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Ida Daisuke／ 井田　大輔

ida-dai@andrew.ac.jp

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桃山学院大学
Momoyama Gakuin University

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On the determinacy condition in the new Keynesian model: The role of deposit rate pass-through☆

Daisuke Ida*

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Abstract

This paper studies the role of deposit rate pass-through in the new Keynesian model with a cost channel. It shows that the degree of deposit rate pass-through crucially changes the determinacy regions. Incompleteness of deposit rate pass-through narrows the determinacy regions. On the other hand, a higher pass-through of the deposit rate expands the determinacy regions. In particular, compared to a current-looking policy rule, a forward-looking policy rule predominately shrinks the regions where the rational expectations equilibrium (REE) is determinate. Thus, this paper addresses the importance how the central bank conducts its monetary policy when the degree of deposit rate pass-through significantly affects the relative dominance of the demand channel of monetary policy over the cost channel.

JEL classifications: E52, E58

Keywords: Determinacy; Monetary policy rule; Deposit rate pass-through; Cost channel

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☆ I would like to thank Kohei Hasui for his helpful suggestions. All remaining errors are my own.

*Department of Economics at Momoyama Gakuin University, 1-1, Manabino, Izumi, Osaka 599-8251, Japan. Tel.: +81-725-54-3131. E-mail: ida-dai@andrew.ac.jp

1. Introduction

The role of financial frictions in the new Keynesian model has been emphasised in the literature (Bernanke, Gertler and Gilchrist, 1999; Ravenna and Walsh, 2006; Chowdhury, Hoffmann and Schabert, 2006). Chowdhury, Hoffmann and Schabert (2006) focus on the degree of financial market imperfection that captures the impact of a monetary policy of the cost channel on inflation. A cost channel is a mechanism wherein an increase in the nominal interest rate induces a rise in inflation through an increase in firms' working capital (Ravenna and Walsh, 2006).

Financial market imperfections, which are generated by the presence of a cost channel, are also related to the degree of pass-through between the lending and policy rates. Chowdhury, Hoffmann and Schabert (2006) argue that an imperfect lending rate pass-through is observed in developed countries. A change in the policy rate has the supply side of monetary policy in a model with a cost channel (Choudhury, Hoffmann, and Schabert, 2006; Surico, 2008; Llosa and Tuesta, 2009). However, these studies assume that the deposit rate pass-through is complete. Indeed, Kwapil and Schaler (2010) stress that considering the incompleteness of deposit rate pass-through is important.[1] Why is pass-through of the deposit rate important in a sticky price model where the cost channel matters?

In the standard new Keynesian model without cost channel, the Taylor principle, which means that the central bank should react more aggressively to inflation, is required to attain a unique REE (Bullard and Mitra, 2002). As long as the central bank conducts its monetary policy by following the Taylor principle, the demand channel of monetary policy stabilises the expectations of inflation as follows. A sufficient increase in the policy rate in response to unanticipated inflation results in an increase in the real interest rate, which leads to a decline in the output gap through the dynamic IS equation. Hence, actual inflation declines through the new Keynesian Phillips curve (NKPC).

However, this mechanism is not applicable to the cost channel case. In particular, an increase in the policy rate induces an increase in the inflation rate when the supply side of monetary policy dominates the demand channel. In this case, the satisfaction of the Taylor principle may not suffice to achieve a unique REE. Consequently, the expectations of inflation are self-fulfilling because monetary tightening results in a decline in the real interest rate. Thus, whether the real interest rate declines in response to a rise in the policy rate crucially depends on the relative strength of the demand channel to the cost channel.

The reason that pass-through of the deposit rate is important is as follows. As I will show, whether the cost channel dominates the demand channel significantly depends on the degree of deposit rate pass-through. A low pass-through of the deposit rate weakens the demand channel.

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[1] See also De Bondt and Mojon (2005), Scharler (2008) and Ida (2014) for a detailed explanation of the pass-through of retail rates.

Therefore, where pass-through of the deposit rate is predominately low, the central bank may not achieve a unique REE even if it satisfies the Taylor principle. This is because the real interest rate declines regardless of whether the central bank reacts more than one-for-one to an increase in the inflation rate. Accordingly, as the supply side of monetary policy works in the presence of the cost channel, sunspot equilibria are likely to occur regardless of monetary tightening. On the other hand, when deposit rate pass-through is considerably high, the central bank can stabilise a non-fundamental shock even if it does not satisfy the Taylor principle. Indeed, Kwapil and Schaler (2010) report several estimated values of the degree of deposit rate pass-through.

