The neo-Fisherian effect in a new Keynesian model with real money balances

Ida, Daisuke

29 March 2024

The neo-Fisherian effect in a new Keynesian model with real money balances*

Daisuke Ida†[a,b]

[a]Faculty of Economics, Momoyama Gakuin University
[b]Research Fellow, Graduate School of Economics, Kobe University

March 26, 2024

Abstract

This study explores how the real money balance effect (RMBE) affects the neo-Fisherian effect (NFE) in a standard new Keynesian model. First, we find that the presence of the RMBE can partly explain the occurrence of the NFE, and that increasing the nonseparability parameter magnifies the positive response of the nominal interest rate to a persistent inflation target shock. Second, we show that the degree of nominal price stickiness is important in explaining how the RMBE amplifies the NFE. In sum, this study addresses how the presence of the RMBE facilitates generating the NFE.

JEL codes: E52; E58

Keywords: Neo-Fisherian effect; New Keynesian model; Real money balances; Interest rates; Inflation

---

*I would like to thank Mitsuhiro Okano for useful comments and suggestions. This paper was supported by JSPS KAKENHI Grant Numbers JP20K01784 and JP23K01410. All remaining errors are my own.

†Faculty of Economics, Momoyama Gakuin University, 1-1, Manabino, Izumi, Osaka 594-1198, Japan. Tel.: +81-725-92-6134. E-mail: ida-dai@andrew.ac.jp

1 Introduction

Does a rise in the central bank's target inflation induce a rise in the nominal interest rate? This is a simple question, but it has recently become crucial for the effectiveness of monetary policy in advanced economies. Central banks in advanced countries have maintained a lower interest rate environment to combat deflationary risks. Several studies have argued that when inflation is too low, the central bank should raise the nominal interest rate to increase inflation (Cochrane, 2016, Williamson, 2019). We have seen that many central banks attempt to raise nominal interest rates to combat inflationary risks. For instance, in the United States, since 2022, the Federal Reserve Board has steadily raised the Federal Funds rate to suppress the inflationary pressures in the real economy. In other words, recent evidence may suggest that the nominal interest rate rises in response to inflationary pressure, showing a positive relationship between inflation and the nominal interest rate.[1]

According to standard macroeconomic theory, we would expect that the inflation rate generally declines after a rise in the nominal interest rate. This prediction is based on the standard monetary transmission mechanism that a monetary tightening shock prevents an increase in the inflation rate. Conversely, the neo-Fisherian hypothesis indicates a positive comovement between the nominal interest rate and inflation in the short run (Airaudo and Hajdini, 2023, Garín, Lester and Sims, 2018, Uribe, 2022). More precisely, this hypothesis implies that a persistent and transitory rise in the interest rate is related to an increase in the inflation rate. How should we reconcile this tension between theoretical and empirical claims?

We focus on the role of the real money balance channel in accounting for this contradiction. Indeed, several studies have addressed the impact of monetary aggregates on the real economy (Belongia and Ireland, 2022, Kurozumi, 2006, Ida, 2023, Woodford, 2003). According to the real money balance channel, a change in money balances impacts the aggregate demand via monetary policy's demand and supply channels. If this channel plays a significant role in the monetary transmission mechanism, it is unclear how the real money balance effect (RMBE) affects the occurrence of the neo-Fisherian effect (NFE). Consequently, it is essential to examine

[1] We do not consider the price puzzle problem in this paper. The price puzzle means that the inflation rate increases with monetary contraction in the empirical studies (Sims, 1992). See Florio (2018), Hanson (2004) and Ida (2024) for a detailed discussion about the role of the price puzzle phenomenon that monetary tightening causes an increase in inflation.

the relationship between inflation and the nominal interest rate. These arguments motivate this study.

According to Garín et al. (2018), this hypothesis implies that a rise in the central bank's target inflation rate increases the nominal interest rate in the short run. Additionally, the money demand function generally posits that an increase in the nominal interest rate causes a reduction in the money aggregate as long as the nominal interest rate does not reach the zero-lower bound floor. In the presence of the RMBE (Benhabib, Schmitt-Grohé and Uribe, 2001), a reduction in real money balances boosts the inflation rate through an aggregate supply relationship in a sticky price model (Ida, 2023, Woodford, 2003). As Kurozumi (2006) and Woodford (2003) pointed out, the degree of nonseparability between consumption and real money balances in the household utility function significantly impact the RMBE's strength.[2] Moreover, Williamson (2019) posited the importance of the money aggregate in explaining the relationship between inflation and the nominal interest rate in the Volker era, arguing that movements in inflation and nominal interest rates during the Volker era are consistent with neo-Fisherianism. Therefore, it is interesting to consider how the RMBE interacts with the NFE in the standard new Keynesian (NK) model.

The paper's main findings are as follows. First, the presence of the RMBE can explain the occurrence of the NFE within empirically plausible values of the nonseparability parameter. In addition, a higher nonseparability parameter value magnifies the nominal interest rate's positive response to a persistent inflation target shock. Second, this study shows that the degree of nominal price stickiness is important in explaining the NFE's amplification due to the RMBE. On the one hand, a persistent inflation target shock drives the positive reaction of the nominal interest rate with an increase in the nonseparability parameter under flexible nominal prices. On the other hand, when nominal prices are predominantly sticky, a higher value of the nonseparability parameter does not magnify the impact response of the nominal interest rate to a persistent inflation target shock.

The intuition and policy implications of these findings are as follows. Given the degree of nominal price stickiness, a larger value of the nonseparability parameter reinforces the RMBE, causing inflation to rise via the new Keynesian Phillips curve (NKPC) (Woodford, 2003). This

[2]Several studies have also questioned the statistical significance of the nonseparability assumption (McKnight and Mihailov, 2015, Poilly, 2010).

means that a persistent inflation target shock, causing inflation to rise, further increases the nominal interest rate under the real money balance channel, amplified by a higher value of the nonseparability parameter. If nominal prices are not sticky, a larger value of the nonseparability parameter generates a larger NFE. When nominal prices are fully sticky, the occurrence of the NFE does not depend on the value of the nonseparability parameter. Thus, this paper argues that the presence of the RMBE causes a stronger NFE than the standard NK model.

Our study makes the following contributions to the literature. This paper is mainly related to Garín et al. (2018), which showed how the NFE occurs in the textbook NK model. However, study differs from Garín et al. (2018) in the following point. To consider the NFE, we address the role of the RMBE captured by the nonseparability parameter. More specifically, we show that increasing the value of this parameter amplifies the NFE. When the empirically plausible value of the nonseparability parameter is chosen, the NFE emerges. As a result, in contrast to their research, we emphasize the interaction between NFE and RMBE.[3]

Our study is also related to Ali and Qureshi (2022) who examined the role of the cost channel in accounting for the NFE. They showed that the NFE arises when the cost channel matters. Similar to the NK model with a cost channel (Ravenna and Walsh, 2006), the RMBE acts as the cost channel via the positive effect of the nominal interest rate on the real marginal cost (Woodford, 2003). In contrast to their research, we investigate how the RMBE interacts with the NFE, demonstrating that the presence of the RMBE significantly amplifies the NFE. They considered the case of a monetary policy shock, whereas we concentrated on an inflation target shock to consider the realization of the NFE.

This study is also relates to Bilbiie (2022), who examined the NFE in the standard NK model with a liquidity trap. Conversely, we focus on how real money balances affect the impact of an inflation target shock on the nominal interest rate instead of assuming a liquidity trap. Moreover, Kurozumi (2006) focused on the determinacy properties in an NK model with real money balances, yet did not consider the role of real money balances in generating the NFE. Airaudo and Hajdini (2023) examined the role of wealth effects in accounting for the occurrence of the NFE by focusing on the nonseparable utility between consumption and the labor supply.

[3]As we will discuss, this paper assumes that the central bank sets the nominal interest rate in response to an inflation target shock. Conversely, Ali and Qureshi (2022) presumed that the central bank sets the nominal interest rate by following the standard Taylor rule in their model.

However, they did not investigate how a real money balance channel induces the NFE.

