Unemployment Fluctuations and Nominal GDP Targeting*

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Abstract

I evaluate the welfare performance of a target for the *level* of nominal GDP in a New Keynesian model with unemployment, accounting for a zero lower bound (ZLB) constraint on the nominal interest rate. Nominal GDP targeting is compared to employment targeting, a conventional Taylor rule, and the optimal monetary policy with commitment. I find that employment targeting is optimal when supply shocks are the source of fluctuations; however, facing demand shocks and the ZLB constraint, nominal GDP targeting can outperform substantially employment targeting.

Keywords: employment targeting, optimal monetary policy, Taylor rule, ZLB

JEL: E24, E32, E52

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1 Introduction

The standard New Keynesian model with staggered price and wage setting allows for unemployment to play a role in the design of monetary policy, while taking into account a zero lower bound (ZLB) constraint on the nominal interest rate.[1] Facing the ZLB, a target for the *level* of nominal GDP is conceptually appealing, as argued by Woodford (2012) and others, because it requires monetary policy to make up for any past shortfalls from the target, which ensures greater policy stimulus during ZLB episodes. Disregarding the ZLB constraint, however, another perspective, since Erceg at al. (2000), is that central banks could seek to stabilize the output *gap* in order to promote stability in price and wage inflation, and contribute to greater social welfare.

In light of such views, I compare the welfare performance of nominal GDP targeting relative to employment targeting, as well as to a conventional Taylor rule (used to calibrate the model) and the optimal monetary policy with commitment (representing an ideal benchmark). This policy evaluation provides two main results, related to whether demand or technology shocks are the source of fluctuations in the economy. First, if supply shocks drive fluctuations, employment targeting improves welfare relative to nominal GDP targeting, and achieves the same welfare as the optimal policy with commitment. This finding complements related analysis, for example Garín et al. (2016), which does not account for the ZLB constraint.[2] As a second result, conditional on demand shocks driving fluctuations and facing the ZLB, nominal GDP targeting outperforms substantially employment targeting and the Taylor rule, in particular when prices are sticky relative to wages. This insight is novel relative to the existing literature.

Next, Section 2 describes the model environment, and Section 3 presents the policy evaluation.

2 The Model

The analysis uses a version of the New Keynesian model with staggered price and wage setting à la Calvo, and with unemployment fluctuations, as proposed in Galí (2011, 2015). The model is augmented with a ZLB constraint on the short-term nominal interest rate, and four monetary-policy

[1] I adopt the standard practice of referring to a zero lower bound on nominal interest rates. The recent experience with negative nominal interest rates in Denmark, Japan, Sweden, Switzerland, and the eurozone suggests the effective lower bound is somewhat below zero. See Svensson (2010) for a discussion.

[2] Erceg at al. (2000) and Garín et al. (2016) discuss the notion of output *gap* targeting. In this model, however, the output *gap* is proportional to the employment *gap* (Section 2.1) and, therefore, whether the central bank seeks to stabilize one or the other variable does not affect the results presented.

frameworks are considered. The calibration of the model is standard.

2.1 Private Sector

The behavior of the private sector is described by a set of equilibrium conditions, which correspond to a closed economy version of the New Keynesian model with staggered price and wage setting, without capital accumulation or a fiscal sector.[3]

The supply side of the economy is described by the following equations representing the dynamics of price and wage inflation, π_t^p and π_t^w, and the labor market conditions:

$$\pi_t^p = \beta E_t\{\pi_{t+1}^p\} + \varkappa_p \tilde{y}_t + \lambda_p \tilde{\omega}_t \tag{1}$$

$$\pi_t^w = \beta E_t\{\pi_{t+1}^w\} + \varkappa_w \tilde{y}_t - \lambda_w \tilde{\omega}_t \tag{2}$$

$$\widetilde{\omega}_t \equiv \widetilde{\omega}_{t-1} + \pi_t^w - \pi_t^p - \Delta\omega_t^n \tag{3}$$

$$n_t = \frac{1}{1-\alpha}(y_t - a_t) \tag{4}$$

$$\hat{u}_t \equiv \frac{1}{\varphi}\left(\tilde{\omega}_t - \left(\sigma + \frac{\varphi}{1-\alpha}\right)\tilde{y}_t\right), \tag{5}$$