This paper is related to the study of Llosa and Tuesta (2009). They show that the cost channel induces equilibrium indeterminacy and expectational instability under adaptive learning in the standard new Keynesian model. Their study assumes, however, that both lending and deposit rates experience complete pass-through. Kwapil and Schaler (2010) emphasize the importance of deposit rate pass-through, and also study whether the deposit rate pass-through affects the determinacy condition in the new Keynesian model. However, Kwapil and Schaler (2010) abstract the role of financial intermediaries. A notable contribution of this paper is to show that pass-through of the deposit rate is crucially important in a sticky price model with financial market imperfections.

The main findings of this paper are summarised as follows. First, imperfect deposit rate pass-through shrinks the determinacy region under a contemporaneous policy rule. In such a case, the central bank cannot retain equilibrium determinacy even if it satisfies the Taylor principle. On the other hand, the determinacy region expands when the increase in the deposit rate is more than the increase in the policy rate. In this case, it is possible that the central bank can achieve determinate equilibrium even if the Taylor principle is not guaranteed. Second, in contrast to the case of a contemporaneous rule, employing a forward-looking policy rule shrinks the determinacy region. In particular, this problem is more severe in cases where an incomplete deposit rate pass-through is present. Third, in the case where the central bank follows a current-looking policy rule, a higher pass-through of the deposit rate can reinforce the demand channel even if financial market imperfections are considerably severe. When the central bank employs a forward-looking policy rule, however, a higher pass-through of the deposit rate cannot strengthen the demand channel if financial market imperfections are considerably severe.

The present study is designed as follows. Section 2 provides the model description. Section 3 derives the determinacy condition in a new Keynesian model in which the pass-through of both lending and deposit rates is incomplete. Section 4 briefly concludes.

2. Model Description

With the exception of the assumption that both lending and deposit rates face incomplete pass-through, the model description in this paper is a standard new Keynesian model[2].

The first equation is the NKPC, which is derived from the optimal condition of firms that are subject to monopolistic competition and Calvo pricing. In a model with a cost channel, firms borrow the working capital from financial intermediaries to finance the wage bill. As shown in Ravenna and Walsh (2006) and Chowdhury et al. (2006), in this case, the term for the nominal interest rate is augmented in the NKPC, which is given

$$\pi_t = \beta E_t \pi_{t+1} + \kappa x_t + \lambda \psi_r R_t \,, \tag{1}$$

where $\kappa = \lambda(\sigma + \eta)$. x_t is the output gap, π_t is the inflation rate and R_t is the nominal interest rate set by the central bank. The parameter κ is the slope of the NKPC and λ is the sensitivity of inflation to the real marginal cost. η is the inverse of the elasticity of labor supply and β denotes the discount factor. E_t is the expectations operator. ψ_R represents the degree of a cost channel.[3] The parameter ψ_R is associated with asymmetrical information in the financial market (Chowdhury, Hoffmann and Schabert, 2006). Hence, a higher value of ψ_R implies that financial market imperfections are severe.

The second equation is a dynamic IS curve, which is derived from the inter-temporal optimal conditions from households. It is given by

$$x_t = E_t x_{t+1} - \sigma^{-1}(R_t^D - E_t \pi_{t+1}) + r_t^n \,, \tag{2}$$

where R_t^D is the deposit rate. The parameter σ is the relative risk aversion coefficient for consumption and r_t^n denotes the natural rate of interest. Following Kwapil and Schalar (2010), the deposit rate evolves as follows:

$$R_t^D = \psi_D R_t \,, \tag{3}$$

where ψ_D denotes the pass-through of the deposit rate.[4] A key parameter in this paper is the degree of deposit rate pass-through ψ_D. The pass-through is incomplete when $\psi_D \leq 1$. A smaller value of ψ_D dampens the demand channel of monetary policy. Also, the deposit rate increases more than an increase in the policy rate when $\psi_D > 1$. In this case, a higher pass-through of the deposit rate reinforces the demand channel.

Finally, to close the model, the model requires a monetary policy rule, which is specified as follows:

$$R_t = \phi_\pi E_t \pi_{t+k} + \phi_x E_t x_{t+k} \,, \text{ for } k = 0,1. \tag{4}$$

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[2] See Woodford (2003) for a detailed derivation of the basic new Keynesian model.