To our knowledge, no study has attempted to provide in-depth insights into the role of real money balances in explaining the occurrence of the NFE in a standard NK model. The money demand function plays an important role in monetary policy transmission as long as the zero-lower bounds on nominal interest rates are not realized. Accordingly, this study addresses the importance of considering the interaction between the real money balance and the NFEs.

The remainder of this paper is organized as follows. Section 2 describes the standard NK model with the RMBE and explains the parameter values adopted in the paper. Section 3 summarizes the paper's main findings, and Section 4 presents some policy implications. Section 5 briefly concludes.

2 The NK model with real money balances

This section briefly explains the standard NK model with real money balances. In Section 2.1, following Woodford (2003), we provide the NK model's description with real money balances. The deep parameters used in this study are then described in Section 2.2.

2.1 Model description

Based on Woodford (2003), the model's structure is summarized as follows. Subject to an intertemporal budget constraint, households maximize their utility function, comprising consumption, real money balances, and labor supply. This paper specifies money in the utility function. More specifically, the model is predicated on the end-of-period timing of the household's money holdings.[4] Firms that face a monopolistically competitive environment determine their optimal prices under Calvo (1983)'s nominal price rigidity. Following Garín et al. (2018), the central bank determines the nominal interest rate so as to satisfy its inflation target. Consequently, except for the monetary policy specification, the model consists of three equations: a dynamic IS equation, an NKPC, and a money demand function. The lowercase variable represents a log-deviation from the steady state.

The first equation is a dynamic IS curve derived from intertemporal optimal household

[4]See Kurozumi (2006) for the role of other specifications of the timing of household's money holding in the standard NK model.

conditions. The dynamic IS curve is given by

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

where x_t is the output gap, π_t is the inflation rate, r_t is the nominal interest rate, and m_t denotes real money balances. Variable r_t^n denotes the natural rate of interest that stands for the real interest rate in the flexible price equilibrium. E_t is the expectations operator conditional on the information about period t. The parameters σ and χ denote the constant relative risk aversion coefficient and the degree of the nonseparability between consumption and real money balances in the utility function, respectively.[5] In the case of $\chi > 0$, a marginal utility of consumption increases with a marginal increase in real money balances. In contrast to the standard NK model, the inclusion of the nonseparable utility function results in the addition of a third term to the IS curve. We observe that an expected change in real money balances impacts the current output gap. Notice that the final term in the IS curve disappears when the separable utility function is assumed (Woodford, 2003).

The second equation is an NKPC derived from the optimal condition of monopolistic competitors' firms and Calvo (1983) type nominal price rigidities. The NKPC is given by

$$\pi_t = \beta E_t\pi_{t+1} + \lambda(\sigma + \varphi)x_t - \lambda\chi m_t, \tag{2}$$

where the slope of the NKPC is given by

$$\lambda = \frac{(1-\theta)(1-\beta\theta)}{\theta}. \tag{3}$$

Parameter θ denotes the Calvo lottery, representing the degree of nominal price rigidity. φ denotes the inverse of Frisch elasticity. When the utility function cannot be separated from consumption and real balances, the NKPC is negatively affected by real money balances. The third term on the right-hand side of the NKPC reflects this channel. When $\chi > 0$, comovement occurs between consumption and real money balances. The real marginal costs negatively depend on the real money balances, whereas they are positively related to consumption. Hence, while an increase in consumption leads to a rise in the real marginal costs, it reduces the real marginal costs via the real money balance channel. When $\chi = 0$, the NKPC reduces to one derived in the standard NK model.

[5]This paper assumes that $\chi > 0$. Benhabib et al. (2001) consider the case of $\chi < 0$.

The third equation is a money demand function derived from the household's optimization problem for money holdings (Walsh, 2017, Woodford, 2003), and more specifically, from the fact that the marginal rate of substitution between consumption and real money balances equals the opportunity costs of money holdings. The log-linearized money demand function is given by

$$m_t = \eta_y x_t - \eta_r r_t, \tag{4}$$

where η_y denotes the income elasticity of money demand and η_r represents the interest elasticity of money demand. Note that the money demand function does not rely on the assumption of the nonseparable utility between consumption and real money balances (Woodford, 2003).

To conduct a further analytical investigation, we provide the following two-equation system by substituting Equation (4) into Equations (1) and (2) as follows:

$$x_t = E_t x_{t+1} - \frac{1}{\sigma - \chi\eta_y}(r_t - E_t\pi_{t+1}) + \frac{\chi\eta_r}{\sigma - \chi\eta_y} E_t \Delta r_{t+1}, \tag{5}$$

$$\pi_t = \beta E_t \pi_{t+1} + \lambda(\sigma + \varphi - \chi\eta_y)x_t + \lambda\chi\eta_r r_t. \tag{6}$$

According to Equation (6), the inflation rate positively depends on the nominal interest rate due to the presence of the RMBE as long as $\chi > 0$.[6] Following Kurozumi (2006) and Woodford (2003), we assume that $\sigma - \chi\eta_y > 0$ to avoid the inverted DIS logic. Under an empirically plausible parameterization, we can easily confirm that the assumption is satisfied.

In what follows, we explain how the RMBE operates in this model. Consider the case for a nominal interest rate increase. A rise in the nominal interest rate reduces the output gap via the following two channels. On the one hand, raising the nominal interest rate reduces real money balances. According to Equation (1), the output gap decreases as the first difference in real balances decreases, reflecting the real money balance channel. On the other hand, a rise in the nominal interest rate directly reduces the output gap via the interest rate's traditional demand channel. Because of the above two channels, a decrease in the output gap results in a decline in inflation. However, it can raise the inflation rate because the real marginal costs in an NK model with real money balances depend on the nominal interest rate. Accordingly, a

[6]As shown in Ravenna and Walsh (2006), the NKPC positively depends on the nominal interest rate in an NK model with a cost channel. This is because the real marginal costs increase with a rise in the nominal interest rate. See Ravenna and Walsh (2006) for a detailed discussion about the cost channel in the NK model.

persistent inflation target shock may generate the NFE when the supply channel of the nominal interest rate outweighs the demand channel.

We now describe the monetary policy specification. Instead of assuming a simple monetary policy rule, such as the Taylor rule (Taylor, 1993), we follow Garín et al. (2018) and presume that an exogenous inflation target specifies monetary policy.[7] An exogenous inflation target shock is characterized by an auto-regressive (AR)(1) process. The central bank manipulates the nominal interest rate in order to achieve its inflation target. In the following, we assume the following monetary policy specification:

$$\pi_t = \pi_t^*, \tag{7}$$

$$\pi_t^* = \rho_\pi \pi_{t-1}^* + \varepsilon_t, \tag{8}$$

where $\rho_\pi \in (0,1)$ denotes the degree of inflation target shock persistence and ε_t is an independent and identically distributed shock with the constant variable σ_π^2.

As previously stated, the presence of the RMBE mitigates the effect of monetary contraction on inflation, but how the RMBE influences the NFE is unclear. Put differently, we must investigate whether an inflation target shock causes a rise in the nominal interest rate. Consider the case of an exogenous inflation target shock. On the one hand, this shock immediately causes an increase in inflation, which given the nominal money aggregate, leads to a decline in real money balances. On the other hand, the money demand function implies that a decrease in real money balances raises the nominal interest rate. Therefore, in contrast to Garín et al. (2018), the NFE may be amplified or dampened by the RMBE. The next section explores how the separability parameter χ affects generating the NFE.

2.2 Parameterization

This section follows the existing literature in the NK model and describes the deep parameters used in this paper. Following Garín et al. (2018), we set the discount factor β, the relative risk aversion coefficient for consumption σ, and the inverse elasticity of the labor supply φ, 0.99, 1.0, and 1.0, respectively. Following Woodford (2003), the income elasticity of money demand η_r is set to 1.0, and the value of the interest elasticity of money demand η_y is set to 7.

[7] Ali and Qureshi (2022) adopted a simple Taylor rule to investigate the occurrence of the NFE in an NK model.

