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Optimal monetary policy in an economy with real rigidity

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Abstract

Several studies address the importance of the effect of real rigidity on macroeconomic variables. The presence of real rigidity might change the property of optimal monetary policy suggested by the canonical new Keynesian model. We examine optimal monetary policy in an economy with real rigidity. According to our simulation results, the welfare gain associated with a commitment policy declines as the degree of real rigidity increases. This paper also finds that price level targeting is an effective policy regime when real rigidity is present.

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1 Introduction

The canonical new Keynesian model has been used in monetary policy analysis. A notable property of the new Keynesian model appears to consider the case in which the central bank can implement its monetary policy through the management of the expectations of the private sector. Such a forward-looking model is often criticized, however, because the model cannot explain the inertial behavior of economic variables to economic shocks. For instance, the empirical performance of the new Keynesian Phillips curve (NKPC), which plays an important role in the model, is not necessarily strong.[1] In addition, as addressed by Blanchard and Galí (2007), lagged macroeconomic variables associated with real rigidity have a great influence on economic dynamics. In such a case the property of optimal monetary policy may depend on the degree of real rigidity.

This paper explores optimal monetary policy when real rigidity is present. Following Blanchard and Galí (2007), we assume the presence of real wage rigidity. Real wage rigidity induces the sluggish movements in the real marginal cost. This implies that real wage rigidity introduces inertial behavior into macroeconomic dynamics. In particular, as argued in Blanchard and Galí (2007), optimal monetary policy depends on how the interaction between real rigidities and shocks is large. In the standard new Keynesian model several studies emphasize the superiority of commitment over discretion. This is because the central bank can alleviate large fluctuations of economic variables associated with exogenous shocks by manipulating the expectations of the private sector. On the other hand, an implication of optimal monetary policy might change in an economy where real rigidities are present.

How should the central bank conduct its monetary policy in an economy with an inertial behavior of macroeconomic variables? Amato and Laubach (2003) and Steinsson (2003) show that in an economy with inflation persistence a discretionary policy generates a greater welfare loss compared to a commitment policy. Also, as pointed out in Erceg, Henderson, and Levin (2000), the central bank faces a trade-off between price inflation, wage inflation, and the output gap when prices and wages are sticky. Moreover, Blanchard and Galí (2007) argue that the introduction of real wage rigidity in the new Keynesian model can improve the empirical performance of the traditional Phillips curve. In particular, according to Blanchard and Galí (2007), it seems that the sluggish adjustment of the real wage contributes to the natural resource of an inertial behavior of inflation. These studies suggest the importance that an inertial behavior of economic variables affects the real economy.

The objective of this paper is to investigate the property of optimal monetary policy in an economy with real rigidity. First, we quantitatively show that real

[1] See Rudd and Whelan (2007) for a detailed discussion of the performance of the NKPC.

rigidity generates a severe trade-off between inflation and the output gap. The presence of real rigidity changes the property of an optimal monetary policy, and it might differ from that suggested by Woodford (2003). As we will show, a targeting rule under commitment contains not only change in the output gap but also the expected inflation rate. Second, the presence of real rigidity affects the welfare gain from a commitment policy. This paper shows that the welfare gain from commitment is smaller as the degree of real rigidity increases. Furthermore, the welfare gain from commitment decreases as the central bank puts a higher weight on the stabilization of the output gap relative to inflation. Thus, the conservative central bank might produce poorer outcomes when real rigidity is present.

We also examine the optimal delegation problem in an economy where real rigidity exists. Several studies have suggested that the government delegates a different loss function with policy inertia to the central bank. According to the findings of Walsh (2003), price level targeting leads to poorer outcomes when inflation is predominately backward-looking. On the other hand, price level targeting can replicate a commitment policy when inflation is purely forward-looking. A speed limit policy dominates a price level target as long as inflation is neither extremely forward-looking nor backward-looking. This paper shows that a price level target leads to preferable outcomes to alternative targeting regimes. This result is robust to the degree of real rigidity.

This paper proceeds as follows. Section 2 describes the model. Section 3 explores optimal monetary policy in an economy with real rigidity, and reports simulation results. Section 4 briefly concludes.

2 The model

Apart from introducing real rigidity, we use the standard new Keynesian model derived in Woodford (2003). It consists of three equations: an expectational IS equation; a new Keynesian aggregate supply curve; and a monetary policy rule. We use lower case variables to denote a log deviation from the steady state. Specifically, a log-linearized variable around the steady state is expressed by $h_t = \log(H_t/\bar{H})$.