[3] See Chowdhury et al. (2006) for a detailed discussion of the presence of the parameter ψ_R in the NKPC.

[4] In contrast to their model, this paper abstracts the presence of the lagged deposit rate because this paper focuses on the effect of immediate pass-through of the deposit rate on equilibrium determinacy.

In this rule, $k = 0$ corresponds to a contemporaneous policy rule, whereas $k = 1$ implies a forward-looking policy rule. ϕ_π is the coefficient for inflation stabilisation and ϕ_x is the coefficient for the stabilisation for the output gap.

3. Determinacy Analysis

This section provides how the deposit rate pass-through is important in that the REE is uniquely determinate in an economy with a cost channel. Section 3.1 examines the determinacy condition under a contemporaneous monetary policy rule. In Section 3.2, I consider the determinacy condition under a forward-looking policy rule.

3.1. A current-looking monetary policy rule

First, I consider the determinacy condition when the central bank follows a current-looking monetary policy rule. To examine how the degree of deposit rate pass-through affects determinacy of the REE, I construct the system that consists of two endogenous variables x_t and π_t.

Substituting a contemporaneous rule into Equations (1) and (2), the system of two endogenous variables x_t and π_t is written as follows:

$$X_t = M\ E_t X_{t+1} + \mu\, r_t^n, \tag{5}$$

where $X_t = [x_t, \pi_t]'$ and

$$M = \frac{1}{(\sigma+\psi_D\phi_x)(1-\lambda\psi_R\phi_\pi)+\psi_D\phi_\pi(\kappa+\lambda\psi_R\phi_x)}\begin{bmatrix} \sigma(1-\lambda\psi_R\phi_\pi) & 1-\lambda\psi_R\phi_\pi-\beta\psi_D\phi_\pi \\ \sigma(\kappa+\lambda\psi_R\phi_x) & \kappa+\lambda\psi_R\phi_x+\beta(\sigma+\psi_D\phi_x) \end{bmatrix}. \tag{6}$$

Note that the form of μ is ignored because it does not affect the following discussion. Since x_t and π_t are endogenous jump variables, both of the eigenvalues of M should be inside the unit circle for determinacy.[5] Thus, we have the following proposition:

Proposition 1. Under the contemporaneous policy rule, the necessary and sufficient conditions for a unique REE are given as follows:

$$\psi_D\phi_x + (\kappa\psi_D - \lambda\sigma\psi_R)\phi_\pi + (1-\beta)\sigma > 0 \tag{7}$$

$$\psi_D\phi_x + (1+\beta)\sigma < (\lambda\sigma\psi_R - \kappa\psi_D)\phi_\pi \tag{8}$$

$$\kappa(\psi_D\phi_\pi - 1) + [(1-\beta)\psi_D - \lambda\psi_R]\phi_x > 0 \tag{9}$$

$$\kappa(\psi_D - 2\sigma\psi_R\lambda\kappa^{-1})\phi_\pi + [(1-\beta)\psi_D + \lambda\psi_R]\phi_x + 2\sigma(1+\beta) + \kappa > 0\,. \tag{10}$$

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[5] See Bullard and Mitra (2002) for a detailed discussion of this condition.

Proof. See Appendix A. ■

As shown in Llosa and Tuesta (2009), when $\psi_D = \psi_R = 1$, the necessary and sufficient conditions for a unique REE need to satisfy Equations (9) and (10). Equation (9) is regarded as the modified Taylor principle. The Conditions (7) and (8) are redundant as long as the pass-through of the lending and deposit rates is complete. However, this paper underlines that unless $\psi_D = \psi_R = 1$, Conditions (7)–(10) should guarantee a unique REE. In particular, equation (7) implies that

$$\psi_D > \frac{\lambda}{\kappa}\sigma\psi_R . \qquad (11)$$

As mentioned earlier, the higher value of ψ_R amplifies the cost channel. In addition, a higher value of ψ_D reinforces the demand channel that implies the effect of the policy rate on the output gap through a change in the real interest rate. Monetary tightening leads to a decline in inflation when the demand channel dominates the cost channel. Given the value of $\sigma\lambda/\kappa$, Condition (11) requires a lower bound for the parameter ψ_D to guarantee the unique REE if financial market imperfections are present. To obtain an intuition of the above conditions, I numerically show determinacy and indeterminacy regions under a contemporaneous monetary policy rule.[6]