Next, consider the calibration of χ. We focus on the assumption of $\chi \geq 0$ to be consistent with the empirical value of the nonseparability parameter. No consensus appears to have been reached among previous empirical studies regarding the estimated value of parameter χ. The presence of a nonseparable utility function has resulted in poorer empirical performance (Ireland, 2001). Conversely, several recent studies reported that the nonseparable parameter χ is statistically significant (Poilly, 2010, Serletis and Xu, 2020). Furthermore, Kurozumi (2006) showed that the parameter χ has a crucial impact on the determinacy condition and assumed that this parameter value ranges from 0 to 0.02. Meanwhile, in McKnight and Mihailov (2015), the parameter range is presumed to be between 0 and 0.03. These parameter values are included in recent studies' reported values (Poilly, 2010, Serletis and Xu, 2020). Moreover, as pointed out in Jia (2021) and Piazzesi, Rogers and Schneider (2019), the degree of the nonseparability parameter is related to the money demand's interest elasticity. Jia (2021) discussed that this value may range from 0.05 to 0.35. Ida (2023) considered that the value of χ ranges from 0 to 0.05. Despite the lack of agreement over the precise ranges of this parameter, we set parameter χ to a range of 0 to 0.05 to be consistent with the calibrated values in previous studies.

3 Main results

This section reports the main findings of this paper. Section 3.1 investigates inflation's reaction to an inflation target shock and confirms the condition of the emerging NFE. In Section 3.2, we report sensitivity experiments with various parameterizations.

3.1 The NFE in an NK model with real money balances

Consider the nominal interest rate's reaction to an inflation target shock. More concretely, we solve the rational expectations (RE) model by considering the undetermined coefficient method (UCM). Doing so allows us to derive an analytical solution using several intuitions about why the NFE occurs in this paper. To obtain the analytical solution in the RE model, McCallum (1983) proposed the minimum state variable (MSV) solution, whom we follow to seek the MSV solution using the UCM.[8] Accordingly, we can derive the MSV solution for the interest rate as

[8] Concentrating on the MSV solution excludes the bubble solution in the RE model.

follows:

$$r_t = \Psi \pi_t^*, \tag{9}$$

where

$$\Psi = \frac{(\sigma - \chi\eta_y)(1-\rho_\pi\beta)(\rho_\pi - 1) + \lambda\rho_\pi(\sigma + \varphi - \chi\eta_y)}{\Omega},$$

$$\Omega = \lambda\{(\sigma + \varphi - \chi\eta_y)[1 - \chi\eta_r(\rho_\pi - 1)] - (\sigma - \chi\eta_y)\chi\eta_r\}.$$

In the following analyses, without loss of generality, we assume that $\Omega > 0$. Similarly, for the output gap, we obtain the MSV solution as follows:

$$x_t = \Gamma \pi_t^*, \tag{10}$$

where

$$\Gamma = \frac{(1-\rho_\pi\beta)[\Omega - \chi\eta_r\lambda^2(\sigma - \chi\eta_y)(\sigma + \varphi - \chi\eta_y)(\rho_\pi - 1)] - \lambda^2(\sigma + \varphi - \chi\eta_y)^2\rho_\pi}{\Omega\lambda(\sigma + \varphi - \chi\eta_y)}.$$

Finally, the real interest rate (rr_t) is given as follows:

$$\begin{aligned} rr_t &= r_t - E_t\pi_{t+1}, \\ &= (\Psi - \rho_\pi)\pi_t^*. \end{aligned} \tag{11}$$

Consider how a change in parameter χ impacts the response of the nominal interest rate to an inflation target shock. As Garín et al. (2018) pointed out, the numerator in the coefficient Ψ is likely to be positive in this model. In contrast to Garín et al. (2018), however, this study considers that parameter χ significantly affects the response of the nominal interest rate to an inflation target shock. Although a higher value of χ lowers the denominator in Ψ, it also decreases the numerator in its coefficient. Accordingly, we conjecture that a higher value of χ reinforces the positive effect of an inflation target shock on the nominal interest rate if the former effect outweighs the latter. Hence, it follows from Equation (11) that this naturally influences the response of the real interest rate to an inflation target shock. When the separable utility between consumption and real money balances is assumed (i.e., $\chi = 0$), the solution (9) reduces to that derived by Garín et al. (2018).

First, we investigate whether increasing the parameter χ reinforces or dampens the effect of an inflation target shock on the nominal interest rate. In other words, we investigate whether a change in parameter χ affects the sensitivity of the nominal interest rate response to an inflation target shock. We have the following result:

Proposition 1 *Let $\rho_\pi \neq \theta$ and $\chi \geq 0$. An increase in the parameter χ always reinforces the positive effect of an inflation target shock on the nominal interest rate if $(1-\rho_\pi\beta)(1-\rho_\pi) > \lambda\rho_\pi$ and $\eta_y[\chi\eta_r(\lambda\eta_y(\rho_\pi - 1) + 1) - \lambda] < \eta_r[\lambda(\rho_\pi - 1)(\sigma + \varphi) - \chi\eta_y\rho_\pi + \sigma]$.*

Proof. Differentiating the coefficient Ψ with respect to χ, we obtain the following result:

$$\frac{\partial\Psi}{\partial\chi} = \frac{AB - CD}{B^2},$$

where

$$A = \eta_y[(1 - \rho_\pi\beta)(1 - \rho_\pi) - \lambda\rho_\pi],$$
$$B = \lambda(\sigma + \varphi - \chi\eta_y)(1 - \chi\eta_r(\rho_\pi - 1)) - \chi\eta_r(\sigma - \chi\eta_y) > 0,$$
$$C = (\sigma - \chi\eta_y)(1 - \rho_\pi\beta)(1 - \rho_\pi) + \lambda(\sigma + \varphi - \chi\eta_y) > 0,$$
$$D = \eta_y[\chi\eta_r(\lambda\eta_y(\rho_\pi - 1) + 1) - \lambda] - \eta_r[\lambda(\rho_\pi - 1)(\sigma + \varphi) - \chi\eta_y\rho_\pi + \sigma].$$

Since the denominator is positive, the coefficient Ψ always becomes positive if A is a positive and D is a negative value. When $\rho_\pi > \theta$, the coefficient A becomes a positive. Furthermore, for the coefficient D to be negative, we require the following condition: $\eta_y[\chi\eta_r(\lambda\eta_y(\rho_\pi - 1) + 1) - \lambda] < \eta_r[\lambda(\rho_\pi - 1)(\sigma + \varphi) - \chi\eta_y\rho_\pi + \sigma]$. $\partial\Psi/\partial\chi > 0$ if these conditions are satisfied. This completes the proof. ■

The intuition of this result is as follows. Consider the case of an exogenous inflation-targeting shock. On the one hand, if the NFE is present, this shock immediately causes an increase in inflation, pushing up the nominal interest rate. Furthermore, given the nominal money aggregate, a rise in the inflation rate generates a decline in real money balances, increasing the nominal interest rate. Given the degree of nominal price stickiness, a higher value of ρ_π indicates a stronger effect of an inflation target shock on the actual inflation rate. Therefore, for the case of a higher value of ρ_π, the RMBE is likely to create a larger NFE.

Based on the calibrated values reported in Section 2.2, we numerically check how the degree of nonseparability χ influences the impact of an inflation target shock on the nominal interest rate. Figure 1 shows that the response of the nominal interest rate to an inflation target shock becomes positive when ρ_π exceeds 0.5. Additionally, an increased value of χ reinforces the positive impact of an inflation target shock on the nominal interest rate. Therefore, in contrast to Garín et al. (2018), this study considers the impact of the RMBE on the NFE in an NK model. For even a smaller value of χ, the RMBE plays a significant role in explaining the occurrence of the NFE.

