Unemployment Fluctuations and Nominal GDP Targeting*

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30 January 2019

Abstract

I evaluate the welfare performance of a target for the level of nominal GDP in the context of a New Keynesian model with unemployment, taking into account a zero lower bound (ZLB) constraint on the nominal interest rate. I compare nominal GDP targeting to employment targeting, a conventional Taylor rule, and the optimal monetary policy with commitment. Employment targeting achieves the same welfare as the optimal policy when supply shocks are the source of fluctuations. But facing demand shocks and the ZLB constraint, nominal GDP targeting can outperform substantially employment targeting and the Taylor rule.

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

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] In such a context, a target for the level of nominal GDP is conceptually appealing (as noted 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 (Erceg at al. (2000)) is that central banks should seek to stabilize employment in order to promote stability in the price of goods, and contribute to greater social welfare.

In light of such debates, 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, when supply shocks drive fluctuations, employment targeting achieves the same welfare as the optimal policy. This finding complements previous analysis in Erceg at al. (2000) and Garín et al. (2016) which disregards the ZLB constraint. As a second result, when demand shocks drive fluctuations and facing the ZLB constraint, nominal GDP targeting can outperform substantially employment targeting and the Taylor rule. 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, as proposed in Galí (2011, 2015). But the model is augmented with a ZLB constraint on the short-term nominal interest rate, and four monetary-policy frameworks are considered. The calibration of the model is standard.

[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.

2.1 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.[2]

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 of employment and unemployment, n_t and u_t:

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

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

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

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

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

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. Furthermore $\hat{u}_t \equiv u_t - u^n$ 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 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.[3]

[2] 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. One can find detailed derivations of these equations, as well as a complete analysis of the model in the absence of the ZLB constraint, in Galí (2015).

[3] As shown in Galí (2015), equations (4) and (5) result from a reinterpretation of the labor market in the model with staggered wage setting, where employment is demand determined (and labor demand is given by the inverse production function) while unemployment fluctuation are associated with variations in the average wage markup.

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

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

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 $r^n_t = \rho - \sigma\left(1-\rho_a\right)\psi_{ya}a_t + (1-\rho_z)z_t$, 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, each with a ZLB constraint on the nominal interest rate. The first framework is described by 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 constraint, 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 employment stability:

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

where the central bank fully stabilizes employment when the ZLB constraint is not binding, whereas employment can fall below its target when the ZLB is a binding constraint.

The third framework is a target for nominal GDP stability:

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

[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.

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, nominal GDP is fully stabilized if the ZLB constraint does not bind but can fall below its target if the ZLB constraint 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 to imply a steady-state real interest rate of 2 percent annual. I set $\sigma = 1$, $\varphi = 5$ and $\alpha = 0.25$. Elasticity of substitution parameters ϵ_p and ϵ_w are set to 9 and 4.5, respectively.[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 to 0.97 and 0.8, respectively, close to the values in Garín et al. (2016). The standard deviation of each shock is chosen so the Taylor rule with ZLB constraint generates a standard deviation of (log) output of 1.6 percent, to match the volatility of HP-detrended (log) real GDP in postwar U.S. data, conditional on only technology or demand shocks being the source of fluctuations.[6] This baseline calibration is summarized in Table 1.

3 The Policy Evaluation

I now present the predictions of the model on the performance of the four monetary-policy frameworks considered. I first show the dynamics arising from shifts in either technology or preferences, and then provide a welfare analysis conditional on such shocks.[7]

[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.

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

3.1 Response to Shocks and the ZLB Constraint

Shown are the responses of unemployment, the output gap, the nominal interest rate, and price inflation, all in deviation from steady state. 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. Unemployment is fully stabilized under the employment target and the optimal policy, but falls under the Taylor rule. Unemployment and the output gap generally move in opposite directions. The nominal interest rate stays fixed under the nominal GDP target, because such a framework requires that prices and output move in opposite directions by the same amount.[8] The nominal interest rate falls the most under the Taylor rule, nevertheless the ZLB constraint is not reached in any of the frameworks considered in response to the technology shocks.

Figures 2 and 3 display the responses to an adverse demand shock, without or with a ZLB constraint, respectively. The size of the shock is such that unemployment rises on impact by 7 percent above its *natural* rate under the Taylor rule and ZLB constraint. As Figure 2 shows, if the ZLB constraint is absent, unemployment rises and inflation falls under the Taylor rule. By contrast, the economy is 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 constraint. As Figure 3 shows, with the ZLB constraint, 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 constraint, relative to the other frameworks considered.