Figure 1 shows how determinacy regions are altered when the parameters ϕ_π and ϕ_x change. Figure 1 (a) is the determinacy region in the case of $\psi_D = 1.0$. This case corresponds to the result of Llosa and Tuesta (2009). In contrast to the standard new Keynesian model, as pointed out by Surico (2008) and Llosa and Tuesta (2009), as long as the central bank does not aggressively raise the policy rate in response to a change in inflation, a larger response to the output gap results in indeterminacy. According to Surico (2008), the reason that a rule that contains a larger response to the output gap leads to indeterminacy is that a larger value of ϕ_x produces a situation that the cost channel dominates the demand channel. In that case, therefore, inflation expectations become self-fulfilling.

[Figure 1 around here]

Figure 1(b) depicts determinacy and indeterminacy regions in the case of $\psi_D = 0.5$. In this case, importantly, the central bank cannot achieve a unique REE even if it satisfies the Taylor principle. In addition, the figure reveals that the central bank should respond more aggressively to inflation as it employs a larger value of the parameter ϕ_x. Intuitively, a smaller value of the parameter ψ_D counteracts the demand channel of monetary policy. In addition, a larger value of ϕ_x makes the

[6] The parameter values used in this simulation are as follows. Based on the existing literature, the calibration is standard. β is set to 0.99. The parameter σ is set to 2.0. λ and η are set to 0.08 and 1.0, respectively. ϕ_x is set to 0.125.

demand channel weaker. Hence, monetary tightening in response to a sunspot shock induces a decline in the real interest rate, which may make the expectations of inflation self-fulfilling. In such a case, the central bank should react more aggressively to a change in inflation. Another way to stabilise a sunspot shock is for the central bank to employ a smaller response to the output gap.

On the other hand, in the case of $\psi_D = 1.5$, the central bank can attain a unique REE even if it does not react more than one-for-one to a change in the inflation rate. Indeed, even if ϕ_π is less than unity, Equation (9), which is the modified Taylor principle, is satisfied as long as $\psi_D \phi_\pi$ is above unity. Intuitively, due to a higher pass-through of the deposit rate, the real interest rate may increase even if the central bank does not satisfy the Taylor principle. Such an increase in the real interest rate prevents self-fulfilling movements of inflation.

[Figure 2 around here]

Figure 2 plots the determinacy and indeterminacy regions in the case of a contemporaneous policy rule. Compared with the case of $\psi_D = 1$, the incomplete deposit rate pass-through shrinks the region where the REE is determinate. Surprisingly, even when financial market imperfections are not severe, the central bank cannot achieve the unique REE unless $\phi_\pi \geq 2$. Intuitively, when the deposit rate pass-through is low, the central bank that employs a weak response to inflation cannot achieve the unique REE even if financial market imperfections are not severe. This is because low deposit rate pass-through simply counteracts the demand channel of monetary policy. On the contrary, the case of $\psi_D > 1$ expands the determinacy regions unless financial market imperfections are predominately severe. The simple reason is that a larger value of ψ_D strengthens the demand channel.

Figure 3 portrays determinacy and indeterminacy regions under a contemporaneous monetary policy rule when the parameters ψ_R and ψ_D change. When the parameter ψ_R is less than 1.5, the REE is determinate as long as the parameter ψ_D is above than 0.6. As the parameter ψ_R takes a higher value than 1.5, indeterminacy regions expand if the parameter ψ_D is smaller values. If pass-through of the deposit rate is above 1.5, however, the REE is determinate even if the cost channel parameter takes a higher value[7]. Thus, in the case where the central bank employs a current-looking policy rule, a higher pass-through of the deposit rate can reinforce the demand channel even if financial market imperfections are considerably severe.

[Figure 3 around here]

[7] This value is considerably high. In the standard new Keynesian model with a cost channel, the price puzzle, which is a situation where a rise in the policy rate increases the inflation rate, emerges when the parameter ψ_R is above 1.5. See Castelnuovo (2007) for a detailed discussion of this issue.