[Figure 1 around here]

Next, our main question is whether the RMBE affects the occurrence of the NFE. More concretely, we present a condition on the parameter χ, which is important in an NK model with real money balances, generate the NFE in this model. Although the NFE requires $\partial r_t/\partial\pi_t^* > 0$, does a change in χ help generate this effect? We provide the following proposition to consider the role of the parameter χ in this study:

Proposition 2 *Let $\rho_\pi \neq \theta$. In an NK model with real money balances, the NFE emerges if either $\chi > \chi^*$ when $\rho_\pi < \theta$ or if $\chi < \chi^*$ when $\rho_\pi > \theta$.*

Proof. The NFE requires that $\partial r_t/\partial\pi_t^* > 0$, implying $\Psi > 0$. Here, the threshold of χ that determines whether the NFE occurs is given as follows:

$$\chi^* = \frac{\sigma(1-\rho_\pi\beta)(\rho_\pi - 1) + \lambda(\sigma+\varphi)\rho_\pi}{\eta_y[(1-\rho_\pi\beta)(\rho_\pi - 1) + \rho_\pi\lambda]}. \tag{12}$$

The value of χ that exceeds this threshold leads to the condition $\Psi > 0$ when $\theta > \rho_\pi$. This is because the threshold takes a smaller value as ρ_π increases in the case of $\theta > \rho_\pi$. Therefore, the value of χ that exceeds the threshold χ^* creates the NFE. The opposite case occurs, however, when $\rho_\pi > \theta$. More precisely, the threshold takes a larger value as ρ_π increases in the case of $\rho_\pi > \theta$. In this opposite case, a value of χ that is less than this threshold produces $\Psi > 0$, implying that the value of χ that is smaller than the threshold χ^* generates the NFE. This completes the proof. ■

This proposition states that the value of ρ_π relative to θ becomes significant in determining the threshold of χ in an NK model with real money balances. This result's intuition is as follows. A positive inflation target shock implies that the inflation rate will rise. A larger value of ρ_π amplifies this effect. Conversely, a higher value of the parameter θ dampens the response of the inflation rate to the economic shock. Furthermore, in the case of $\chi > 0$, the nominal interest rate positively affects the inflation rate via the RMBE in the NKPC. Accordingly, in the case of $\rho_\pi > \theta$, an inflation target shock leads to increased inflation, which is easily amplified by a smaller value of χ. Thus, as long as the condition $\rho_\pi > \theta$ is satisfied, a lower value of χ suffices to produce the positive response of the nominal interest rate to a persistent inflation target shock.

Conversely, when $\theta > \rho_\pi$, a higher value of the parameter χ is required to generate the NFE via the RMBE in the NKPC because an inflation target shock has difficulty in inducing a persistent increase in the inflation rate. Conversely, when $\rho_\pi > \theta$, a higher value of χ does not generate the NFE. The sensitivity of the output gap to the real interest rate is attenuated as parameter χ takes a larger value. In particular, a decline in the real interest rate causes a drop in the output gap when $\chi\eta_r > \sigma$. However, as Kurozumi (2006) pointed out, such a larger parameterization of χ is strongly excluded to retain the stable RE equilibrium in an NK model with real money balances. Consequently, in this paper, the parameter range of χ that produces the NFE would be significantly restricted by the condition $\sigma > \chi\eta_r$.

Summing up, in the case of $\theta > \rho_\pi$, the NFE does not occur within the empirically plausible value of the nonseparability parameter. However, if the condition $\theta < \rho_\pi$ is satisfied, the real money balance channel generates the NFE.

In the following discussion, based on the calibrated values in Section 2.2, we numerically examine the threshold of χ to cause the NFE. Figure 2 illustrates the thresholds of χ when $\theta = 0.7$. It turns out that the value of χ that exceeds the threshold χ^* generates the NFE as long as $\theta > \rho_\pi$. However, once ρ_π is larger than θ, a minimal value of χ easily produces an increase in the nominal interest rate to an inflation target shock. The calibration of $\theta = 0.7$ is standard in the NK model (Walsh, 2017, Woodford, 2003). Moreover, as mentioned in Section 2.2, a range of χ between 0 and 0.05 is empirically supported by previous studies (Ida, 2023, Kurozumi, 2006, McKnight and Mihailov, 2015, Woodford, 2003). Thus, under empirically plausible calibrated values, we do not obtain the positive response of the interest rate to an inflation target shock in the presence of the RMBE. This result starkly contrast with Garín et al. (2018).

[Figure 2 around here]

Figure 2 also shows that when $\rho_\pi > \theta$, a very smaller value of χ satisfies the neo-Fisherian region that an inflation target shock leads to a rise in the nominal interest rate. A larger value of χ that exceeds the threshold χ does not generate the NFE when ρ_π takes a larger value. However, such a parameterization is not supported by previous empirical studies. Summing up, for the larger value of ρ_π, we can easily find the empirically plausible value of χ that satisfies the condition of Proposition 2.

Figure 3 shows the impact response of the nominal interest rate to an inflation target shock under several parameterizations of the parameter χ when θ is fixed at 0.7. First, consider the case of no RMBE, i.e., $\chi = 0$, which corresponds to the case of Garín et al. (2018). When the parameter ρ_π is below 0.6, an inflation target shock reduces the nominal interest rate, consistent with that of Garín et al. (2018). Second, consider the case with the RMBE. Regardless of the nonseparability parameter degree, there is no positive relationship between inflation and the nominal interest rate if the parameter ρ_π is less than 0.6. As in Garín et al. (2018), the NFE occurs when the parameter ρ_π exceeds 0.6. However, in contrast to Garín et al. (2018), the role of the nonseparability parameter in determining the impact of an inflation target shock on the nominal interest rate is discussed. Indeed, Figure 3 illustrates that a higher value of χ magnifies the impact response of the nominal interest rate to an inflation target shock. Thus, despite the degree of the nonseparability parameter, an inflation target shock always leads to a negative response of the nominal interest rate as long as $\theta > \rho_\pi$. Moreover, a larger value of χ amplifies the NFE when introducing a persistent but transitory inflation target shock.

[Figure 3 around here]

Figure 4 shows the impulse response of the nominal interest rate to an inflation target shock in the case of $\rho_\pi = 0.65$. Garín et al. (2018) shows that the impact response of the nominal interest rate to the shock is positive when ρ_π is above 0.6. The result of our model confirms their result in the case of $\chi = 0$. We stress that a higher value of χ creates a larger response of the nominal interest rate to an inflation target shock. In particular, a higher value of χ significantly reinforces the impact of an inflation target shock on the nominal interest rate. Accordingly, a higher value of χ naturally causes a persistent response of the nominal interest rate after the shock. Given the degree of nominal price stickiness, a higher value of χ strengthens the RMBE, generating inflation via the NKPC. Hence, a persistent inflation target shock raises the nominal interest rate under the RMBE, reinforced by a higher nonseparability parameter value.

[Figure 4 around here]

3.2 Sensitivity experiments

Sensitivity experiments are provided in this section. First, we consider whether the degree of nominal price stickiness significantly affects the impact of real money balances on the NFE. Garín et al. (2018) showed that the degree of nominal price stickiness is critical for the occurrence of the NFE; when nominal price stickiness is high enough, the effect does not appear unless an extremely persistent inflation target shock is introduced. We also consider whether, given the values of θ and ρ_π, the degree of χ affects the occurrence of the NFE in our study.

Figure 5 shows how changing the parameter χ affects the nominal interest rate's response to an inflation target shock under several parameterizations of nominal price stickiness θ. First, consider the case for flexible nominal prices. Consistent with Garín et al. (2018), regardless of inflation target shock persistence, a persistent inflation target shock induces an increase in the nominal interest rate in this paper. More concretely, a higher value of ρ_π amplifies the impact of an inflation target shock on the nominal interest rate.

[Figure 5 around here]

We next examine how the degree of nominal price stickiness affects the occurrence of the NFE in an NK model with real money balances. When moderate nominal price stickiness is present, as shown in Garín et al. (2018), an inflation target shock decreases the nominal interest rate when the inflation target shock is less persistent. In the right-upper panel in Figure 5, the nominal interest rate is negatively related to an inflation target shock when ρ_π is less than 0.4. Similar to flexible nominal prices, a higher value of χ amplifies the impact response of the nominal interest rate when an inflation target shock is predominately persistent. When the calibrated value of θ is assumed as the benchmark case (i.e., $\theta = 0.7$), the NFE disappears when ρ_π is less than 0.6. In contrast to Garín et al. (2018), a higher value of χ dampens the negative impact of an inflation target shock on the nominal interest rate. In the case of $\theta = 0.7$, the NFE emerges when ρ_π exceeds 0.6. However, the impact on the response of the nominal interest rate seems to be slightly affected by an increased parameter χ.

