equation (8) would contain  $L$  forward guidance shocks that affect the inflation target. Therefore, the duration of the forward guidance horizon is defined by  $L$ . Following Del Negro et al. (2012) and Laséen and Svensson (2011), the forward guidance shocks are expressed in recursive form by adding the following equations:

$$v_{1,t} = v_{2,t-1} + \varepsilon_{1,t}^{FG} \quad (9)$$

$$v_{2,t} = v_{3,t-1} + \varepsilon_{2,t}^{FG} \quad (10)$$

$\vdots$

$$v_{L,t} = \varepsilon_{L,t}^{FG} \quad (11)$$

The vector  $v_t = [v_{1,t}, v_{2,t}, \dots, v_{L,t}]'$  contains all central bank promises known to agents in period  $t$  that the inflation target will change  $1, 2, \dots, L$  periods later. For instance,  $v_{1,t}$  defines all forward guidance information that agents know in period  $t$  such that the inflation target will change one period later. It contains central bank communication given to agents in period  $t - 1$  that influences the inflation target 2 periods later ( $v_{2,t-1}$ ) and current period forward guidance affecting the inflation target one period later ( $\varepsilon_{1,t}^{FG}$ ). Since  $L$  is the maximum amount of periods ahead that the central bank issues forward guidance,  $v_{L,t}$  only contains current period forward guidance that affects the inflation target  $L$  periods later. In addition, one can use equations (9) - (11) to show that  $v_{1,t-1} = \sum_{l=1}^L \varepsilon_{t,t-l}^{FG}$ , which is the last term in equation (8). It should also be noted that modeling forward guidance as in equations (8) - (11) provides a tractable way to model a constant inflation target path. The forward guidance shocks in equations (9) - (11) can be chosen so that the inflation target is constant across the forward guidance horizon. This path is similar to the Federal Reserve announcing a long-run inflation target of 2%. This exercise will be described in Section 3.2.

### 2.1.2 Price-Level Targeting with Forward Guidance

When targeting the price level in the economy, the central bank adjusts the short-term nominal interest rate to changes in itself, output gap, price level from its target, and an unanticipated monetary policy shock. Following Honkapohja and Mitra (2015a), Honkapohja and Mitra (2015b), and Giannoni (2014), the monetary policy rule under a price-level targeting regime is given by

$$i_t = \rho i_{t-1} + (1 - \rho)[\chi_p(p_t - \bar{p}_t) + \chi_x x_t] + \varepsilon_t^{MP} \quad (12)$$

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<sup>7</sup>Schmitt-Grohé and Uribe (2012) utilize the anticipated shocks from a news perspective. Cole (2016), Cole (2015), and Del Negro et al. (2012) model the anticipated shocks as forward guidance on the interest rate.

where  $\varepsilon_t^{MP}$  is defined as in equation (6). Following Woodford (2003, chap. 2), a monetary policy regime under equation (12) is called “Wicksellian.” In addition, the difference between inflation and price-level targeting rules is that the central bank under the latter policy responds to changes in the price level from a deterministic trend  $\bar{p}_t$  that satisfies

$$\bar{p}_t = \bar{p}_{t-1} + \pi^* \tag{13}$$

To add central bank forward guidance under price-level targeting,  $\pi^*$  in equation (13) is replaced by the time-varying inflation target as defined in equation (8). The targeted price level becomes

$$\bar{p}_t = \bar{p}_{t-1} + \pi_t^* \tag{14}$$

In other words, the central bank is giving guidance on the future course of the long-run inflation target.<sup>8</sup> Since this is the same forward guidance as in Section 2.1.1, I can compare the effects of forward guidance under both inflation and price-level targeting regimes. To re-emphasize the point made in the previous subsection, forward guidance also will be implemented such that the time-varying inflation target will be constant.

To summarize, the model with forward guidance and inflation targeting is given by aggregate demand, New Keynesian Phillips Curve, price level, AR(1) processes for the structural disturbances, monetary policy rule with inflation targeting, time-varying inflation target, and all central bank promises regarding changing the inflation target, that is, equations (1)-(6) and (8)-(11). When the monetary authority implements forward guidance and targets the price level, equation (6) is replaced by equations (12) and (14).

### 2.1.3 History Dependence of Price-Level Targeting

The monetary policy regimes in equations (6) and (12) share both similarities and differences. A key similarity is that both inflation and price-level targeting monetary policy rules respond to the lagged interest rate, which implies at least some common degree of history dependence for the two policies. However, the key difference between inflation and price-level targeting regimes is that the latter includes additional history dependence than that produced with only interest rate inertia. Under a price-level targeting regime, equation (12) shows that the interest rate is adjusted as the price level changes. By equation (3), the price level depends on past rates of inflation. Thus, a central bank that targets the price level inherently considers inflationary shocks that occurred in the past when setting monetary policy.

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<sup>8</sup>Equations (9)-(11) are also added to the system as forward guidance is defined in the same way as in Section 2.1.1.

Figure 1 displays the impulse response function of inflation and the price level to a negative one unit cost-push shock. The solid line is the model with forward guidance under inflation targeting while the dashed line is the model with forward guidance under price-level targeting. As a helpful reference, a dotted line is plotted at zero in the top panel of Figure 1.

This figure graphically displays how history dependence is a more apparent feature under price-level targeting than inflation targeting. Under the former policy, inflation and the price level both decrease. Because the central bank target takes into account the previous decrease in inflation, it will use its policy instrument to increase the price level towards its target as seen in the bottom panel of Figure 1. This action causes a period of above average inflation as seen by the dashed line moving above the dotted line in the top panel of Figure 1. As the price level approaches its target, inflation eventually decreases to its long-run target. Under inflation targeting, the price level and inflation both decrease. The central bank gradually moves the inflation rate back to its target and is not concerned with the previous decrease in the price level as it is only targeting the inflation rate. This latter feature is seen in the bottom panel of Figure 1 as the price level stays low. Thus, unlike price-level targeting, there is no period of above average inflation.

### 3 Results

#### 3.1 Parameterization

The values of the model’s structural parameters are displayed in Table 1 and are based on previous literature.  $\beta = 0.99$  is a standard value used in prior studies. The intertemporal elasticity of substitution of consumption across periods,  $\sigma$ , is set to 0.15. This closely follows Fuhrer (2000). The value of  $\kappa$  is set to 0.02 which is taken from Giannoni (2014). In addition, the degree of price stickiness in the model is assumed to be high at 0.90, which closely corresponds to Milani and Treadwell (2012). As a robustness check in Section 5.1, the model’s main results will be examined under a lower degree of price stickiness. There also exists a high degree of persistence in  $r_t^n$  as  $\rho_n = 0.95$  which agrees closely with Kuester, Müller, and Stölting (2007). The value of  $\rho_\mu$  is set to equal 0.5, which roughly follows the rational expectations model of Milani (2009). I also assume that the white noise shocks are not highly dispersed and there is no covariance between them.