The expectational IS equation is derived from the representative household's Euler equation for optimal consumption. More precisely, the expectational IS equation is given as follows:

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

where x_t is the output gap, which is defined as $x_t = y_t - y_t^n$. y_t is actual output, and y_t^n denotes the efficient level of output. r_t denotes the nominal interest rate, and π_t represents the inflation rate. Also, r_t^n is the natural rate of interest, which

is the real interest rate held in the flexible price equilibrium. The parameter σ is the relative risk aversion coefficient for consumption.

Inflation adjustment is depicted by the NKPC. This equation is key component in the new Keynesian model. The derivation of the NKPC is based on a Calvo (1983) type staggered nominal price rigidity. Thus, the canonical NKPC is derived from the assumptions that firms are characterized by monopolistic competition and that each firm is subject to a constraint whereby some firms cannot adjust their prices each period. This is the natural resource of the distortion associated with the relative price. More precisely, a fraction $1-\alpha$ of all firms can adjust their price while the remaining fraction α cannot. Following Blanchard and Galí (2007), we introduce real rigidity generated by the sluggish movements in the real wage. Under these conditions, we obtain the following NKPC:

$$\pi_t = \beta E_t \pi_{t+1} + \kappa(1-\gamma)x_t + \kappa\gamma x_{t-1} + u_t, \tag{2}$$

where

$$\kappa \equiv \frac{(1-\alpha)(1-\alpha\beta)}{\alpha}(\psi+\sigma).$$

The parameter ψ denotes the elasticity of labor supply and u_t is a cost-push shock associated with a time-varying mark-up.[2] The parameter κ is the slope of the NKPC. The parameter γ represents the degree of real rigidity. Unlike the standard new Keynesian model, Eq. (2) includes the lagged output gap, which is created by real rigidity. Thus, real rigidity produces the sluggish movements in the real marginal cost through the adjustment of the real wage. As argued in Blanchard and Galí (2007), this is very important because real rigidity causes an inertial behavior of the inflation rate which is supported by several empirical studies for the Phillips curve.

3 Optimal monetary policy in an economy with real rigidity

This section explores optimal monetary policy in an economy with real rigidity. In a purely forward-looking economy the optimal commitment policy can reduce the welfare losses associated with economic shocks by managing private sector expectations. This prescription might change, however, when real rigidity affects macroeconomic variables. It is possible, therefore, that real rigidity generates a severe trade-off between inflation and the output gap compared to the standard

[2]See Woodford (2003) and Steinsson (2003) for a detailed explanation of a cost-push shock. Also, see Walsh (2010) for a detailed derivation of Eq. (2).

new Keynesian economy. We analyze the property of a commitment policy in an economy with real rigidity, and quantitatively show that the degree of real rigidity influences the gain from commitment. Also, we assess the gain from employing alternative targeting regimes when the central bank cannot commit its monetary policy.

3.1 Optimal monetary policy

We describe the central bank's loss function to examine optimal monetary policy. As shown in Woodford (2003), the second-order approximation of the household's utility function corresponds to the central bank's loss function. In other words, we obtain the central bank's loss function with a micro-foundation. The corresponding loss function is

$$L_t = \sum_{t=0}^{\infty} \beta^t \Big(\pi_t^2 + \lambda x_t^2 \Big), \tag{3}$$

where λ represents an weight on the stabilization of the output gap relative to inflation.[3]

We derive the optimal conditions under a commitment policy. When the central bank implements its monetary policy with commitment, the Lagrangian is defined as follows:

$$\Gamma = E_0 \sum_{t=0}^{\infty} \beta^t \Big[\pi_t^2 + \lambda x_t^2 - 2\phi_t \Big(\beta \pi_{t+1} + \kappa(1-\gamma) x_t + \kappa\gamma x_{t-1} + u_t - \pi_t \Big) \Big],$$

where ϕ_t denotes the Lagrange multiplier.