Figure 5 (iv) illustrates the impact of an inflation target shock on the nominal interest rate to an inflation target shock when nominal price stickiness is extremely high. Garín et al. (2018) shows that the NFE does not occur as long as an inflation target shock is predominately persistent. As in the case of $\theta = 0.7$, a higher value of χ dampens the negative impact of an inflation target shock on the nominal interest rate for a smaller value of ρ_π. In particular, when nominal prices are highly stickier, the impact on the nominal interest rate is almost unaffected by an increased value of parameter χ even if ρ_π takes a considerably high value.

We further present the impulse response of several key macrovariables to an inflation target shock. Figures 6 (i) and (ii) depict the impulse response when the inflation target shock is not persistent. A positive inflation target shock raises the inflation rate while also lowering the nominal interest rate. A fall in the nominal interest rate increases the output gap but decreases the real interest rate. However, as long as an inflation target shock is less persistent, the impulse responses are unaffected by a change in the parameter χ.

As shown by Figure 6 (iii), in the case of $\rho_\pi = 0.6$, the real interest rate response is unaffected by a change in χ. However, while the response of the nominal interest rate becomes negative in the case where χ is less than 0.02, the case of $\chi = 0.05$ produces a smaller negative response of the nominal interest rate to an inflation target shock. Thus, a higher value of the parameter χ causes the NFE when an inflation target shock has moderate persistence.

Finally, consider the case of $\rho_\pi = 0.9$. Remarkably, Figure 6 (iv) illustrates that the response of the nominal interest rate becomes positive after an inflation target shock, namely, the occurrence of the NFE. This figure also depicts that a higher value of χ significantly amplifies its effect. Hence, a reduction in the real interest rate is attenuated since a higher value of χ causes a further increase in the nominal interest rate. In particular, the real interest rate increases when $\rho_\pi = 0.9$, inducing a further decline in the output gap through an IS curve. As a result, a drop in the output gap is the largest in the case of $\chi = 0.05$.

[Figure 6 around here]

4 Discussion

This section presents the policy implications of our findings. This paper aimed to investigate whether the RMBE accounts for the occurrence of the NFE in an NK model. Although the presence of the RMBE may not fully explain the occurrence of the NFE, we found that increasing the nonseparability parameter strengthens the effect of the RMBE on the NFE phenomenon. This implies that the money demand function significantly impacts the NFE as long as the central bank does not face nonnegativity constraints on nominal interest rates.[9] As shown by Garín et al. (2018), we confirmed that a persistent inflation target shock generates a positive response of the nominal interest rate to an inflation target shock, given the standard calibrated value of nominal price stickiness. Unlike Garín et al. (2018), in the presence of the real money balance channel, we demonstrated that a higher value of the nonseparability parameter magnifies the NFE via the RMBE.

What implications does our finding have for monetary policy? Due to the deflationary risk posed by a negative shock to the natural interest rate, advanced-country central banks have set their nominal interest rates at an effective lower-bound floor. However, since 2022, advanced-country central banks have sought to raise nominal interest rates to combat an inflationary risk in which actual inflation exceeds the central bank's inflation target. According to the neo-Fisherian hypothesis, a higher inflation target value increases the nominal interest rate. Furthermore, as shown in Woodford (2003), when the money demand function is present, an NKPC indicates that a decrease in real money balances raises the inflation rate through a rise in the nominal interest rate.

Although the zero-lower bound on nominal interest rates breaks the stable money demand relationship between money and the interest rate (Ida, 2023), such a relationship is revived when interest rates are positive. Our research found that if nominal prices are not too sticky, the RMBE significantly strengthens the NFE if introducing a persistent inflation target shock.[10] As a result, this study considers that central banks should consider the role of the RMBE when analyzing the relationship between its target inflation rate and the nominal interest rate to combat inflationary pressures on the economy. As previously noted, Williamson (2019) stated the importance of money aggregate in the Volker era, arguing that movements in both inflation and nominal interest rates were consistent with the concept of neo-Fisherianism. Because recent studies have also argued for a role of monetary aggregate (Belongia and Ireland, 2018, Billi, Söderström and Walsh, 2020, Jia, 2021), our study has important policy implications for recent monetary policy analysis.

[9] This is due to the fact that once the nominal interest rate reaches the effective lower-bound floor, the money demand function may no longer hold.

[10] We do not consider the role of the RMBE in accounting for the NFE when a liquidity trap occurs. See Bilbiie (2022) for a detailed discussion of the NFE under a liquidity trap.

5 Conclusions

Does a rise in the central bank's target inflation induce a rise in the nominal interest rate? This simple question has recently become critical to the effectiveness of monetary policy in advanced economies. According to standard macroeconomics, we would expect that the inflation rate generally declines after a rise in the nominal interest rate. Conversely, the neo-Fisherian hypothesis indicates the positive comovement between the nominal interest rate and inflation in the short run. Recently, several studies focused on the real money balance channel, implying that a change in money balances impacts the aggregate demand via monetary policy's demand and supply channels.

The NFE was investigated in this study using a standard NK model with real money balances. In particular, we focus on the role of the nonseparability parameter, capturing the RMBE, in considering the occurrence of the NFE. This paper makes several main findings. First, we found that the presence of the RMBE may explain the occurrence of the NFE within empirically plausible values of the nonseparability parameter. Second, this study showed that the degree of nominal price stickiness helps to create the NFE's amplification. On the one hand, a persistent inflation target shock drives the positive reaction of the nominal interest rate with an increase in the nonseparability parameter under flexible nominal prices. On the other hand, when nominal prices are predominantly sticky, a higher value of the nonseparability parameter does not magnify the impact response of the nominal interest rate to a persistent inflation target shock. In sum, this study emphasizes how the presence of the RMBE facilitates accounting for the occurrence of the NFE.

Finally, we would like to mention some upcoming projects. Although this study focused on the case of an inflation target shock as a monetary policy specification, other monetary policy rules, such as the Taylor rule, could also be considered. It will be interesting to see if the RMBE significantly impacts the NFE under an alternative monetary policy rule. Furthermore, while our model is based on the purely forward-looking NK model with real money balances, we intend to extend it with lagged endogenous variables such as inflation persistence and consumption habit formation.

References

Airaudo, M., Hajdini, I., 2023. Wealth effects, price markups, and the neo-fisherian hypothesis. European Economic Review , 104482.

Ali, S.Z., Qureshi, I.A., 2022. A note on the Neo-Fisher effect in the New Keynesian model. Macroeconomic Dynamics , 1–17.

Belongia, M., Ireland, P., 2018. Targeting constant money growth at the zero lower bound. International Journal of Central Banking 14, 159–204.

Belongia, M.T., Ireland, P.N., 2022. A reconsideration of money growth rules. Journal of Economic Dynamics and Control , 104312.

Benhabib, J., Schmitt-Grohé, S., Uribe, M., 2001. Monetary policy and multiple equilibria. American Economic Review 91, 167–186.

Bilbiie, F.O., 2022. Neo-fisherian policies and liquidity traps. American Economic Journal: Macroeconomics 14, 378–403.

Billi, R.M., Söderström, U., Walsh, C.E., 2020. The role of money in monetary policy at the lower bound .

Calvo, G.A., 1983. Staggered prices in a utility-maximizing framework. Journal of monetary Economics 12, 383–398.

Cochrane, J.H., 2016. Do higher interest rates raise or lower inflation? Unpublished paper, February, https://faculty. chicagobooth. edu/john. cochrane/research/papers/fisher. pdf .

Florio, A., 2018. Nominal anchors and the price puzzle. Journal of Macroeconomics 58, 224–237.

Garín, J., Lester, R., Sims, E., 2018. Raise rates to raise inflation? Neo-Fisherianism in the New Keynesian model. Journal of Money, Credit and Banking 50, 243–259.

Hanson, M.S., 2004. The "price puzzle" reconsidered. Journal of Monetary Economics 51, 1385–1413.

Ida, D., 2023. The effect of real money balances on international monetary policy transmission. Journal of International Money and Finance 139, 102964.

Ida, D., 2024. Household heterogeneity and the price puzzle in a new keynesian model. Journal of Macroeconomics 79, 103587.

Ireland, P.N., 2001. Money's role in the monetary business cycle.

Jia, P., 2021. Understanding a New Keynesian model with liquidity .

Kurozumi, T., 2006. Determinacy and expectational stability of equilibrium in a monetary sticky-price model with Taylor rule. Journal of Monetary Economics 53, 827–846.