where $\tilde{y}_t \equiv y_t - y_t^n$ and $\tilde{\omega}_t \equiv \omega_t - \omega_t^n$ denote respectively the output and wage *gaps*, with $y_t^n \equiv \psi_{ya}a$ and $\omega_t^n \equiv \psi_{\omega a}a_t$ representing the (log) *natural* output and (log) *natural* wage (i.e. their equilibrium values in the absence of nominal rigidities) ignoring constant terms. a_t is an exogenous technology shifter which follows an $AR(1)$ process with autoregressive coefficient ρ_a. n_t denotes employment. The employment *gap* is then given by $\tilde{n}_t \equiv n_t - n_t^n = \frac{1}{1-\alpha}\tilde{y}_t$ and is proportional to the output *gap*. $\hat{u}_t \equiv u_t - u^n$ denotes the unemployment *gap*, with $u^n \equiv \frac{1}{\varphi}\log\left(\frac{\epsilon_w}{\epsilon_w - 1}\right)$ representing the *natural* rate of unemployment which is constant due to the assumption of a constant desired wage markup.

In addition, $\varkappa_p \equiv \frac{\alpha\lambda_p}{1-\alpha}$, $\varkappa_w \equiv \lambda_w\left(\sigma + \frac{\varphi}{1-\alpha}\right)$, $\lambda_p \equiv \frac{(1-\theta_p)(1-\beta\theta_p)}{\theta_p}\frac{1-\alpha}{1-\alpha+\alpha\epsilon_p}$, $\lambda_w \equiv \frac{(1-\theta_w)(1-\beta\theta_w)}{\theta_w(1+\epsilon_w\varphi)}$, $\psi_{ya} \equiv \frac{1+\varphi}{\sigma(1-\alpha)+\varphi+\alpha}$ and $\psi_{\omega a} \equiv \frac{1-a\psi_{ya}}{1-a}$, where $\theta_p \in [0,1)$ and $\theta_w \in [0,1)$ are the Calvo indexes of price and wage rigidities, and $\epsilon_p > 1$ and $\epsilon_w > 1$ denote the elasticities of substitution among varieties of goods and labor services, respectively. Parameters σ, φ and β denote the household's coefficient of

[3] All the equations are log-linearized around a steady state with zero price and wage inflation, and with a wage subsidy that exactly offsets the distortions resulting from price and wage markups. In particular, equations (4) and (5) result from a reinterpretation of the labor market in the model with staggered wage setting, where employment is demand determined, labor demand is given by the inverse production function, and unemployment fluctuation are associated with variation in the average wage markup. Galí (2015) provides the detailed derivations of these equations, as well as a complete analysis of the model in the absence of the ZLB constraint.

relative risk aversion, the curvature of labor disutility and the discount factor, respectively. Parameter α denotes the degree of decreasing returns to labor in production.

The demand side of the economy is described by a dynamic IS equation:

$$\widetilde{y}_t = E_t\{\widetilde{y}_{t+1}\} - \frac{1}{\sigma}\left(i_t - E_t\{\pi^p_{t+1}\} - r^n_t\right), \tag{6}$$

where i_t is the nominal interest rate, and r^n_t represents the *natural* rate of interest. Under the assumptions made and ignoring constant terms $r^n_t \equiv \rho - \sigma(1-\rho_a)\psi_{ya}a_t + (1-\rho_z)z_t$, where $\rho \equiv -\log\beta$ is the discount rate. z_t is an exogenous preference shifter (or demand shock) which follows an $AR(1)$ process with autoregressive coefficient ρ_z.