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:

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

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

where the welfare loss has three components, respectively associated with the volatilities in the output gap, price inflation, and wage inflation.[9] Tables 2 and 3 illustrate the effect of price and wage rigidities on the (total) welfare loss, $\mathbb{L}$, conditional on either technology or demand shocks. Each table reports the outcomes with or without the ZLB constraint, in the top and bottom panels, respectively.

Table 2 shows the welfare loss conditional on only technology shocks. Facing such shocks, the ZLB constraint does not bind in any of the frameworks considered.[10] If prices and wages are rigid (first column), the nominal GDP target is the least effective framework in terms of welfare, because the nominal interest rate stays fixed in response to technology shocks, as explained earlier. 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 the output gap and price inflation (not shown) in the face of technology shocks.

Table 3 reports the welfare loss conditional on only demand shocks. Facing demand shocks, with or without the ZLB constraint, the Taylor rule is the least effective framework in welfare terms. Absent the ZLB constraint, and regardless of whether prices or wages are flexible, the economy is fully stabilized under the employment target, nominal GDP target, and optimal policy. But with the ZLB constraint, all the frameworks considered become less effective in welfare terms because the ZLB constraint binds. Present the ZLB constraint, what is the effect of nominal rigidities on the performance of the frameworks? If prices and wages are rigid, the nominal GDP target outperforms the employment target in welfare terms. If prices are flexible, 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, all the frameworks become less effective in welfare terms. Furthermore, the deterioration in welfare from wage flexibility is substantially larger under the employment target and the Taylor rule. Thus, facing demand shocks and the ZLB constraint, the nominal GDP target can outperform substantially the employment target and the Taylor rule.

[9] 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.

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

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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).

Table 1: Baseline calibration.

Parameter	Description	Value
β	Discount factor	0.995
σ	Curvature of consumption utility	1
φ	Curvature of labor disutility	5
α	Index of decreasing returns to labor	0.25
ϵ_p	Elasticity of substitution of goods	9
ϵ_w	Elasticity of substitution of labor	4.5
θ_p	Calvo index of price rigidities	0.75
θ_w	Calvo index of wage rigidities	0.75
ϕ_i	Smoothing coefficient in the Taylor rule	0.8
ϕ_p	Rule coefficient on price inflation	1.5
ϕ_u	Rule coefficient on unemployment	0.5
ρ_a	Persistence of technology shock	0.97
ρ_z	Persistence of demand shock	0.80
σ_a	Std. deviation of technology shock	0.017
σ_z	Std. deviation of demand shock	0.048

Note: Values are shown in quarterly rates.

Table 2: 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 3: 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.