McCallum, B.T., 1983. On non-uniqueness in rational expectations models: An attempt at perspective. Journal of Monetary Economics 11, 139–168.

McKnight, S., Mihailov, A., 2015. Do real balance effects invalidate the Taylor principle in closed and open economies? Economica 82, 938–975.

Piazzesi, M., Rogers, C., Schneider, M., 2019. Money and banking in a New Keynesian model. Standford WP .

Poilly, C., 2010. Does money matter for the identification of monetary policy shocks: A DSGE perspective. Journal of Economic Dynamics and Control 34, 2159–2178.

Ravenna, F., Walsh, C.E., 2006. Optimal monetary policy with the cost channel. Journal of Monetary Economics 53, 199–216.

Serletis, A., Xu, L., 2020. Functional monetary aggregates, monetary policy, and business cycles. Journal of Economic Dynamics and Control 121, 103994.

Sims, C.A., 1992. Interpreting the macroeconomic time series facts: The effects of monetary policy. European Economic Review 36, 975–1000.

Taylor, J.B., 1993. Discretion versus policy rules in practice, in: Carnegie-Rochester conference series on public policy, Elsevier. pp. 195–214.

Uribe, M., 2022. The neo-Fisher effect: Econometric evidence from empirical and optimizing models. American Economic Journal: Macroeconomics 14, 133–62.

Walsh, C.E., 2017. Monetary Theory and Policy. MIT press.

Williamson, S., 2019. Neo-fisherism and inflation control. Canadian Journal of Economics 52, 882–913.

Woodford, M., 2003. Interest and Prices: Foundations of a Theory of Monetary Policy. Princeton university press.

Figure 1: The effect of χ on the coefficient Ψ

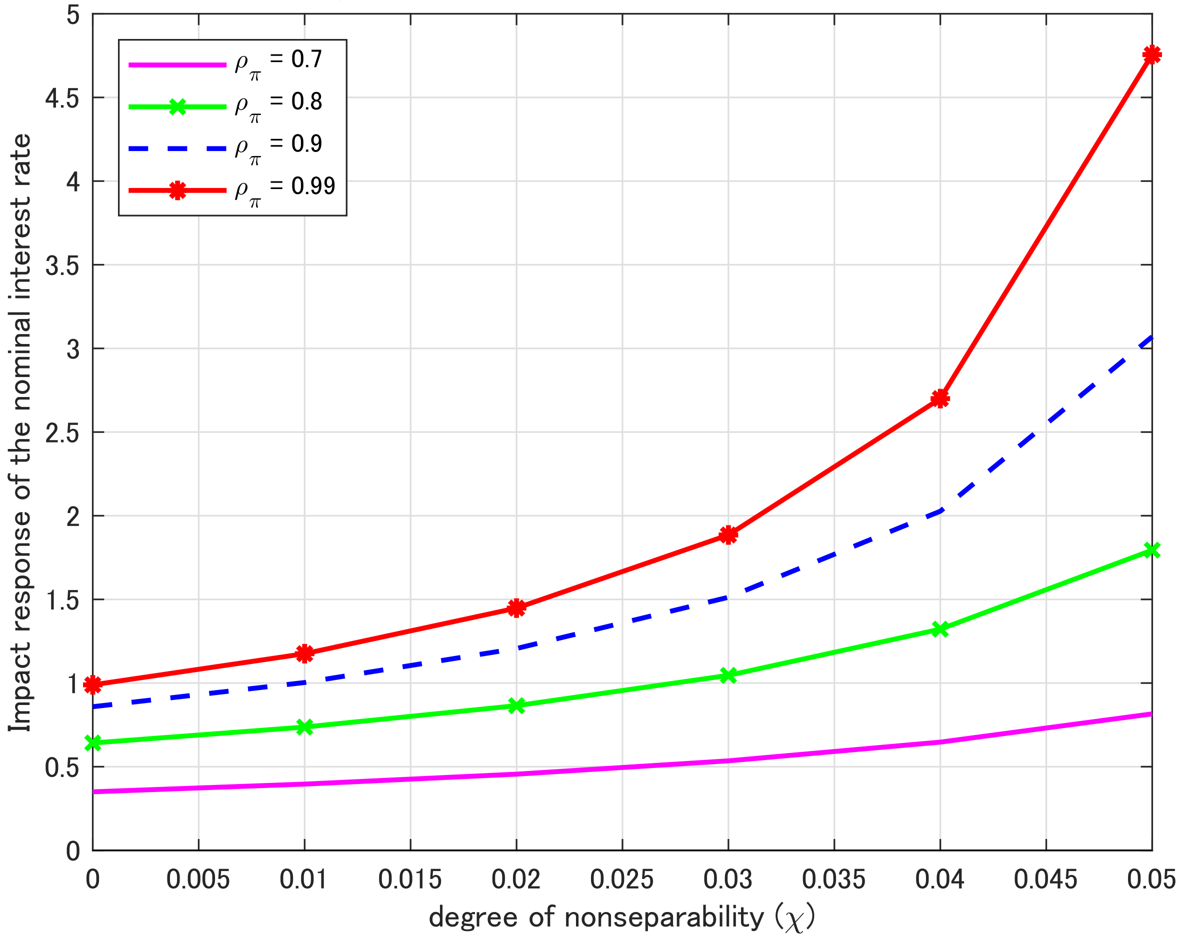


Figure 2: Threshold of χ and the NFE

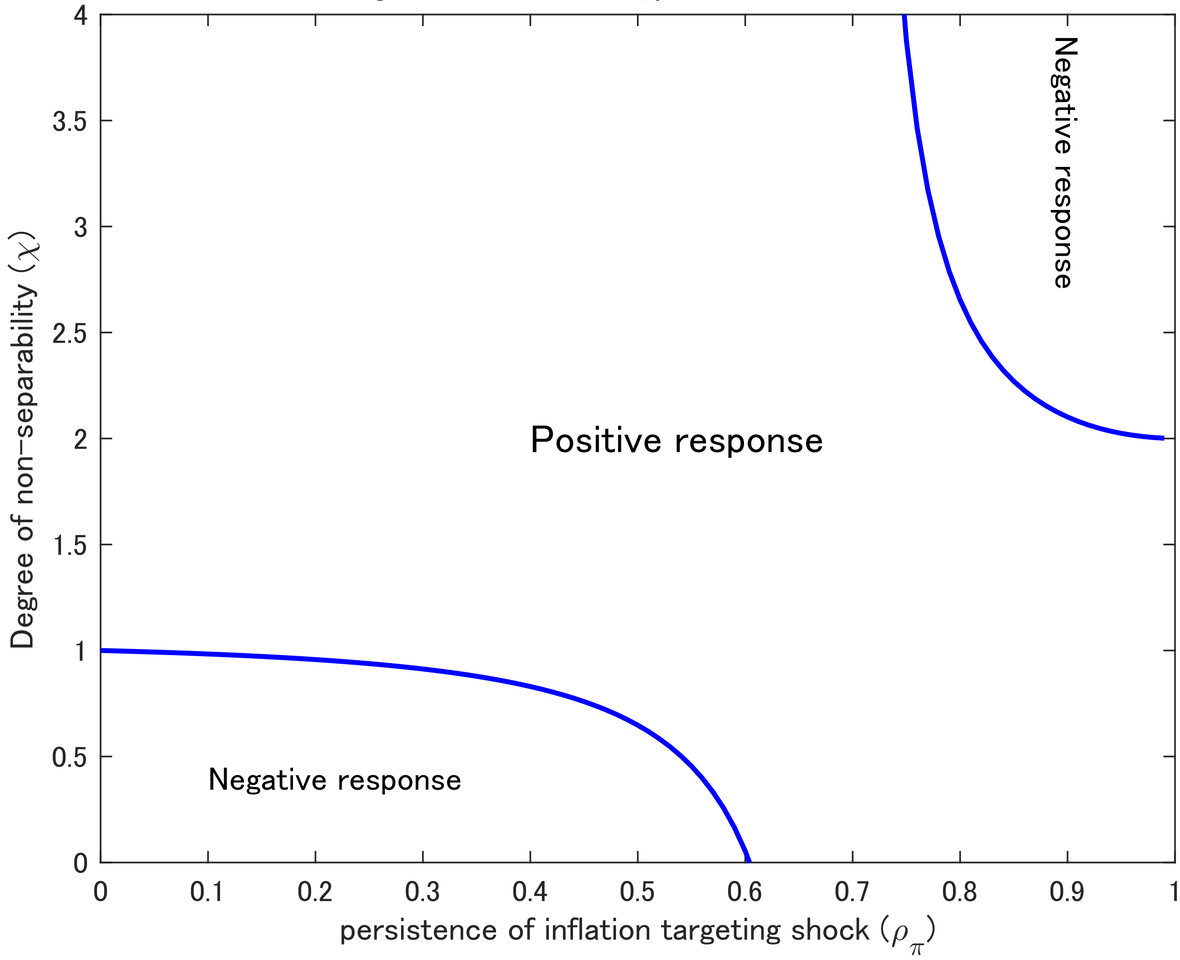


Figure 3: Impact response of the nominal interest rate to an inflation-targeting shock: The role of χ