The values of the monetary policy parameters closely follow prior studies. Under an inflation targeting regime, the parameter controlling the response of the interest rate to deviations of inflation from its target is set equal to 1.4. This number roughly follows the rational expectations model found in Milani (2007). Under a central bank targeting the price level, the parameter  $\chi_p$  governs the response of the interest rate to deviations of the price level from its target.  $\chi_p$  is set to 0.25

which is taken from Honkapohja and Mitra (2015a), Honkapohja and Mitra (2015b), and Williams (2010). The central bank also adjusts the interest rate positively to the output gap as  $\chi_x = 0.1$ , which follows closely Cole (2015). There exists a high degree of inertia in the time-varying inflation target as  $\rho_{\pi^*}$  is set equal to 0.99. This value follows from Milani (2009) and Del Negro, Giannoni, and Schorfheide (2014). A high level of interest rate inertia also is present as  $\rho = 0.75$ . In addition, the duration of the central bank’s forward guidance horizon  $L$  is chosen to be 12. This value is somewhat arbitrary. Therefore, the model’s results will be examined in Section 5.2 under shorter and longer forward guidance horizons as a robustness check.

### 3.2 The Effects of Forward Guidance under Inflation and Price-Level Targeting

Forward guidance and price-level targeting have received notable consideration since the 2007-2009 financial crisis. Central bank forward guidance was implemented in response to the global financial recession. Evans (2012) also argues that price-level targeting can be justified when the economy is dealing with the effects of an economic recession as the central bank would be missing both components of its dual mandate, that is, high unemployment and low inflation. For instance, price-level targeting can bring a period of above-average inflation to help stimulate the economy. With that event in mind, this section examines the effects of forward guidance under inflation and price-level targeting regimes while the economy is experiencing a recession. This exercise is summarized next and closely follows Cole (2016), Cole (2015), and Del Negro et al. (2012).<sup>9</sup>

A nontechnical description of the exercise is given first before detailing the actual procedure. The economy is assumed to start during a period of “normal” times. A recession then occurs that severely lowers demand, and consequently, inflation. The central bank responds via its unconventional monetary policy tool of forward guidance. Specifically, it announces to the public its long-run target of inflation that will be present in the economy for today and  $L$  periods into the future. The results are then compared across forward guidance with price-level targeting and forward guidance with inflation targeting.

This exercise is implemented in the following manner. The model is simulated until period  $T+1$  upon which a large negative demand shock ( $r_t^n$ ) occurs and causes a recession. Negative demand shocks also occur in the following five time periods.<sup>10</sup> The central bank responds by issuing forward guidance such that the long-run inflation target  $\pi_t^* = \bar{\pi}^*$  for today and  $L$  periods into the future. This corresponds to an unanticipated change in the current period of  $\pi_t^*$  and anticipated changes of

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<sup>9</sup>Cole (2016), Cole (2015), and Del Negro et al. (2012) conduct a similar exercise with forward guidance on the interest rate.

<sup>10</sup>The six period length of the recession corresponds to the duration of the 2007-2009 global financial crisis defined by the National Bureau of Economic Research.

$\pi_t^*$  for  $L$  periods into the future. Specifically, the central bank chooses the unanticipated inflation target shock ( $\varepsilon_t^{\pi^*}$ ) and the anticipated forward guidance shocks ( $\varepsilon_{1,t}^{FG}, \varepsilon_{2,t}^{FG}, \dots, \varepsilon_{L,t}^{FG}$ ) such that  $\pi_t^* = \bar{\pi}^*$  for the current period and  $L$  periods into the future. The macroeconomic results are then compared across inflation and price-level targeting regimes with forward guidance. Furthermore, by following Honkapohja and Mitra (2015b), the value of  $\bar{\pi}^*$  is chosen to be 1.005.

Figure 2 and Table 2 show the macroeconomic effects of this forward guidance across the two monetary policy regimes. The top, middle, and bottom panels of Figure 2 display the difference in the values of the macroeconomic variables between forward guidance with inflation targeting and forward guidance with price-level targeting. For instance, a negative number implies the value of the variable is greater under the latter than former monetary policy. In addition, the top panel of Table 2 under “Benchmark” shows the values of the loss function which is given by

$$\mathcal{L} = VAR(\pi_t - \pi_t^*) + \lambda VAR(x_t) + \nu VAR(i_t) \quad (15)$$

Equation (15) follows from Williams (2010).<sup>11</sup> I assume  $\lambda = 0.5$  and  $\nu = 0.1$  which is taken from Williams (2010).

The results show that the attenuation of the effects of forward guidance can be solved if a central bank switches from inflation targeting to price-level targeting. Figure 2 shows that forward guidance produces more favorable results of the macroeconomic variables when a monetary authority pursues a policy of targeting the price level rather than the inflation rate. The paths of output and inflation under forward guidance with price-level targeting are higher than under forward guidance with inflation targeting. This result agrees with Billi (2008) who found that price-level targeting helps to alleviate the probability that an economy will move into a deflationary or recession period.<sup>12</sup> The top panel in Table 2 under “Benchmark” also describes a similar situation. The loss function’s value is lower under forward guidance with price-level targeting than forward guidance with inflation targeting. Under forward guidance with inflation targeting, the value of the loss function is 94.09 while its counterpart is 49.89.<sup>13</sup>

What accounts for the more favorable responses under forward guidance with price-level targeting than forward guidance with inflation targeting? The first reason regards the history dependence feature of the former monetary policy regime. A price-level targeting central bank takes into account the prior declines in the inflation rate and price level due to the recession. It will target a higher price level which leads to subsequent above average inflation. The second reason

<sup>11</sup>Williams (2010) examines price-level targeting under the adaptive learning approach

<sup>12</sup>Billi (2008) examines price-level targeting but does not include forward guidance.