3.2. A forward-looking monetary policy rule

Next, this section studies determinacy and indeterminacy analysis under a forward-looking policy rule. In a forward-looking policy rule, the matrix M is modified as follows:

$$M = \frac{1}{\sigma}\begin{bmatrix} \sigma - \psi_D \phi_x & 1 - \psi_D \phi_\pi \\ \kappa(\sigma - \psi_D \phi_x) + \kappa\sigma\psi_R \phi_x & \kappa(1 - \psi_D \phi_\pi) + \sigma(\beta + \lambda\psi_R \phi_\pi) \end{bmatrix}. \tag{11}$$

In this case the necessary and sufficient conditions for a unique REE are given as follows:

Proposition 2. Under the forward-looking policy rule the necessary and sufficient conditions for a unique REE are given as follows:

$$\sigma\lambda\psi_R \phi_\pi < (\lambda\psi_R + \beta\psi_D)\phi_x + \sigma(1-\beta) \tag{12}$$

$$(\lambda\psi_R + \beta\psi_D)\phi_x < \sigma\lambda\psi_R \phi_\pi + \sigma(1+\beta) \tag{13}$$

$$\kappa(\psi_D \phi_\pi - 1) + [(1-\beta)\psi_D - \lambda\psi_R]\phi_x > 0 \tag{14}$$

$$\kappa(\psi_D - \lambda\sigma\psi_R \kappa^{-1})\phi_\pi + [(1-\beta)\psi_D + \lambda\psi_R]\phi_x > 2\sigma(1+\beta) + \kappa. \tag{15}$$

Proof. See Appendix B. ■

Equations (12) to (15) are the modified version of the conditions derived Llosa and Tuesta (2009). Thus, when $\psi_D = \psi_R = 1$, these conditions reduce to those of Llosa and Tuesta (2009). Equation (12) shows that the response to inflation is bounded from above. Equation (14) is again the modified Taylor principle. In contrast to Llosa and Tuesta (2009), in this model these conditions are affected by the parameter ψ_D. To intuitively understand this proposition, I again use numerical methods.

Figure 4 illustrates determinacy and indeterminacy regions under a forward-looking monetary policy rule. First, consider the determinacy regions shown in Figure 4(a). This case corresponds to Llosa and Tuesta (2009). As in the prescription derived in the standard new Keynesian model, inflation reaction is bounded from above (Bullard and Mitra, 2002). As shown in Equation (13), the response to the output gap is also bounded from below. A larger value of the parameter ϕ_x leads to indeterminacy, even if the Taylor principle is satisfied.

As shown in Figure 4(b), the determinacy condition is severe in the case of incomplete pass-through of the deposit rate. This case is more severe than the case of complete pass-through. Thus, while the central bank faces the upper bound for ϕ_π and the lower bound for ϕ_x, it must consider a larger response to both inflation and the output gap to achieve a unique REE. For instance, for any value of the parameter ϕ_π, a REE is never determinate when the parameter ϕ_x is less than about 0.6. This is because the parameter ϕ_x violates a lower bound for it. Moreover, even if the parameter ϕ_x is above 0.6, the REE is not determinate unless the central bank responds more aggressively to the inflation rate.

[Figure 4 around here]

On the other hand, the determinacy regions expand in the case of $\psi_D = 1.5$. Interestingly, in this case, the parameter ϕ_x faces both upper and lower bounds. In particular, the REE is always determinate if the parameter ϕ_x is set by the central bank within such bounds. Thus, as long as the parameter ϕ_x satisfies lower bounds, the central bank can lead the economy to the determinacy regions even if $\phi_\pi \leq 1$. Figure 5 shows the determinacy regions in the case of a forward-looking policy rule. Compared with Figure 2, the determinacy regions shrinks in the case of a forward-looking rule. This problem is severer when $\psi_D = 0.5$.

[Figure 5 around here]
[Figure 6 around here]

Figure 6 displays determinacy regions under a forward-looking monetary policy rule. In contrast to the case of a contemporaneous rule, a forward-looking policy rule shrinks determinacy regions further. As long as ψ_R is less than 0.5, the REE is determinate if the parameter ψ_D is above 0.5. However, regions where the REE is indeterminate expand as the parameter ψ_R is above 0.5. In particular, the REE is never determinate in the case of $\psi_R \geq 1.5$. When the central bank employs a forward-looking policy rule, a higher pass-through of the deposit rate cannot enhance the demand channel if financial market imperfections are considerably severe.

4. Concluding Remarks

This paper has shown the role of deposit rate pass-through in the new Keynesian model using a simple cost channel. The main findings of this paper are summarised as follows.