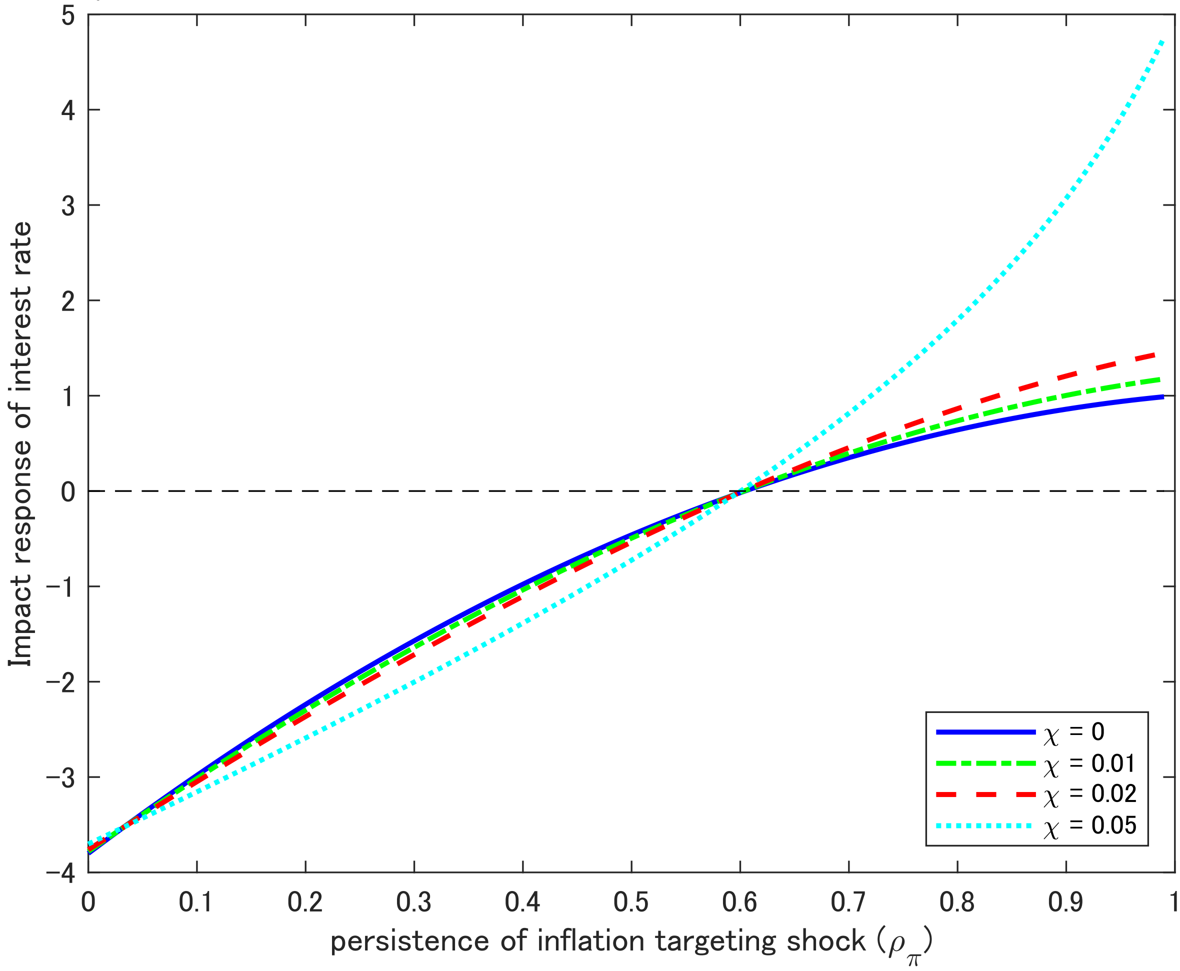


Figure 4: Impulse response of the nominal interest rate to an inflation-targeting shock: $\rho_\pi = 0.65$

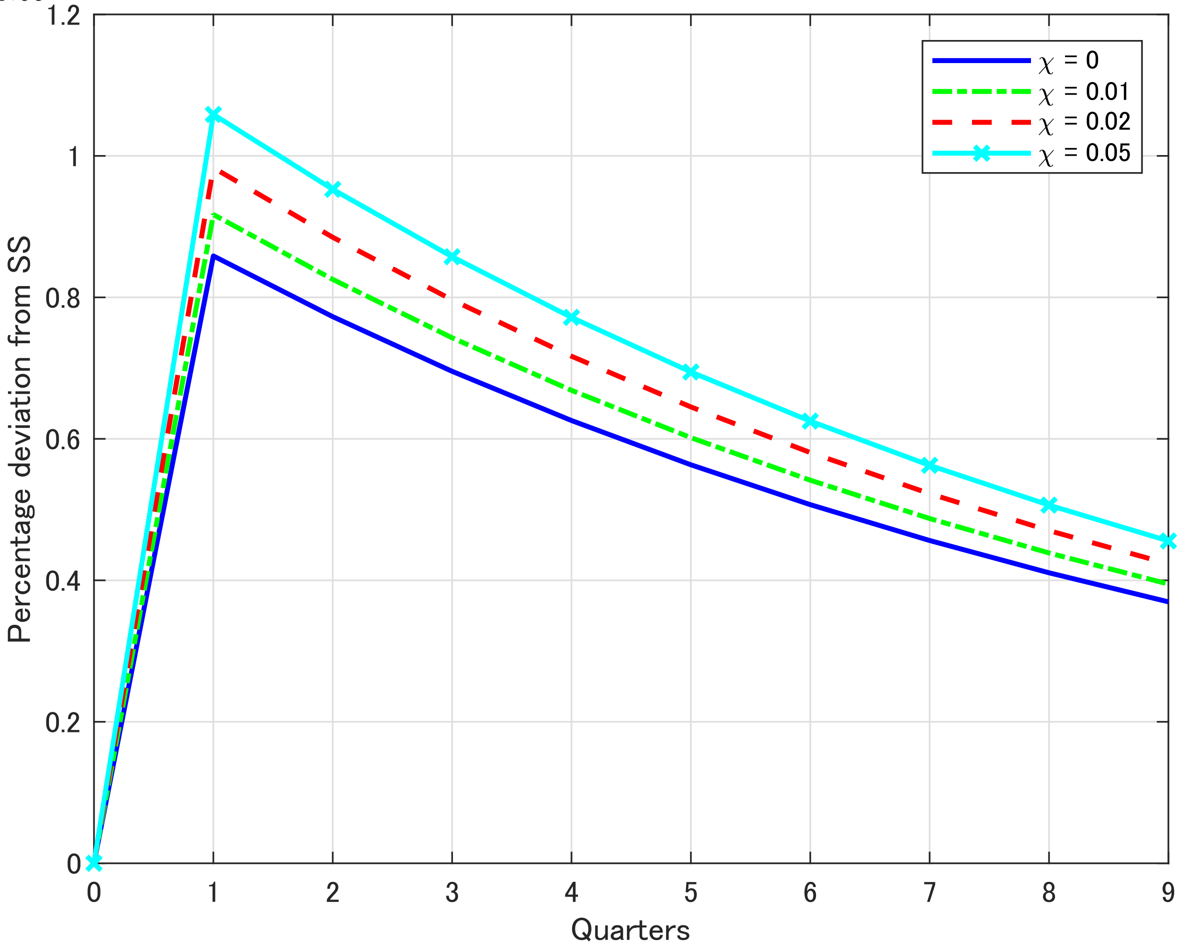


Figure 5: Impact response of the nominal interest rate to an inflation-targeting shock: The role of nominal price stickiness