<sup>13</sup>These numbers are higher compared to Williams (2010) who investigated price-level targeting without forward guidance. However, the recession assumed in this current paper can add to the loss function’s total.

concerns how agents' forecasts react to the forward guidance statements given by the monetary authority. When the central bank announces that it will pursue a long-term inflation target that is above the current inflation rate, agents will expect a price-level targeting regime to target higher price levels in the future. This generates higher levels of expected inflation and expected output gap under price-level targeting than inflation targeting. Figure 3 displays this reasoning. The lines in Figure 3 display the difference in the value of the variable between forward guidance with inflation targeting and forward guidance with price-level targeting. Across the forward guidance horizon, the expectations of the output gap and inflation are higher under price-level targeting than inflation targeting. The higher levels of expected output gap and inflation lead to greater current output gap and inflation under forward guidance with price-level targeting than forward guidance with inflation targeting. In addition, the more favorable responses of expectations under price-level than inflation targeting confirm the statement of Billi (2008, pg. 3): "...the policymaker can shape private-sector expectations more effectively under price-level targeting than inflation targeting."

Overall, the results of this section show that the attenuation of the effects of forward guidance can be solved if a central bank switches from inflation targeting to price-level targeting. During a recession, the values of output and inflation are higher under forward guidance with price-level targeting than forward guidance with inflation targeting. Central bank forward guidance is also better able to influence agents' expectations under price-level targeting than inflation targeting. Private sector expectations under the former monetary policy regime react more favorably to forward guidance than under the latter policy. This outcome leads to higher levels of output and inflation under forward guidance with a central bank that targets the price level than the inflation rate.

## 4 Investigating the Differences

The previous section showed that forward guidance is more effective under a central bank that targets the price level than the inflation rate. The current portion of this paper seeks to understand this performance gap in depth by asking the following question: is there a way to narrow this disparity? To attempt to answer this question, the rest of this section examines two notions—aggressive monetary policy and interest rate inertia—that can affect the performance of forward guidance under the two monetary policy rules.

## 4.1 Aggressive Monetary Policy

The first potential solution to the question of whether or not the disparity between price-level and inflation targeting with forward guidance can be alleviated regards an aggressive central bank policy. Specifically, what would the results of Section 3.2 look like if an inflation targeting regime placed a greater emphasis on deviations of the inflation rate from its target? What if a price-level targeting central bank also responded more aggressively to deviations of the price level from its target? This scenario is described next and is motivated by Billi (2008).

The forward guidance exercise from Section 3.2 is repeated under different assumptions about the responsiveness of the central bank to deviations of inflation from its target and price level from its target. Specifically, the value of  $\chi_\pi$  is changed from its original value of 1.4 to 2.5. To allow a central bank under price-level targeting to also respond more to the price level, the value of  $\chi_p$  increases from 0.25 to 1. The new “aggressive” numbers are taken from Billi (2008).

Figure 4 and Table 2 show the results of this exercise. Each line in Figure 4 shows the difference in the values of the macroeconomic variables between forward guidance with inflation targeting and forward guidance with price-level targeting. For example, a negative number indicates the value of the macroeconomic variable is higher under the latter than the former monetary policy regime. The solid line represents the baseline case from Section 3.2 (i.e.  $\chi_\pi = 1.4$  and  $\chi_p = 0.25$ ). The dashed line indicates aggressive inflation and price-level targeting central banks (i.e.  $\chi_\pi = 2.5$  and  $\chi_p = 1$ ). The dotted line means only an aggressive inflation targeting regime (i.e.  $\chi_\pi = 2.5$  and  $\chi_p = 0.25$ ). The second panel of Table 2 also displays the loss function’s value under an aggressive parameter scheme.

The results show that a more aggressive monetary policy narrows the performance gap, but forward guidance still performs better with a price-level targeting regime. Figure 4 displays that the aggressive monetary policy case (i.e. the dashed line) is above the benchmark (i.e. the solid line), but still negative throughout the forward guidance horizon. Central banks that respond more to deviations of inflation from its trend and price level from its trend close the gap between the two monetary policy regimes as indicated by the dashed line being above the solid line. However, the negative values of the dashed line still confirm the results of Section 3.2 that forward guidance performs better under price-level than inflation targeting. The second panel of Table 2 also shows that forward guidance under price-level targeting is superior to forward guidance under inflation targeting, but the disparity does decrease. The values of the loss function are 43.60 and 28.10 under forward guidance with inflation targeting and forward guidance with price-level targeting, respectively. The difference between the two previously stated values is smaller than the benchmark

case of Section 3.2, but still indicates preference for forward guidance with price-level targeting than forward guidance with inflation targeting.

Why does the gap decrease under the more aggressive central bank parameter scheme? The aggressive inflation targeting may be helping to alleviate the disparity between the two monetary policy regimes. The dotted line in Figure 4 represents only aggressive inflation targeting (i.e.  $\chi_\pi = 2.5$  and  $\chi_p = 0.25$ ). The reader can see that this line ventures into positive values. This indicates that aggressive inflation targeting can have a magnified effect on the results. This outcome seems to be driving the smaller disparity when there is aggressive targeting of inflation and the price level as described in the previous paragraph. However, when a price-level targeting central bank is also allowed to respond more aggressively to deviations of price from its trend, forward guidance with inflation targeting is still not the preferred option.

## 4.2 Interest Rate Inertia

A distinguishing feature of a price-level targeting monetary policy rule is its inherent history dependence as explained in Section 2.1.3. This characteristic is a reason why forward guidance produced more favorable responses of the macroeconomic variables under price-level than inflation targeting. In addition, the model in Section 2 added an amount of history dependence common to both monetary policy regimes by allowing interest rate inertia in equations (6) and (12). However, a natural question may arise regarding the inclusion of  $i_{t-1}$  and the performance of forward guidance under both central bank regimes. Specifically, does the performance of forward guidance with inflation targeting relative to forward guidance with price-level targeting deteriorate when interest rate inertia is not introduced into the model? To put it another way does the disparity between the two policy regimes under forward guidance decrease by allowing history dependence via  $i_{t-1}$ ?

This section performs the exercise from Section 3.2 under the baseline case of interest rate inertia and no interest rate inertia. Specifically, equations (6) and (12) are assumed with  $\rho = 0.75$  and  $\rho = 0$ . The results are displayed in Figure 5 and in the third panel of Table 2. In Figure 5, each panel depicts the difference between the macroeconomic variable's value under forward guidance with inflation targeting and forward guidance with price-level targeting. The solid line represents the baseline case of  $\rho = 0.75$  and the dashed line indicates  $\rho = 0$ . The loss function values without interest rate inertia are also displayed in the third panel of Table 2.