2.2 Monetary Policy

The analysis considers four monetary-policy frameworks, subject to a ZLB constraint on the nominal interest rate. The first framework is a "truncated" Taylor rule given by:

$$i_t = \max\left[0, i^*_t\right],$$

where

$$i^*_t = \phi_i i^*_{t-1} + (1-\phi_i)\left(\rho + \phi_p \pi^p_t - \phi_u \hat{u}_t\right).$$

This rule, which incorporates explicitly the ZLB, can be viewed as capturing in a parsimonious way the behavior of central banks in many advanced economies. i^*_t can be interpreted as a *shadow* interest rate in that context.[4]

The second framework is a target for the employment *gap*:

$$\tilde{n}_t i_t = 0 \quad \text{subject to} \quad \tilde{n}_t \leq 0 \text{ and } i_t \geq 0,$$

where the central bank seeks to stabilize the employment *gap* (or the output *gap*, equivalently), while employment can fall below its *natural* rate when the ZLB constraint is binding.

[4] This specification of the rule for the shadow rate, which makes the latter a function of its own lag (as opposed to the lag of the actual policy rate) implies a kind of "forward guidance" that may compensate partly for the lost monetary stimulus due to the presence of a ZLB constraint.

The third framework is a target for the nominal GDP *level*:

$$h_t i_t = 0 \quad \text{subject to} \quad h_t \leq 0 \text{ and } i_t \geq 0,$$

where $h_t \equiv p_t + y_t$ denotes the (log) *level* of nominal GDP, and $p_t \equiv p_{t-1} + \pi_t^p$ is the (log) price level. Thus, the nominal GDP *level* can fall below its target (or *trend*) if the ZLB binds.

The fourth framework is the optimal policy under commitment with a ZLB constraint. It is a state-contingent plan that maximizes the representative household's welfare, subject to an infinite sequence of private-sector constraints given by (1) through (6), and $i_t \geq 0$, for $t = 0, 1, 2, ...$ This problem is shown formally in the Appendix and gives rise to a set of difference equations which, together with (1) to (6), describe the equilibrium under the optimal policy.

2.3 Calibration

The model's calibration is conventional and largely follows Galí (2015). The discount factor β is set to 0.995 so the steady-state real interest rate is 2 percent annual. I set $\sigma = 1$, $\varphi = 5$ and $\alpha = 0.25$. Elasticity of substitution parameters ϵ_p and ϵ_w are set respectively to 9 and 4.5.[5] I set $\theta_p = \theta_w = 0.75$, consistent with an average duration of price and wage spells of one year. I use the Taylor rule coefficients in Galí (2015), i.e. $\phi_p = 1.5$ and $\phi_u = 0.5$. The smoothing coefficient ϕ_i is set to 0.8, close to the estimates in Galí et al. (2011) and others.

In addition, the autoregressive coefficient of the shocks ρ_a and ρ_z are set respectively to 0.97 and 0.8, close to the values in Garín et al. (2016). The standard deviation of the shocks σ_a and σ_z are set respectively to 0.017 and 0.048 so that, conditional on only technology or demand shocks being the source of fluctuations, the Taylor rule with ZLB imposed generates a standard deviation of (log) output of 1.6 percent. The latter value matches the volatility of HP-detrended (log) real GDP in postwar U.S. data.[6]

3 The Policy Evaluation

I now present the predictions of the model regarding the performance of the four monetary-policy frameworks, with or without the ZLB constraint imposed. I first show the dynamics arising from

[5] This calibration is consistent with an average unemployment rate of 5 percent as in Galí (2015).
[6] Data source https://fred.stlouisfed.org/series/GDPC1.

shifts in either technology or preferences, and then provide a welfare analysis conditional on each type of shock.[7]

3.1 Response to Shocks and the ZLB Constraint

Shown are the impulse responses of the unemployment and output *gaps*, price inflation, and nominal interest rate, all in deviation from steady state.[8] Figure 1 displays the responses to a *positive* technology shock, with a size of one standard deviation. When productivity increases, inflation falls in all the frameworks considered, whereas the response of unemployment depends on the framework in place. The unemployment *gap* is fully stabilized under the employment target and the optimal policy, but falls under the Taylor rule because the central bank leans against the deflationary pressure. The unemployment and output *gaps* generally move in opposite directions. The nominal interest rate stays fixed under the nominal GDP target, because such a framework requires that after a technology shock the price level and output move in opposite directions by the same amount.[9] The nominal interest rate falls the most under the Taylor rule, nevertheless the ZLB is not reached facing the technology shock.