The first order conditions of this optimization problem are as follows:

$$\pi_t + \phi_t - \phi_{t-1} = 0, \tag{4}$$

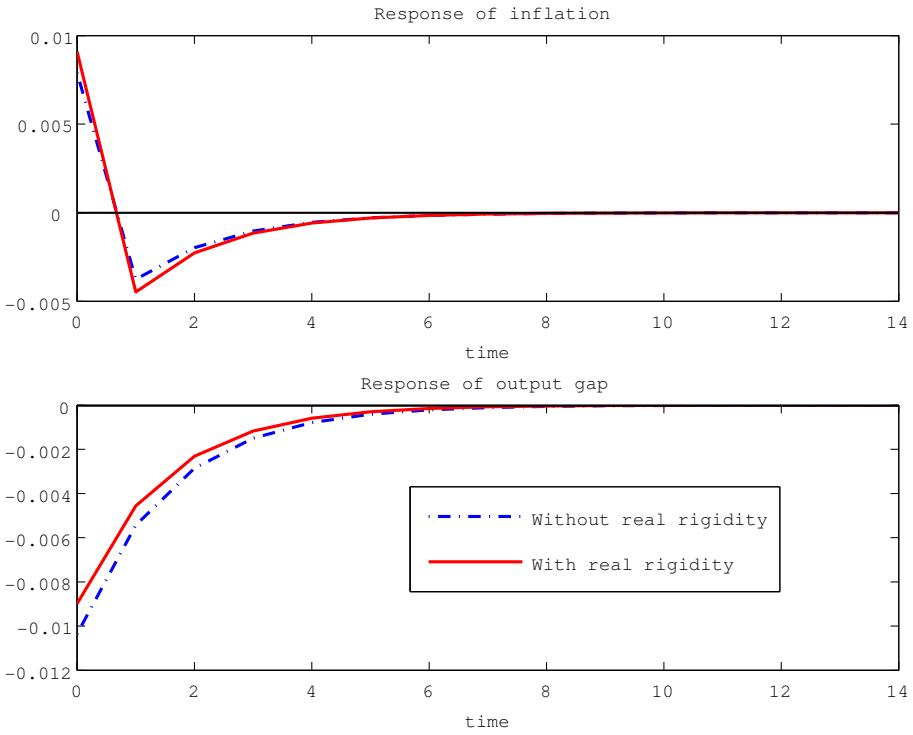
$$\lambda x_t - \kappa(1-\gamma)\phi_t - \beta\kappa\gamma E_t \phi_{t+1} = 0. \tag{5}$$

From the optimal conditions, we obtain

$$\pi_t = -\frac{\lambda}{\kappa[1 + (1-\beta)\gamma(1 - L^{-1})]} (x_t - x_{t-1}), \tag{6}$$

[3]In the case of the presence of real rigidity, the true central bank's loss function might not correspond to Eq. (3). We employ the standard central bank's loss function for three reasons. First, the existing literature uses the central bank's loss function, such as Eq. (3), for optimal monetary policy. Second, this loss function seems to describe the actual dual mandate for the central bank to stabilize inflation and output gaps. Third, this loss function is simple and intuitively understandable.

Figure 1: Impulse response to a cost-push shock



where L denotes the Lag operator. We can rewrite this equation as follows:

$$\kappa\pi_t + (1-\beta)\kappa\gamma(\pi_t - E_t\pi_{t+1}) = -\lambda(x_t - x_{t-1}).$$

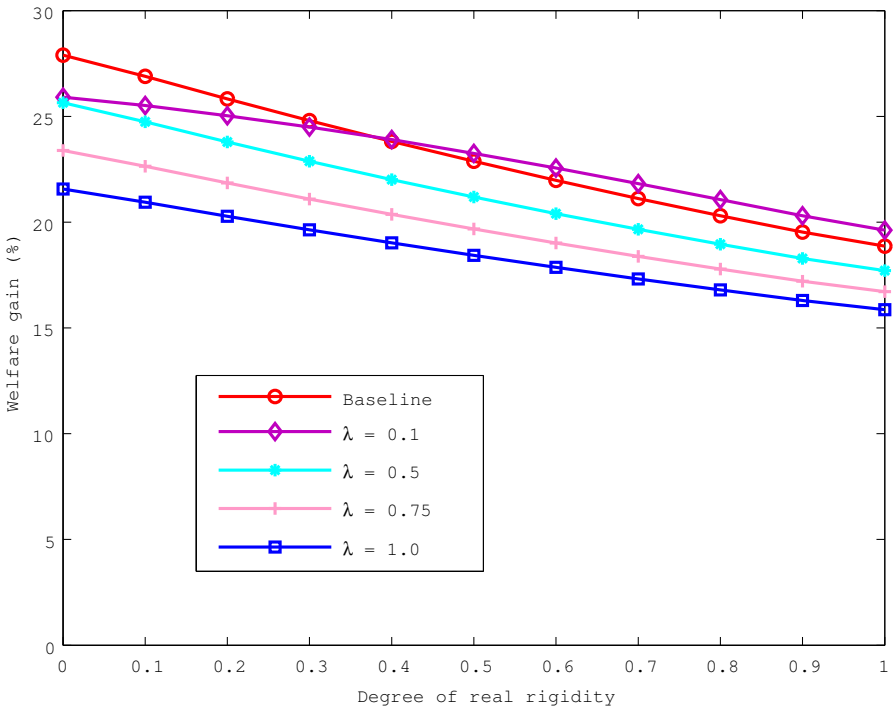
Rearranging this equation, we obtain the following result.