The results show that the introduction of interest rate inertia narrows the performance of forward guidance between the two monetary policy regimes, but with price-level targeting still preferred. When  $\rho = 0$ , Figure 5 reveals that output and inflation are still higher under price-level



than inflation targeting. This outcome supports the main results of Section 3.2. However, these differences decrease when interest rate inertia is included. Figure 5 shows that the line without interest rate inertia (i.e. the dashed line) is below the baseline case (i.e. solid line) throughout the forward guidance horizon.<sup>14</sup> In addition, the third panel of Table 2 shows that the difference in the values of the loss function between forward guidance with inflation targeting and forward guidance with price-level targeting is smaller when  $\rho = 0.75$  than  $\rho = 0$ . While forward guidance with price-level targeting is still preferred, the previous result indicates that the performance gap shrinks when interest rate inertia is included.

The reason for the improved performance of forward guidance with inflation targeting regards the increase in history dependence. When interest rate inertia does not exist, history dependence is found only in the price-level targeting rule as it responds to previous inflationary shocks. When  $i_{t-1}$  exists in both monetary policy rules, inflation targeting now assumes a degree of history dependence making its characteristics and performance closer to the price-level targeting rule. In addition, this history dependence is a desirable feature for monetary policy. Giannoni (2014) explains that an optimal price-level targeting rule achieves more desirable fluctuations in the macroeconomic variables than under a Taylor rule with inflation targeting.

Overall, the results of the previous two subsections suggest additional affirmation for forward guidance with price-level targeting. A monetary authority that responds aggressively to deviations of the inflation rate from its target can improve the performance of forward guidance. However, a central bank that also responds aggressively to deviations of the price level from its target is still preferable when implementing forward guidance. In addition, introducing a lagged interest rate into both models helps to improve the performance of forward guidance. However, this unconventional monetary policy still achieves better results under price-level targeting than inflation targeting.

## 5 Robustness

### 5.1 Influence of Price Stickiness

The results in Section 3.2 showed that the attenuation of the effects of forward guidance are solved if the monetary authority switched from inflation to price-level targeting. This result was assumed under  $\alpha = 0.90$ , which is a high degree of price stickiness in the economy. A natural question that arises is how does the effectiveness of forward guidance under price-level targeting change if the price level is more flexible. Since this monetary policy regime is inherently concerned with the price

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<sup>14</sup>The results agree with Giannoni (2014) who found that price-level targeting regimes are still preferable to inflation targeting when a high level of interest rate inertia exists in the model.

level, will the results of Section 3.2 change if price stickiness is lowered? This section investigates this question by examining the robustness of the model's results to a lower price stickiness value.

Figure 6 and the fourth panel of Table 2 display the results under different values of the price stickiness parameter. To capture a lower degree of price stickiness, the dashed line in Figure 6 represents the model's results under  $\alpha = 0.1$ . The baseline case of  $\alpha = 0.90$  is also included and depicted by the solid line. As is similar to the previously described exercises, each panel represents the difference between the macroeconomic variable's value under forward guidance with inflation targeting and forward guidance with price-level targeting. Furthermore, the fourth panel in Table 2 shows the values of the loss function under  $\alpha = 0.1$ .

The results confirm that forward guidance with price-level targeting is preferred to forward guidance with inflation targeting and that flexible prices can magnify these results. The fourth panel of Table 2 shows that the value of the loss function under forward guidance with price-level targeting is still lower than under forward guidance with inflation targeting. Figure 6 displays that forward guidance produces values of output and inflation that are higher under price-level than inflation targeting across the different values of  $\alpha$ . These results agree with the main outcomes of Section 3.2. In addition, the reduction in value of the  $\alpha$  changes the effectiveness of forward guidance with price-level targeting. By assuming more flexible prices in the economy, the difference between forward guidance with price-level targeting and forward guidance with inflation targeting is more favorable under  $\alpha = 0.1$  than  $\alpha = 0.90$ . The dashed line is below the the solid line in the second panel of Figure 6 indicating a higher level of inflation under forward guidance with price-level targeting. As price stickiness decreases, the central bank can influence the price level more, and thus, forward guidance with price-level targeting is more effective than forward guidance with inflation targeting. A notable feature is that the dashed line is higher than the solid line for output.<sup>15</sup> The reason is as follows. Because the inflation rate is higher under forward guidance with price-level targeting under  $\alpha = 0.1$  than  $\alpha = 0.90$ , the interest rate is also higher under this monetary policy as seen in the bottom panel of Figure 6. The higher interest rate reduces the effects on output. Therefore, the differences between output's value under forward guidance with price-level targeting and forward guidance with inflation targeting are not as large when  $\alpha = 0.1$  rather than  $\alpha = 0.90$ .

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<sup>15</sup>However, the dashed line is still negative indicating higher values of output under price-level targeting than inflation targeting.

## 5.2 Alternative Forward Guidance Horizons

This section examines the importance of forward guidance effectiveness when the forward guidance horizon is changed. Specifically, does the superior performance of forward guidance under price-level targeting relative to inflation targeting depend on the length of the forward guidance horizon? To answer this question, the exercise from Section 3.2 is repeated under different values of  $L$ . To capture a long forward guidance horizon, the results are examined under  $L = 18$ . This alternative is represented by the dotted line in Figure 7 and the sixth panel in Table 2.<sup>16</sup> To capture a short forward guidance horizon, the results are studied under  $L = 6$  as indicated by the solid line in Figure 7 and the fifth panel in Table 2. The benchmark outcomes under  $L = 12$  are also represented by the dashed line in Figure 7.

Figure 7 and Table 2 show that forward guidance with price-level targeting is still preferable to forward guidance with inflation targeting regardless of the length of the central bank's commitments. The values of output and inflation are higher under forward guidance with price-level targeting than inflation targeting across the different forward guidance horizons. This result is evidenced by each line in Figure 7 being negative indicating that forward guidance with price-level targeting is more effective than forward guidance with inflation targeting. In addition, the three lines follow the same path until its respective forward guidance horizon is complete. Thus, the length of the superior performance of forward guidance with price level targeting relative to inflation targeting is either increased or decreased depending on if the forward guidance horizon is extended or reduced. Furthermore, the values of the loss function confirm that forward guidance with price-level targeting is preferred regardless of the length of the forward guidance horizon. The bottom two panels in Table 2 show that the loss function is larger under forward guidance with inflation targeting than forward guidance with price-level targeting across shorter and longer horizons.

Overall, the results of the previous robustness subsections indicate preference for forward guidance with price-level targeting than forward guidance with inflation targeting. Forward guidance produces higher values of output and inflation under price-level than inflation targeting across low and high levels of the price stickiness parameter  $\alpha$ . Forward guidance also produces more favorable results under the former monetary policy scheme regardless of the length of the central bank's forward guidance horizon.

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<sup>16</sup>As is similar to Section 3.2, Figure 7 shows the difference in forward guidance's effectiveness between inflation and price-level targeting. Thus, a negative value indicates that the value of the macroeconomic variable is larger under forward guidance with price-level targeting than forward guidance with inflation targeting.