Figures 2 and 3 display the responses to a *negative* demand shock, respectively without or with the ZLB imposed. The size of the shock is one standard deviation, and on impact it raises unemployment by 5 percent above its *natural* rate under the Taylor rule with the ZLB. As Figure 2 shows, if the ZLB is absent, unemployment rises and inflation falls under the Taylor rule. By contrast, unemployment and inflation are fully stabilized under the employment target, nominal GDP target, and optimal policy. However, to achieve full stability in such frameworks, the nominal interest rate has to fall below the ZLB. As Figure 3 shows, with the ZLB imposed, unemployment rises and inflation falls on impact in all the frameworks considered. Furthermore, with the optimal policy, unemployment undershoots and inflation overshoots during the recovery, because the nominal interest rate stays longer at the ZLB, relative to the other frameworks considered.

[7] The model outcomes are obtained with Dynare using an extended-path method. Replication files are available from the author upon request.

[8] In the figures, the unemployment and output *gaps* are shown in percentage points (pp) while the inflation rate and nominal interest rate are shown in percent annualized (pa).

[9] Furthermore the parameter σ is set to 1, which implies a slope of unity in the dynamic IS equation.

3.2 Nominal Rigidities, the ZLB Constraint, and Welfare

I use as a welfare metric the second-order approximation of the average welfare loss experienced by the representative household as a result of fluctuations around an efficient, zero-inflation steady state, expressed as a fraction of steady-state consumption. Such a welfare loss function can be written as:

$$\mathbb{L} = \frac{1}{2}\left[\left(\sigma + \frac{\varphi+\alpha}{1-\alpha}\right) var\left(\tilde{y}_t\right) + \frac{\epsilon_p}{\lambda_p} var\left(\pi_t^p\right) + \frac{\epsilon_w(1-\alpha)}{\lambda_w} var\left(\pi_t^w\right)\right],$$

where the welfare loss has three components, respectively associated with the volatilities in the output *gap*, price inflation, and wage inflation.[10] Tables 1 and 2 illustrate the effects of price and wage rigidities on the (total) welfare loss, $\mathbb{L}$, conditional on either technology or demand shocks driving fluctuations. Each table reports the outcomes with or without the ZLB imposed, respectively in the top and bottom panels.

Table 1 shows the welfare loss conditional on only technology shocks. Facing such shocks, the ZLB does not bind in any of the frameworks considered.[11] If prices and wages are rigid (first column), the nominal GDP target is the least effective framework in terms of welfare, because as explained earlier the nominal interest rate stays fixed in response to technology shocks. However, the employment target achieves the same welfare as the optimal policy. What if either prices or wages are fully flexible in the model? If prices are flexible (second column), all the frameworks considered become more effective in welfare terms, and only the Taylor rule does not fully stabilize the economy. But if wages are flexible (third column), the nominal GDP target is the only framework considered that becomes less effective in welfare terms. The reason is that, when the nominal interest rate stays fixed, wage flexibility causes greater variation in price inflation (not shown) in the face of technology shocks. Overall, regarding technology shocks, these results are consistent with Garín et al. (2016).

Next, Table 2 reports the welfare loss conditional on only demand shocks. Facing demand shocks, with or without the ZLB, the Taylor rule is the least effective framework in welfare terms. Absent the ZLB (bottom panel), and regardless of whether prices or wages are flexible, the economy is fully stabilized under the employment target, nominal GDP target, and optimal policy. However, with the ZLB imposed (top panel), all the frameworks considered become less effective in welfare terms because the ZLB binds. Facing the ZLB, what do the nominal rigidities imply for the performance of

[10] See Galí (2015) for the derivation. Parameters θ_p and θ_w enter the welfare loss function respectively through λ_p and λ_w, to which they are inversely related. Thus, if price are fully flexible then $var\left(\pi_t^p\right)$ is irrelevant for welfare, whereas if wages are fully flexible then $var\left(\pi_t^w\right)$ is irrelevant for welfare.