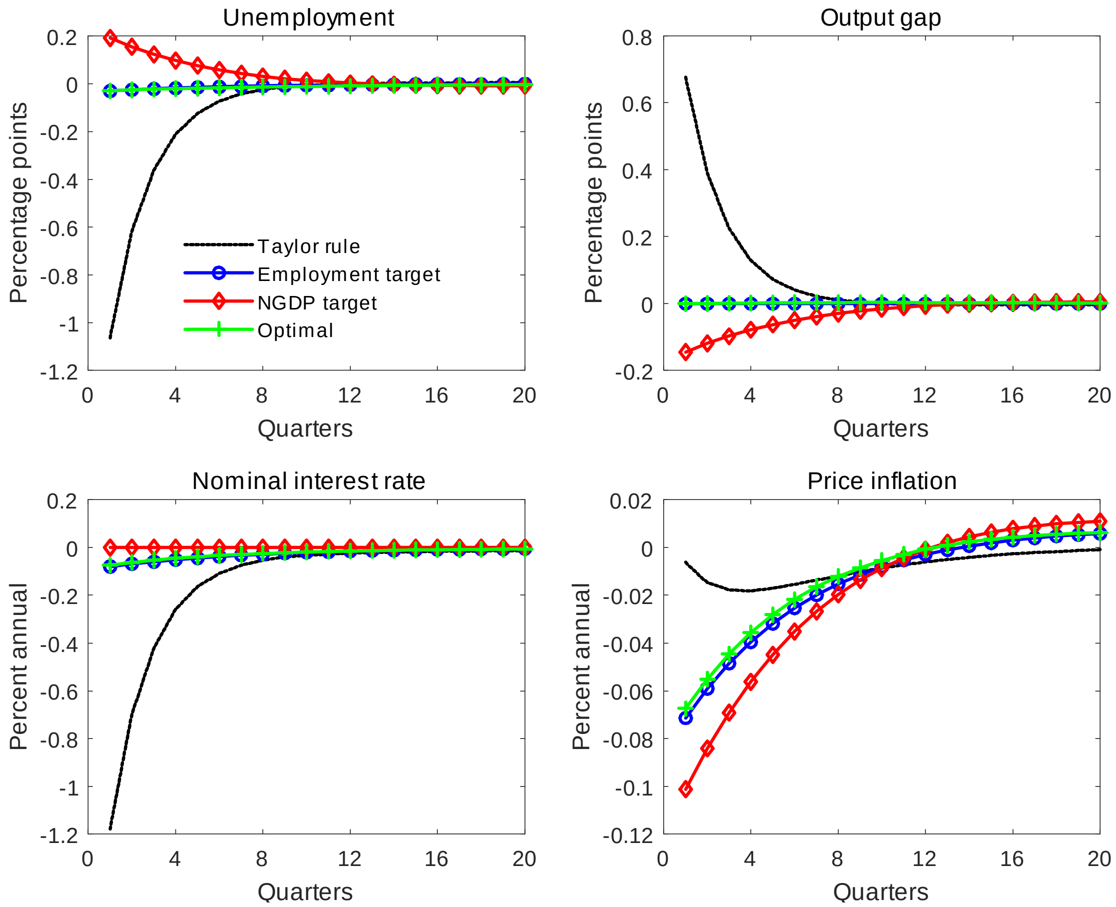

Figure 1: Dynamic responses to a technology shock with a ZLB constraint.