## 6 Conclusion

Forward guidance has emerged as a pertinent tool for central bank authorities since the 2007-2009 Great Recession. However, U.S. inflation has continually missed the Federal Reserve's target of 2% over the period April 2012 to July 2016. In addition, since the global financial crisis, price-level targeting has gained notable attention due to its predictions of above-average inflation in response to deflationary episodes. Thus, it is of interest to investigate whether forward guidance's effect on the economy can be increased under a central bank targeting the price level instead of the inflation rate.

This paper investigates the effectiveness of central bank forward guidance across two policy regimes: inflation and price-level targeting. The results show that the attenuation of the effects of forward guidance can be solved if a central bank switches from inflation to price-level targeting. When the central bank communicates guidance on the future course of its inflation target, output and inflation produce more favorable responses to forward guidance under price-level targeting than inflation targeting during an economic crisis. The reasons are twofold. The inherent history dependence feature of the former monetary policy implies a period of above average inflation. Agents' expectations of output and inflation also respond more favorably to forward guidance with price-level targeting than inflation targeting. In addition, the performance gap between the two monetary policies narrows if a central bank aggressively responds to the inflation rate and includes interest rate inertia in its monetary policy role. However, output and inflation still respond more favorably to forward guidance under price-level than inflation targeting. The results are also robust to flexible or rigid prices and shorter or longer forward guidance horizons. Overall, the type of targeting policy by a central bank is important when understanding the effectiveness of central bank forward guidance.

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# Appendix

## A Tables and Figures

Table 1: Parameter Values

	<b>Description</b>	<b>Value</b>
$\sigma$	IES	0.15
$\beta$	Discount Factor	0.99
$\kappa$	Function of Price Stickiness	0.02
$\alpha$	Price Stickiness	0.90
$\chi_\pi$	Feedback Inflation	1.4
$\chi_x$	Feedback Output Gap	0.1
$\chi_p$	Feedback Price	0.25
$\lambda$	Loss Function	0.5
$\nu$	Loss Function	0.1
$\rho_n$	Autoregressive Demand	0.95
$\rho_\mu$	Autoregressive Cost-Push	0.5
$\rho_{\pi^*}$	Autoregressive Inflation Target	0.99
$\rho$	Interest Rate Inertia	0.75
$L$	FG Horizon	12

*Note:* The standard deviations of the structural shocks are set to 0.001. FG means forward guidance.

Table 2: Loss Function Values

	<b>Inflation Targeting</b>	<b>Price-Level Targeting</b>
Benchmark	94.09	49.89
Aggressive Monetary Policy ( $\chi_\pi = 2.5$ & $\chi_p = 1$ )	43.60	28.10
No Interest Rate Inertia ( $\rho = 0$ )	107.26	44.12
Low Price Stickiness ( $\alpha = 0.1$ )	40.95	7.12
Short FG Horizon ( $L = 6$ )	165.18	77.07
Long FG Horizon ( $L = 18$ )	78.01	65.31

*Note:* The loss function is found in equation (15). FG means forward guidance.



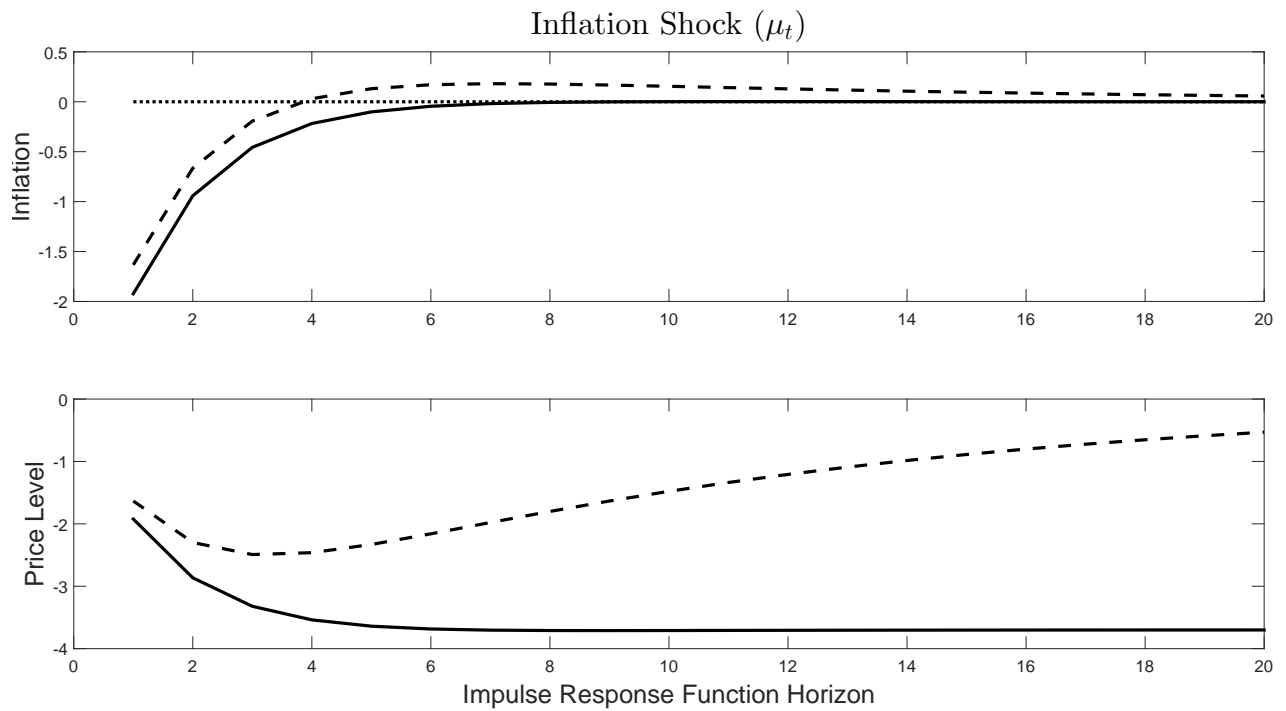


Figure 1: History Dependence of Price-Level Targeting

*Note:* The graphs show the responses of inflation and the price level to a negative one-unit inflation shock ( $\mu_t$ ). The solid line indicates forward guidance with inflation targeting. The dashed line represents forward guidance with price-level targeting. As a helpful reference, a dotted line is plotted at zero in the top panel.