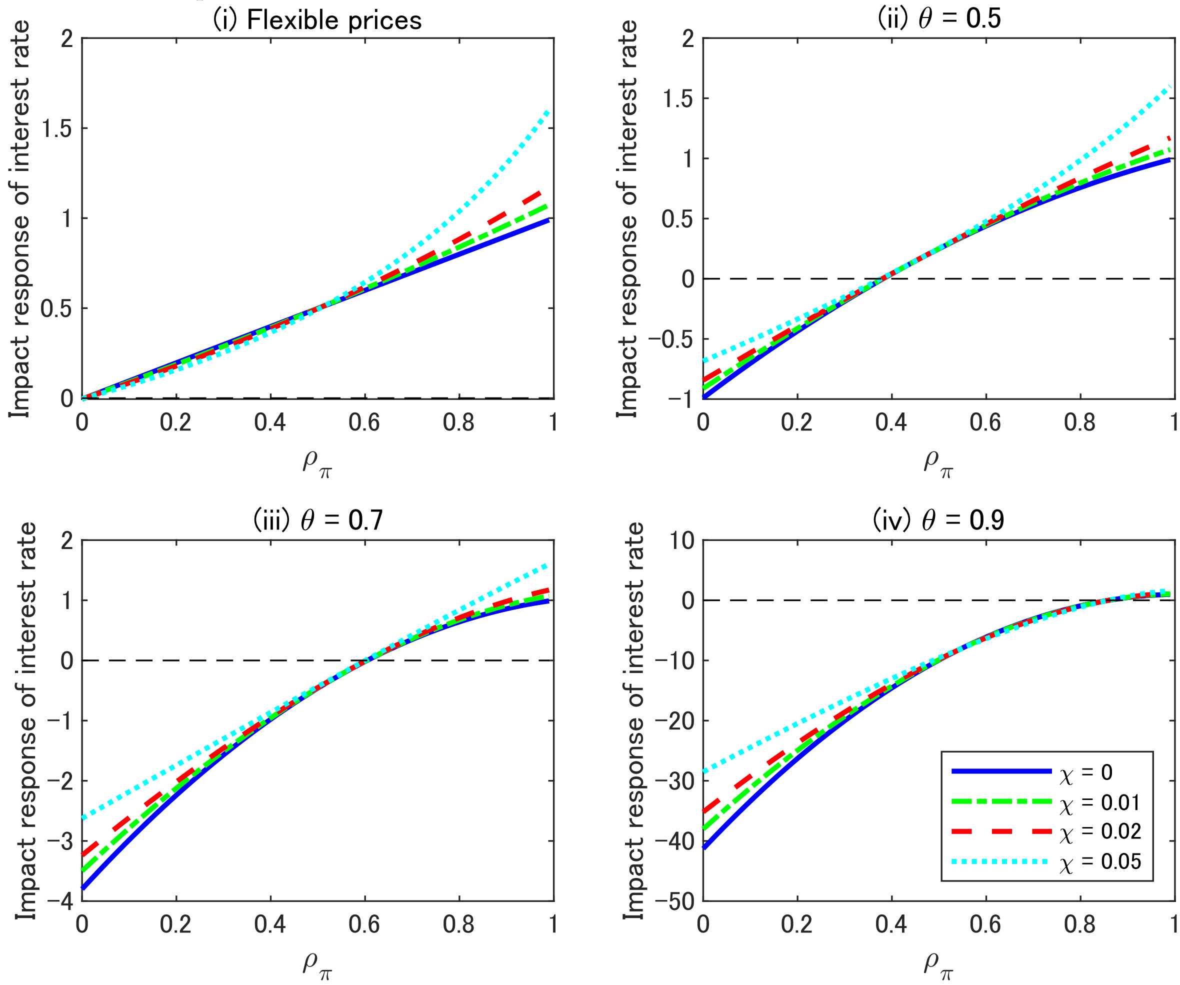
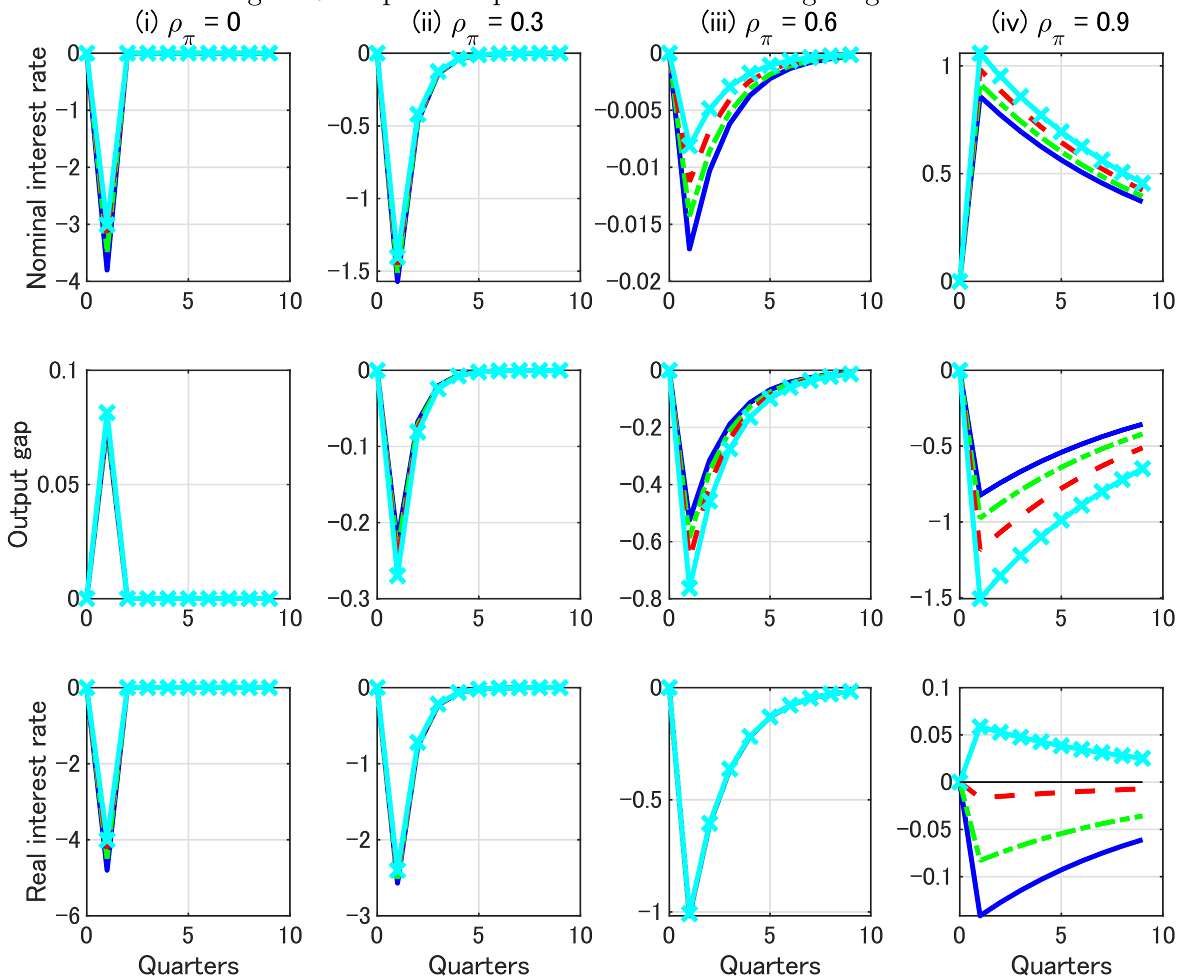


Figure 6: Impulse response to an inflation-targeting shock



Note: A solid line denotes $\chi = 0$, a dash-dotted line denotes $\chi = 0.02$, a dashed line denotes $\chi = 0.03$, and a line with (x) denotes $\chi = 0.05$, respectively.