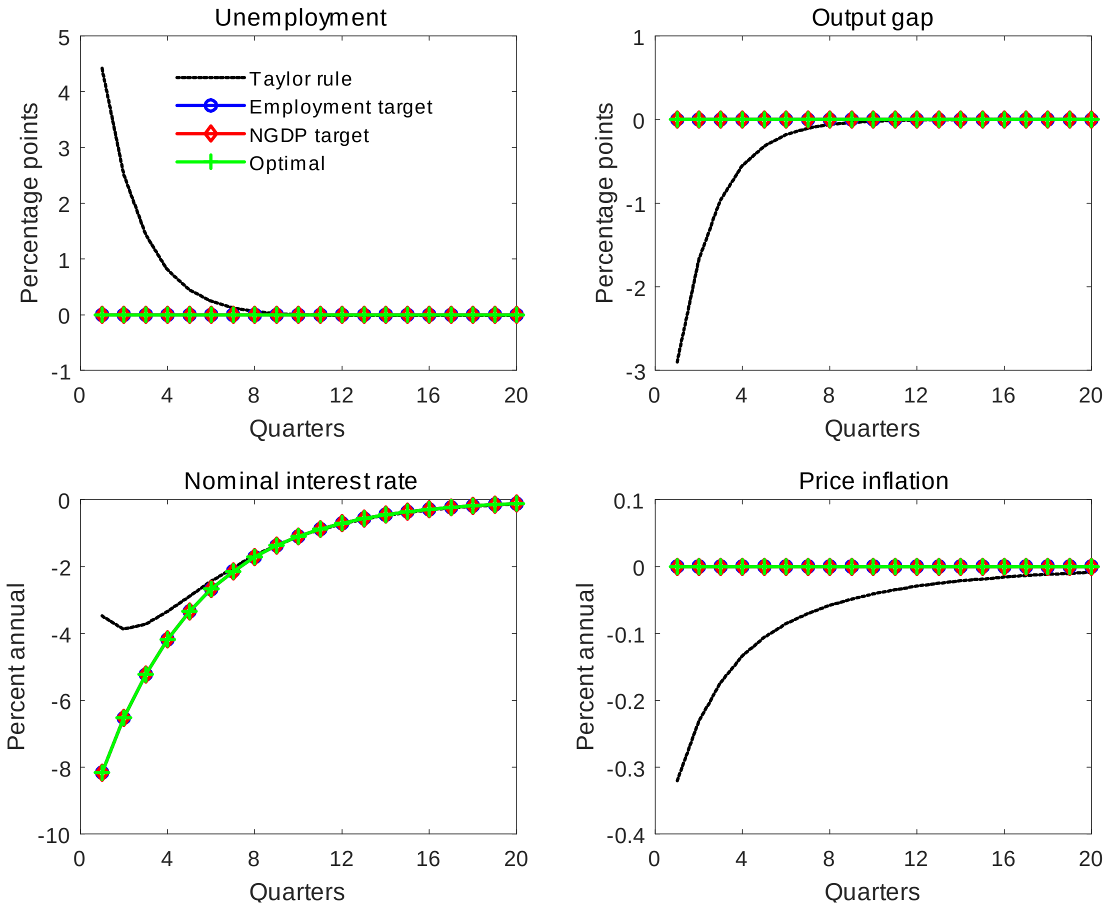

Figure 2: Dynamic responses to a demand shock without a ZLB constraint.

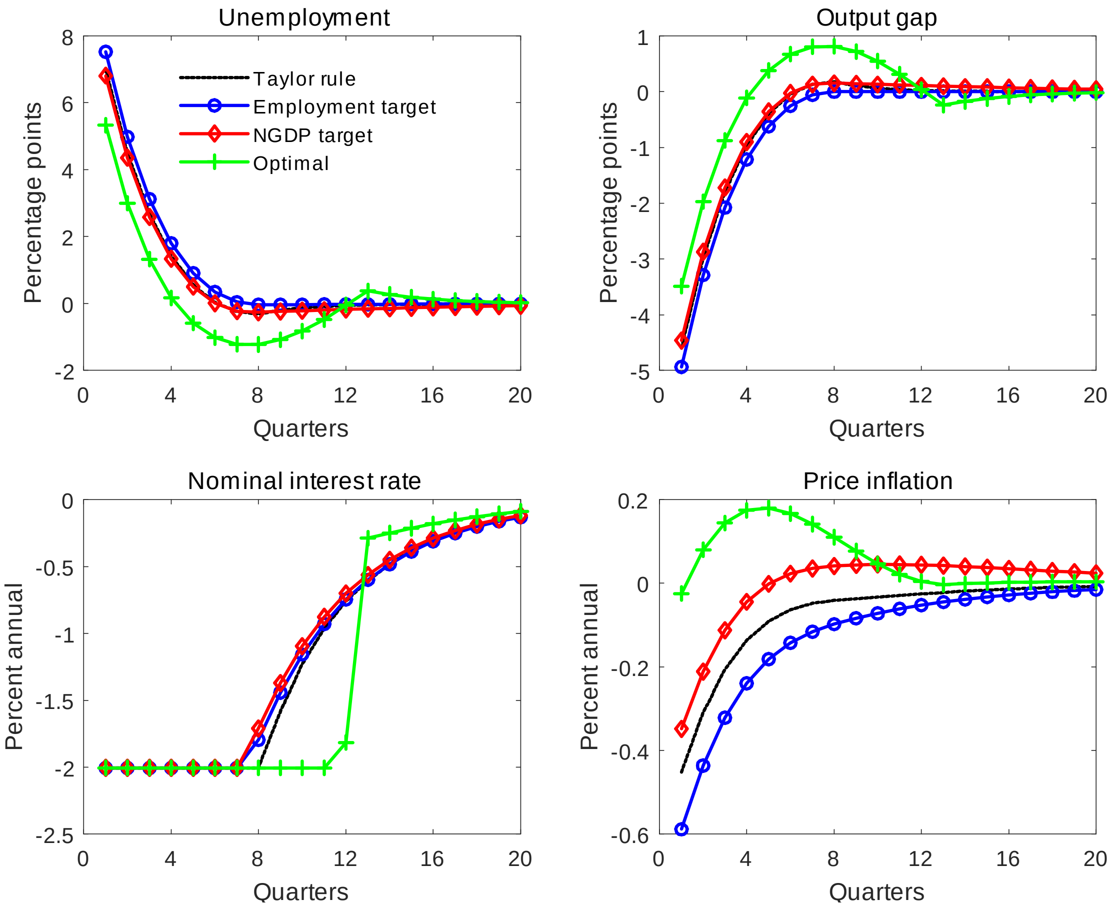

Figure 3: Dynamic responses to a demand shock during a ZLB episode.