[11] Thus, the top and bottom panels of this table display identical outcomes.

the frameworks? If prices and wages are rigid (first column), the nominal GDP target outperforms the employment target in welfare terms. If prices are flexible (second column), all the frameworks considered become more effective in welfare terms, and the nominal GDP target achieves the same welfare as the optimal policy. But if wages are flexible (third column), all the frameworks become less effective in welfare terms. The reason is that, facing demand shocks and the ZLB, wage flexibility causes greater variation in price inflation (not shown). Furthermore, the deterioration in welfare from wage flexibility is substantially larger under the employment target and the Taylor rule. In summary, after taking into account the ZLB constraint, the nominal GDP target outperforms substantially the employment target and the Taylor rule, in particular when prices are sticky relative to wages.

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APPENDIX: Optimal Policy under Commitment with a ZLB Constraint

The problem of optimal policy with commitment is given by

$$\min \frac{1}{2} E_0 \sum_{t=0}^{\infty} \beta^t \left[\left(\sigma + \frac{\varphi + \alpha}{1-\alpha} \right) \tilde{y}_t^2 + \frac{\epsilon_p}{\lambda_p} (\pi_t^p)^2 + \frac{\epsilon_w (1-\alpha)}{\lambda_w} (\pi_t^w)^2 \right],$$

subject to (1)-(6) and $i_t \geq 0$.

Write the period Lagrangian

$$\begin{aligned}
L_t = & \frac{1}{2} \left[\left(\sigma + \frac{\varphi + \alpha}{1-\alpha} \right) \tilde{y}_t^2 + \frac{\epsilon_p}{\lambda_p} (\pi_t^p)^2 + \frac{\epsilon_w (1-\alpha)}{\lambda_w} (\pi_t^w)^2 \right] + \beta E_t V_{t+1} \\
& + m_{1t} \left[y_t + \frac{1}{\sigma} \left(i_t - \rho - (1-\rho_z) z_t \right) \right] - \frac{1}{\beta} m_{1t-1} \left(y_t + \frac{1}{\sigma} \pi_t^p \right) \\
& + m_{2t} \left(\pi_t^p - \varkappa_p \tilde{y}_t - \lambda_p \tilde{\omega}_t \right) - m_{2t-1} \pi_t^p \\
& + m_{3t} \left(\pi_t^w - \varkappa_w \tilde{y}_t + \lambda_w \tilde{\omega}_t \right) - m_{3t-1} \pi_t^w \\
& + m_{4t} \left(\omega_t - \omega_{t-1} - \pi_t^w + \pi_t^p \right).
\end{aligned}$$

The Kuhn-Tucker conditions are

$$0 = \frac{\partial L_t}{\partial y_t} = \left(\sigma + \frac{\varphi + \alpha}{1-\alpha} \right) \tilde{y}_t + m_{1t} - \frac{1}{\beta} m_{1t-1} - \varkappa_p m_{2t} - \varkappa_w m_{3t} \tag{7}$$

$$0 = \frac{\partial L_t}{\partial \pi_t^p} = \frac{\epsilon_p}{\lambda_p} \pi_t^p - \frac{1}{\beta\sigma} m_{1t-1} + m_{2t} - m_{2t-1} + m_{4t} \tag{8}$$

$$0 = \frac{\partial L_t}{\partial \pi_t^w} = \frac{\epsilon_w (1-\alpha)}{\lambda_w} \pi_t^w + m_{3t} - m_{3t-1} - m_{4t} \tag{9}$$

$$0 = \frac{\partial L_t}{\partial \omega_t} = \frac{\partial \beta E_t V_{t+1}}{\partial \omega_t} - \lambda_p m_{2t} + \lambda_w m_{3t} + m_{4t} \tag{10}$$

$$0 = \frac{\partial L_t}{\partial i_t} i_t = \frac{1}{\sigma} m_{1t} i_t, \quad m_{1t} \geq 0 \text{ and } i_t \geq 0, \tag{11}$$

whereas the envelope condition gives

$$\frac{\partial \beta E_t V_{t+1}}{\partial \omega_t} = -\beta E_t m_{4t+1}.$$

The equilibrium conditions under the optimal policy are then given by (1)-(11).