Proposition 1 *In an economy with real rigidity the optimal targeting rule under a commitment policy is given as follows:*

$$\pi_t = \frac{1}{\kappa[1+(1-\beta)\gamma]}\Big[\kappa\gamma(1-\beta)E_t\pi_{t+1} - \lambda(x_t - x_{t-1})\Big]. \tag{7}$$

According to this proposition, a targeting rule under a commitment policy includes the future inflation rate in an economy where real rigidity is present. As in Walsh (2010), the targeting rule under commitment should react to forward-looking endogenous variables when inflation persistence is present. According to Walsh (2010), the expected output gap emerges when the central bank conducts monetary policy with commitment in an economy in which inflation endogenously persists. On the other hand, our result indicates that the central bank also targets the expected inflation rate when real rigidity influences the real economy.

Figure 2: Welfare gain from commitment



To observe the property of a commitment policy in an economy with real rigidity, we simulate the model using the following deep parameters. First, we set the degree of price rigidity α to 0.70, and the discount factor β to 0.99. We set the relative risk aversion coefficient for consumption σ to 1.5. Next, we set the elasticity of labor supply ψ to 1.0 based on Walsh (2010). Also, following Walsh (2010), we set the stabilization weight on the output gap relative to inflation to 0.25 as a baseline value. Finally, following Walsh (2003), in regard to economic shocks, we set the standard deviation for a natural interest shock σ_g to 0.015 and the standard deviation for cost-push shock σ_u to 0.015. Also, based on Walsh (2003), we set the serial correlation of potential output, the serial correlation of demand shock, and the standard deviation of potential output to 0.97, 0.3, and 0.005, respectively.

Figure 1 illustrates the impulse response to a cost-push shock. It follows that real rigidity generates a severe trade-off between inflation and the output gap. Compared to the case of no real rigidity, the initial response of the inflation rate is large, whereas the response of the output gap is small. As suggested by Eq. (7), in the presence of real rigidity an optimal targeting rule under commitment includes the response of the future inflation rate. Therefore, the initial response

of inflation is large compared to the economy without real rigidity.

We quantitatively calculate the welfare gain from commitment for values of γ between 0 and 1. Figure 2 shows the welfare gain from commitment in an economy with real rigidity. The welfare gain is defined as the ratio of welfare loss under commitment and welfare loss under discretion. The commitment policy produces welfare gains when this value exceeds zero. According to Figure 2, the gain from a commitment policy declines as the parameter γ takes a higher value. Intuitively, inflation persistence is high as the lagged output gap plays an important role in the NKPC. As pointed out in Steinsson (2003), the welfare loss is large when the lagged output gap influences inflation dynamics.[4]

Hence, our result suggests that the lagged output gap significantly affects inflation dynamics. Moreover, this might imply that the central bank should recognize that real rigidity is a natural resource of an inertial behavior of the inflation rate when implementing its monetary policy. In addition, a higher weight on the stabilization of the output gap reduces the welfare gain from commitment. The difference between discretion and commitment decreases as the private sector expects a higher value of λ.

3.2 Targeting regimes

We now investigate optimal monetary policy in the case where the central bank cannot commit its monetary policy. Several studies have suggested that the government delegates a different loss function with policy inertia to the central bank in such a case. As pointed out in Jensen (2002), Walsh (2003), and Vestin (2006), there are welfare gains when the government delegates policy regimes that differ from the true loss function of the central bank. For example, Jensen (2002) suggests a nominal income growth targeting policy as an alternative policy objective, and finds that a nominal income growth targeting policy is quite similar in outcome to a commitment policy. Walsh (2003) argues the effectiveness of speed limit policy that depends on change in the output gap. Vestin (2006) examines whether a price level target is superior to a pure discretionary policy.