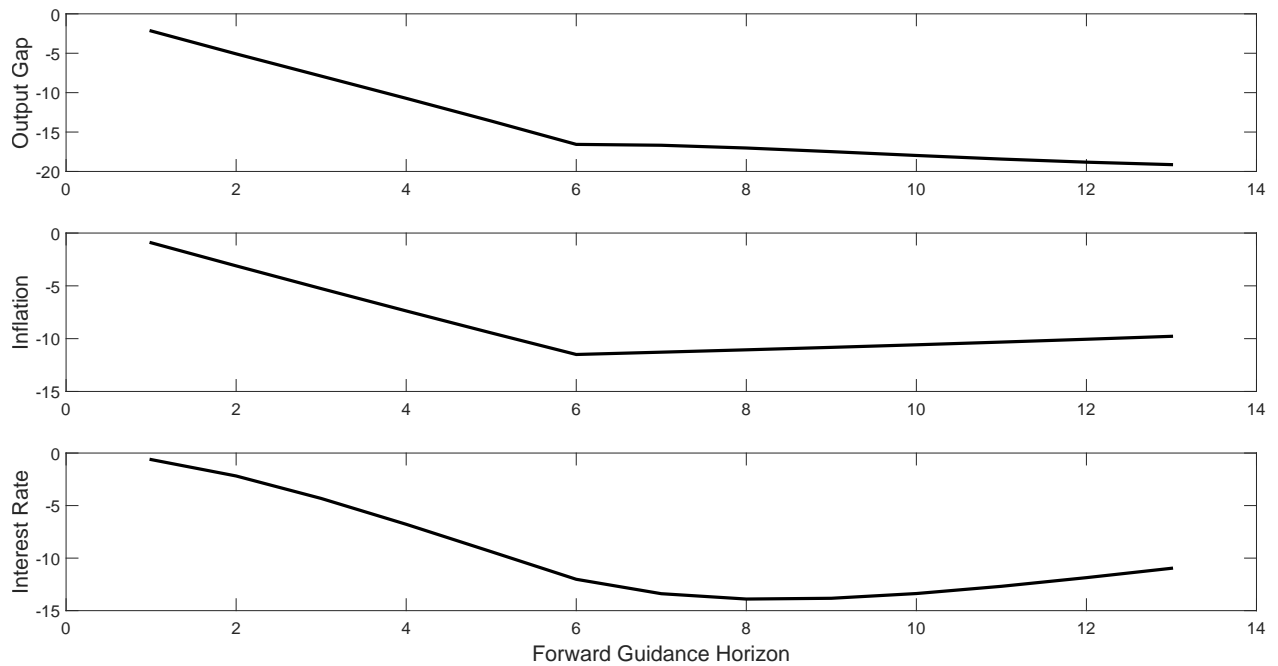


Figure 2: Macroeconomic Effects of Forward Guidance under Inflation and Price-Level Targeting

*Note:* The graphs show the difference in the macroeconomic variables between forward guidance with inflation targeting and forward guidance with price-level targeting. A positive value indicates the value under inflation targeting is higher than under price-level targeting. A negative value indicates the variable's value under price-level targeting is higher than under inflation targeting.

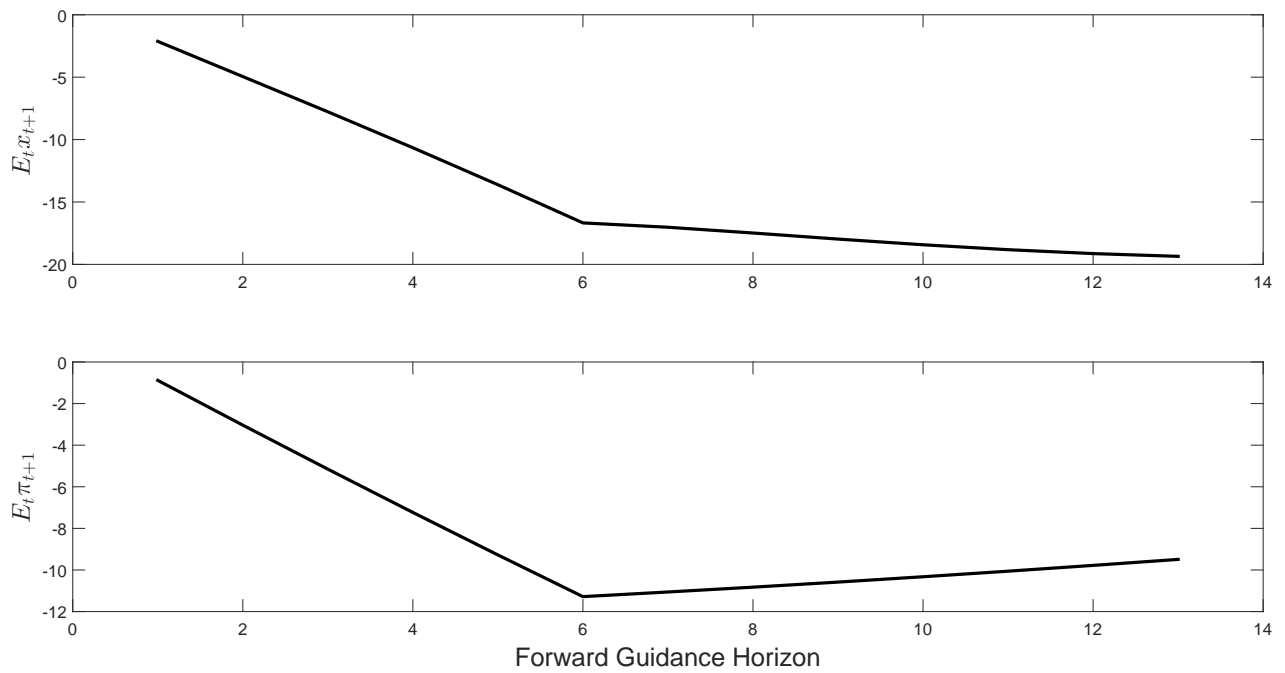


Figure 3: Difference in the Expectations of Output Gap and Inflation between Inflation and Price-Level Targeting

*Note:* The graphs show the difference in expectations between forward guidance with inflation targeting and forward guidance with price-level targeting. A positive value indicates the value under inflation targeting is higher than under price-level targeting. A negative value indicates the variable's value under price-level targeting is higher than under inflation targeting.