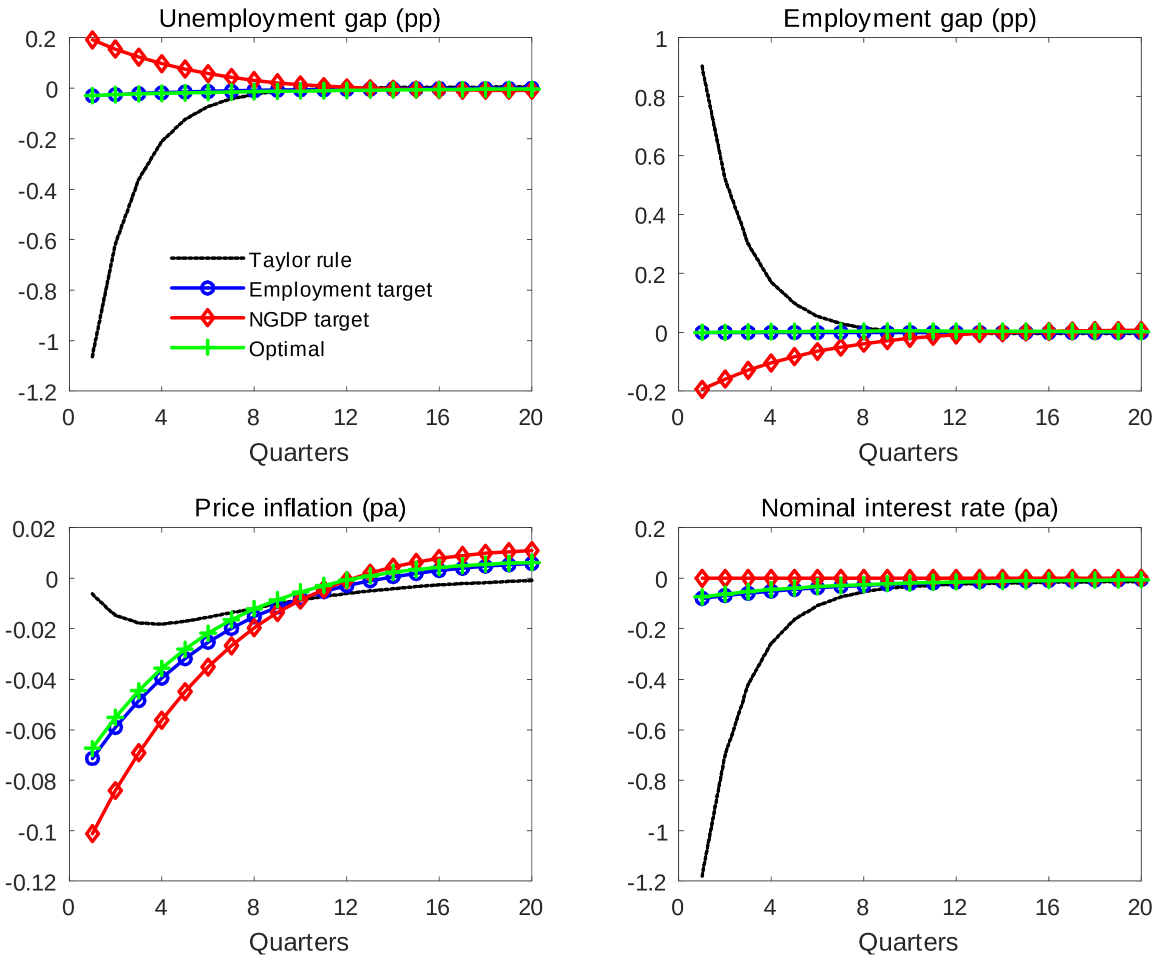

Figure 1: Responses to technology shock, ZLB not reached.