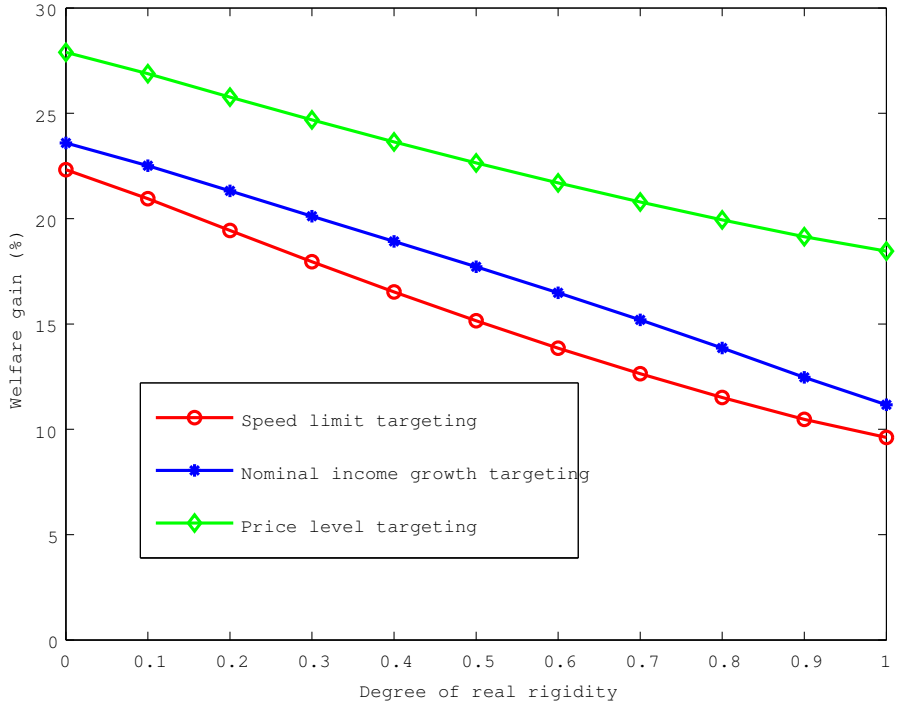
Jensen (2002) points out that a nominal income growth target—i.e., government delegates the policy objective with the nominal income growth to the central bank—is effective. A nominal income growth target is suggested by

$$L_t^{NIGT} = \pi_t^2 + \lambda(\pi_t + y_t - y_{t-1})^2. \tag{8}$$

It follows from Eq.(8) that the nominal income growth target has inertia for output, which is characterized by the second term on the right hand side of Eq.(8).

[4]We also check whether the performance of the gain from commitment depends on the change of parameters α, σ, and ψ, and find that the results are robust to the change of these parameters. A technical appendix is available on request.

Figure 3: Welfare gains under alternative targeting regime relative to inflation targeting when $\lambda = 0.25$



Walsh (2003) also suggests a speed limit policy that government assigns the policy objective with the output gap growth to the central bank. The loss function under a speed limit policy is proposed by