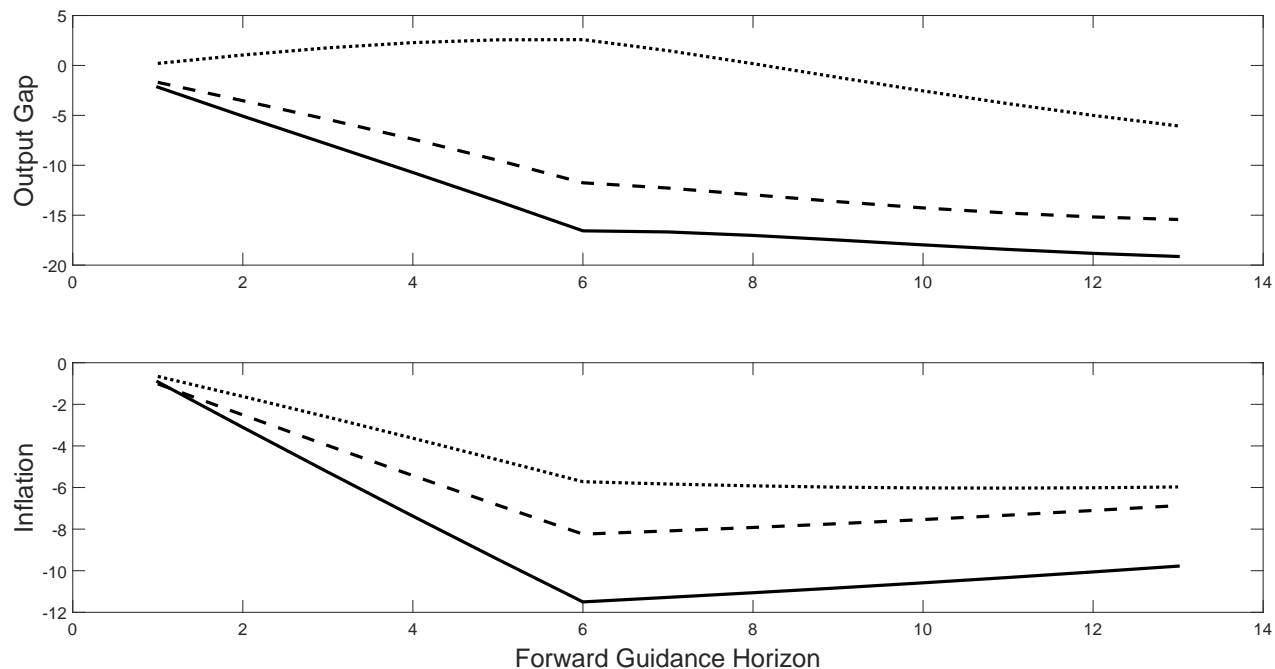


Figure 4: Forward Guidance under Inflation and Price-Level Targeting with Aggressive Monetary Policy

*Note:* The graphs show the difference in the macroeconomic variables between forward guidance with inflation targeting and forward guidance with price-level targeting with or without aggressive monetary policies. A positive value indicates the value under inflation targeting is higher than under price-level targeting. A negative value indicates the variable's value under price-level targeting is higher than under inflation targeting. The solid line represents the benchmark case:  $\chi_\pi = 1.4$  and  $\chi_p = 0.25$ . The dashed line indicates aggressive inflation and price-level targeting central banks:  $\chi_\pi = 2.5$  and  $\chi_p = 1$ . The dotted line means an aggressive inflation targeting regime:  $\chi_\pi = 2.5$  and  $\chi_p = 0.25$ .

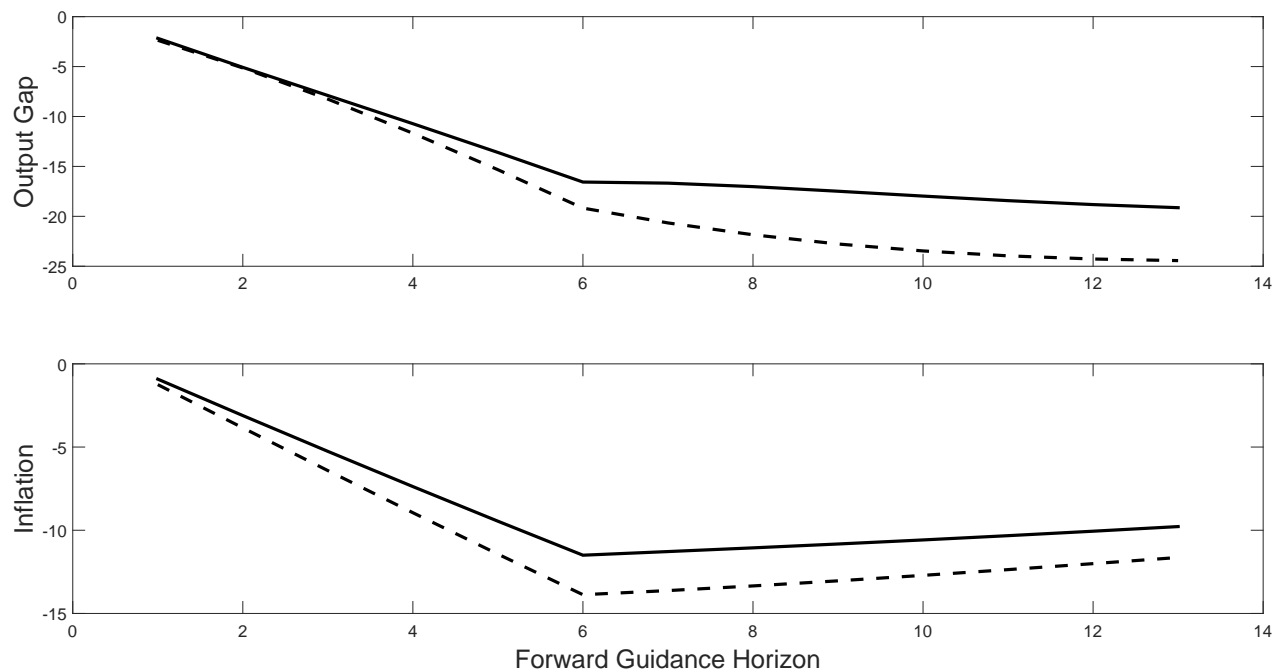


Figure 5: Forward Guidance under Inflation and Price-Level Targeting and the Effect of Interest Rate Inertia

*Note:* The graphs show the difference in the macroeconomic variables between forward guidance with inflation targeting and forward guidance with price-level targeting under different values of  $\rho$ . A positive value indicates the value under inflation targeting is higher than under price-level targeting. A negative value indicates the variable's value under price-level targeting is higher than under inflation targeting. The solid line represents the benchmark case:  $\rho = 0.75$ . The dashed line indicates no interest rate inertia:  $\rho = 0$ .