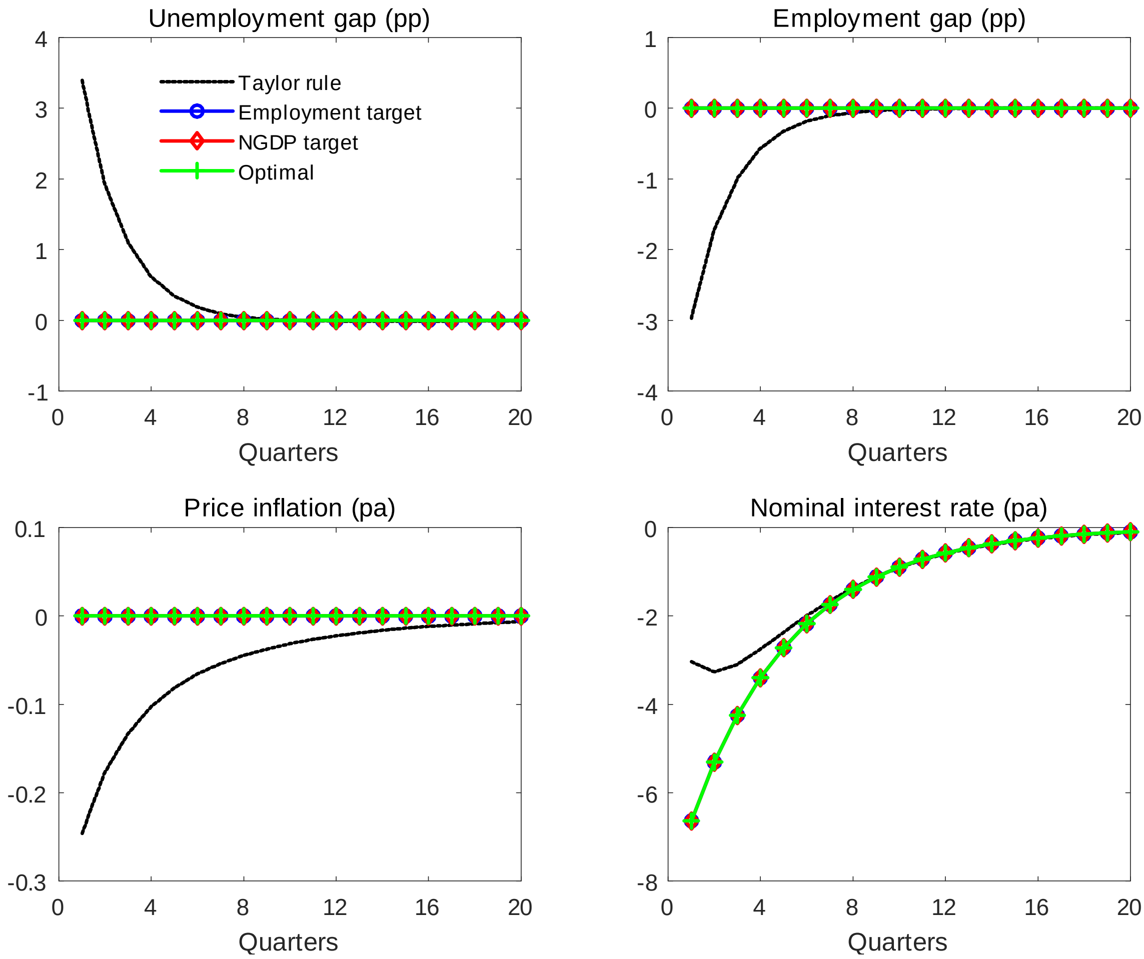

Figure 2: Responses to demand shock if ZLB absent.