$$L_t^{SLP} = \pi_t^2 + \lambda(x_t - x_{t-1})^2. \tag{9}$$

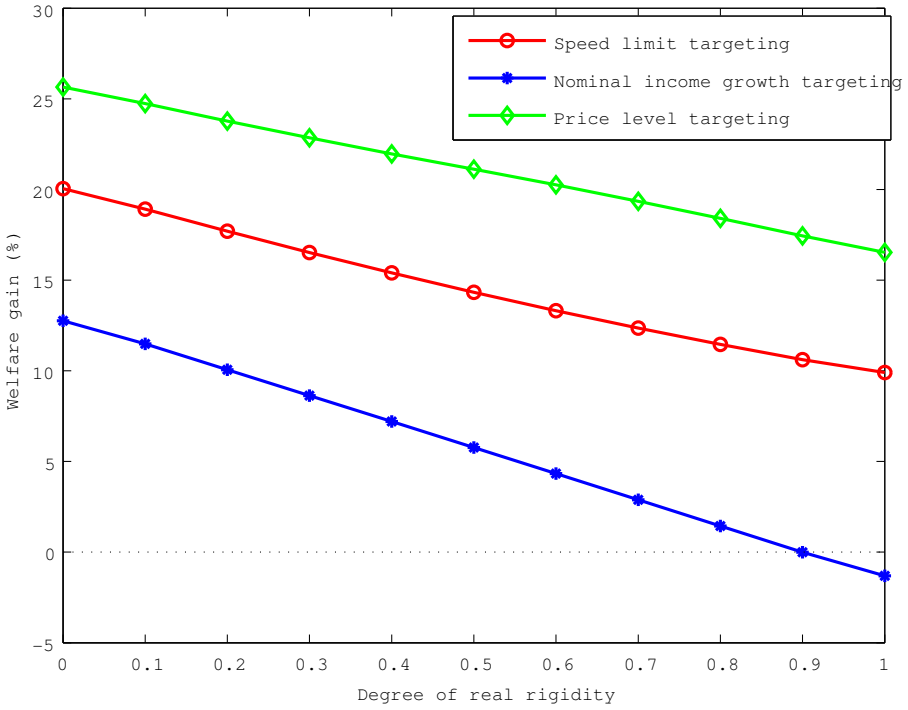
Finally, we investigate whether a price level target supported by Vestin (2006) replicates a commitment policy. The objective function under the price level target is suggested by

$$L_t^{PLT} = p_t^2 + \lambda x_t^2, \tag{10}$$

where p_t denotes the price level. The price level target attempts to stabilize the price level rather than inflation. As shown in Galí (2008), a price level target corresponds to a commitment policy in the standard new Keynesian model.

Figure 3 illustrates the welfare gains from alternative targeting regimes when the parameter γ ranges from 0 to 1. The welfare gain is defined as the ratio of welfare loss under alternative targeting regimes and welfare loss under inflation

Figure 4: Welfare gains under alternative targeting regime relative to inflation targeting when $\lambda = 0.5$



targeting. Thus, alternative targeting regimes produce welfare gains when this value exceeds zero. Interestingly, a price level target leads to preferable outcomes to alternative targeting regimes in an economy with real rigidity. This result seems to show that a price level target can replicate an optimal monetary policy under commitment. Welfare loss under a nominal income growth target is less than under a speed limit policy. This might be slightly inconsistent with Walsh (2003).

Figure 4 shows the welfare gains when $\lambda = 0.5$. Surprisingly, compared to the case of $\lambda = 0.25$, the performance of a nominal income growth target drastically worsens when $\lambda = 0.5$.[5] In this case, a speed limit target suggested by Walsh (2003) leads to preferable outcomes to a nominal income growth target. In addition, welfare loss under a nominal income growth target exceeds that under inflation targeting when the parameter γ considerably takes a higher value. This result suggests that the weight on the stabilization of the output gap affects the

[5]We check that the gain from a speed limit policy is large when λ takes a higher value, whereas the gain from a nominal income growth target is large when λ takes a smaller value.

performance of alternative targeting regimes because the welfare loss is evaluated by the true loss function.[6]

In summary, price level targeting is effective when the central bank cannot commit its monetary policy in an economy with real rigidity. In addition, it is important that the central bank considers uncertainty about the weight on the output gap in the loss function when the government delegates the alternative objective with policy inertia to the central bank in an economy with real rigidity.

4 Concluding remarks

This paper has investigated the property of optimal monetary policy in an economy with real rigidity. First, as argued in Blanchard and Galí (2007), we have shown that real rigidity generates a severe trade-off between inflation and the output gap. This indicates that the existence of real rigidity changes the property of a commitment policy.

Second, this paper has shown that the welfare gain from commitment declines as the degree of real rigidity increases. Furthermore, the welfare gain from commitment decreases as the central bank puts a higher weight on the stabilization of the output gap relative to inflation. Thus, the conservative central bank might produce poorer outcomes in an economy with real rigidity.

Finally, we have examined the optimal delegation problem in an economy with real rigidity. Several studies suggest that the government delegates a different loss function with policy inertia to the central bank. We have found that a price level target leads to preferable outcomes to alternative targeting regimes. This result is robust to the degree of real rigidity.

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[6]The parameter κ might affect the performance of targeting regimes. Therefore, we check whether the performance of targeting regimes depends on the change of parameters α, σ, and ψ, and find that the result are robust to the change of these parameters. A technical appendix is available on request.

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