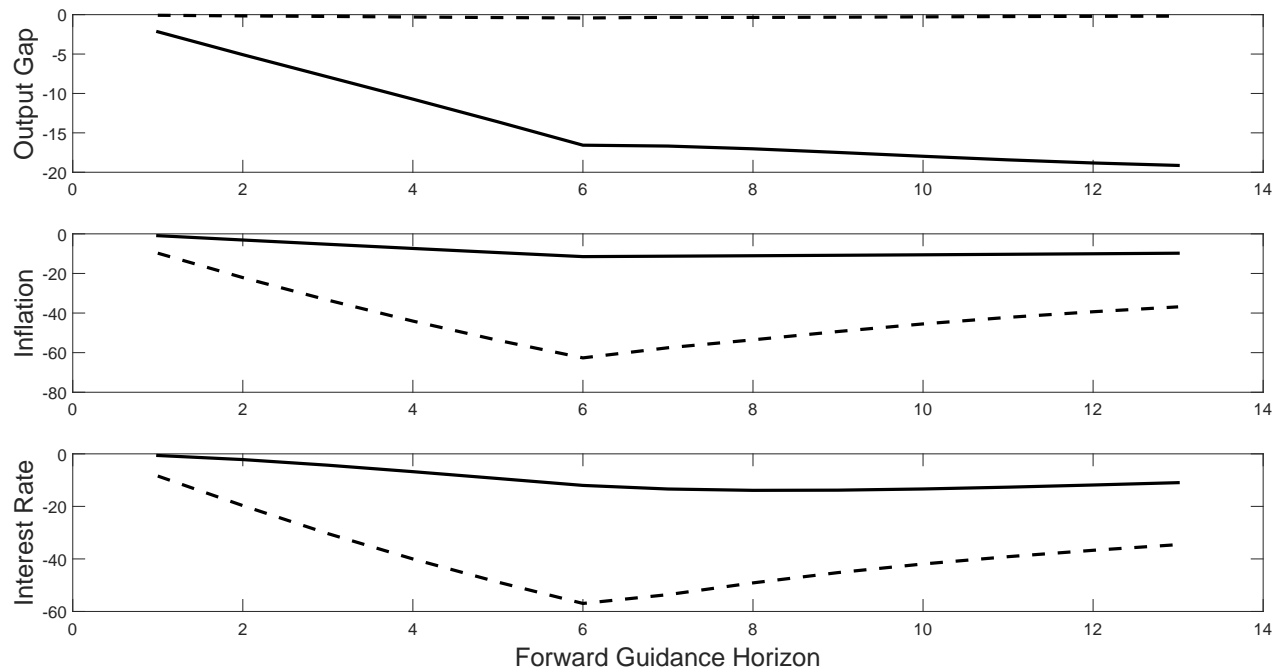


Figure 6: Forward Guidance under Inflation and Price-Level Targeting and the Effect of Flexible Prices

*Note:* The graphs show the difference in the macroeconomic variables between forward guidance with inflation targeting and forward guidance with price-level targeting under different values of  $\alpha$ . A positive value indicates the value under inflation targeting is higher than under price-level targeting. A negative value indicates the variable's value under price-level targeting is higher than under inflation targeting. The solid line represents the benchmark case:  $\alpha = 0.90$ . The dashed line indicates flexible prices:  $\alpha = 0.1$ .

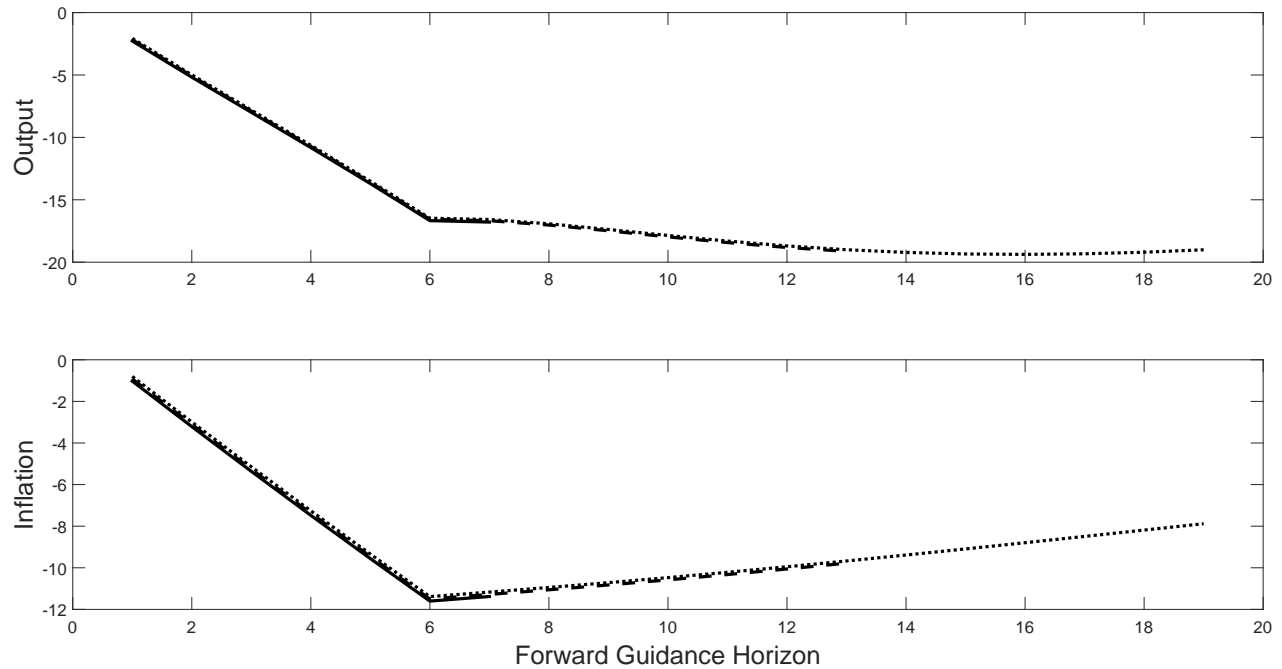


Figure 7: The Effects of Forward Guidance under Inflation and Price-Level Targeting and across Different Horizons

*Note:* The graphs show the difference in the macroeconomic variables between forward guidance with inflation targeting and forward guidance with price-level targeting across different forward guidance horizons. A positive value indicates the value under inflation targeting is higher than under price-level targeting. A negative value indicates the variable's value under price-level targeting is higher than under inflation targeting. The solid line represents a short forward guidance horizon:  $L = 6$ . The dotted line indicates a long forward guidance horizon:  $L = 18$ . The dashed line denotes the benchmark case:  $L = 12$ .