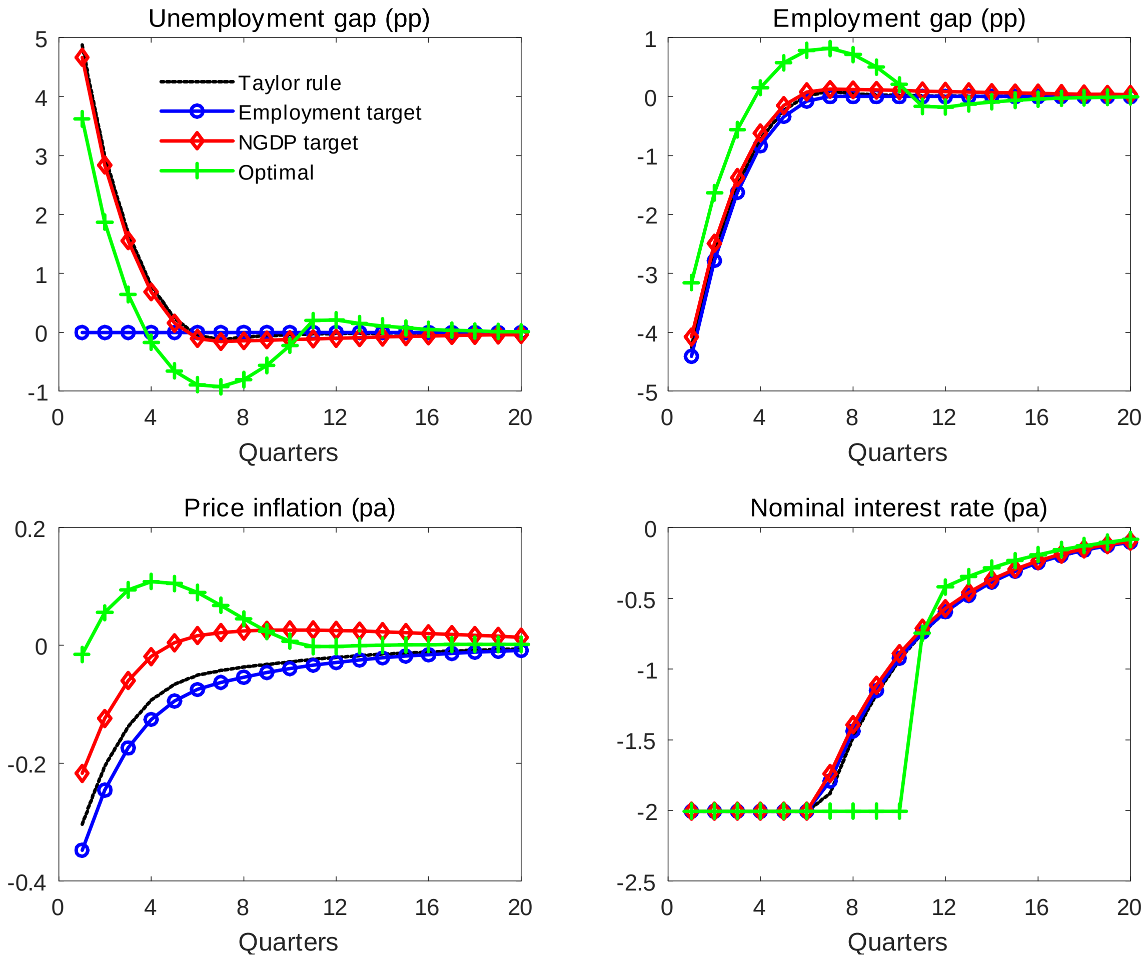

Figure 3: Responses to demand shock during ZLB episode.

Table 1: Welfare loss if technology shocks.

	$\theta_p = 0.75$ $\theta_w = 0.75$	$\theta_p \approx 0$ $\theta_w = 0.75$	$\theta_p = 0.75$ $\theta_w \approx 0$
ZLB			
Taylor rule	0.03	0.01	0.02
Employment target	0.01	0.00	0.00
NGDP target	0.05	0.00	0.07
Optimal	0.01	0.00	0.00
No ZLB			
Taylor rule	0.03	0.01	0.02
Employment target	0.01	0.00	0.00
NGDP target	0.05	0.00	0.07
Optimal	0.01	0.00	0.00

Note: Shown is the permanent consumption loss in percentage points.

Table 2: Welfare loss if demand shocks.

	$\theta_p = 0.75$ $\theta_w = 0.75$	$\theta_p \approx 0$ $\theta_w = 0.75$	$\theta_p = 0.75$ $\theta_w \approx 0$
ZLB			
Taylor rule	0.15	0.10	1.68
Employment target	0.11	0.05	1.26
NGDP target	0.06	0.03	0.09
Optimal	0.05	0.03	0.07
No ZLB			
Taylor rule	0.09	0.07	1.27
Employment target	0.00	0.00	0.00
NGDP target	0.00	0.00	0.00
Optimal	0.00	0.00	0.00

Note: Shown is the permanent consumption loss in percentage points.