The main findings of this paper are summarised as follows. First, imperfect deposit rate pass-through shrinks the determinacy region under a contemporaneous policy rule. In such a case, the central bank cannot retain equilibrium determinacy even if it satisfies the Taylor principle. On the other hand, the determinacy region expands when the increase in the deposit rate is more than the increase in the policy rate. In this case, it is possible that the central bank can achieve determinate equilibrium even if the Taylor principle is not guaranteed. Second, in contrast to the case of a contemporaneous rule, employing a forward-looking policy rule shrinks the determinacy region. In particular, this problem is more severe in cases where an incomplete deposit rate pass-through is present. Third, in the case where the central bank follows a current-looking policy rule, a higher pass-through of the deposit rate can reinforce the demand channel even if financial market imperfections are considerably severe. Furthermore, when the central bank employs a forward-looking policy rule, a higher pass-through of the deposit rate cannot strengthen the demand channel if financial market imperfections are considerably severe.

Thus, this paper underlines the importance how the central bank conducts its monetary policy when the degree of deposit rate pass-through significantly affects the relative dominance of the demand channel of monetary policy over the cost channel.

Appendix A: Proof of Proposition 1

The characteristic polynomial of M is given by $p(\mu) = \mu^2 - tr(M)\mu + \det(M)$ where

$$tr(M) = \frac{\sigma(1-\lambda\psi_R\phi_\pi) + \kappa + \lambda\psi_R\phi_x + \beta(\sigma+\psi_D\phi_x)}{(\sigma+\psi_D\phi_x)(1-\lambda\psi_R\phi_\pi) + \psi_D\phi_\pi(\kappa+\lambda\psi_R\phi_x)},$$

$$\det(M) = \frac{\sigma\beta}{(\sigma+\psi_D\phi_x)(1-\lambda\psi_R\phi_\pi) + \psi_D\phi_\pi(\kappa+\lambda\psi_R\phi_x)}.$$

Both eigenvalues of M are inside the unit circle if both of the following conditions hold:

(i) $|\det(M)| < 1,$ (A.1)

(ii) $|tr(M)| < 1 + \det(M).$ (A.2)

The first condition implies Equations (7) and (8) and the second equation implies Equations (9) and (10).

Appendix B: Proof of Proposition 2

The characteristic polynomial of M is given by $p(\mu) = \mu^2 - tr(M)\mu + \det(M)$ where

$$tr(M) = \frac{\sigma(1+\beta) + \lambda\sigma\psi_R\phi_\pi - (\kappa\psi_D\phi_\pi + \phi_x\psi_D) + \kappa}{\sigma},$$

$$\det(M) = \frac{\sigma\beta - \beta\psi_D\phi_x + \sigma\lambda\psi_R\phi_\pi - \lambda\psi_R\phi_x}{\sigma}.$$

The first condition (A.1) implies equations (12) and (13); on the other hand, the condition (A.2) implies equations (14) and (15).

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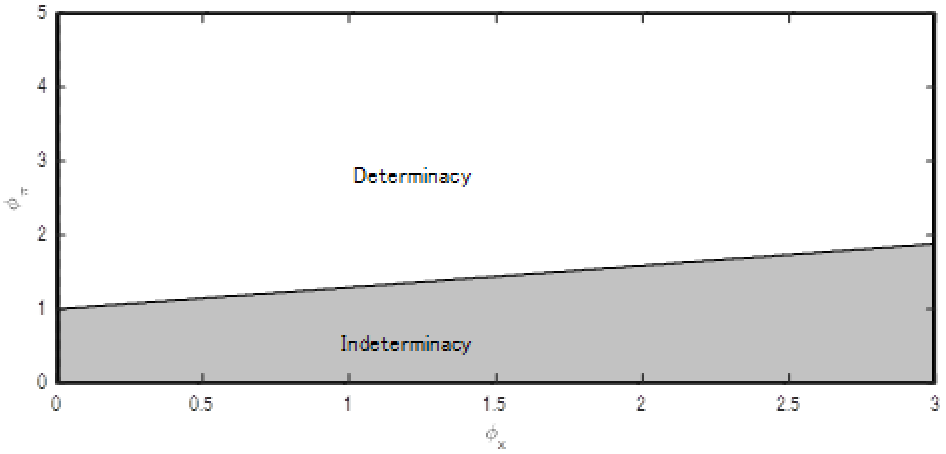
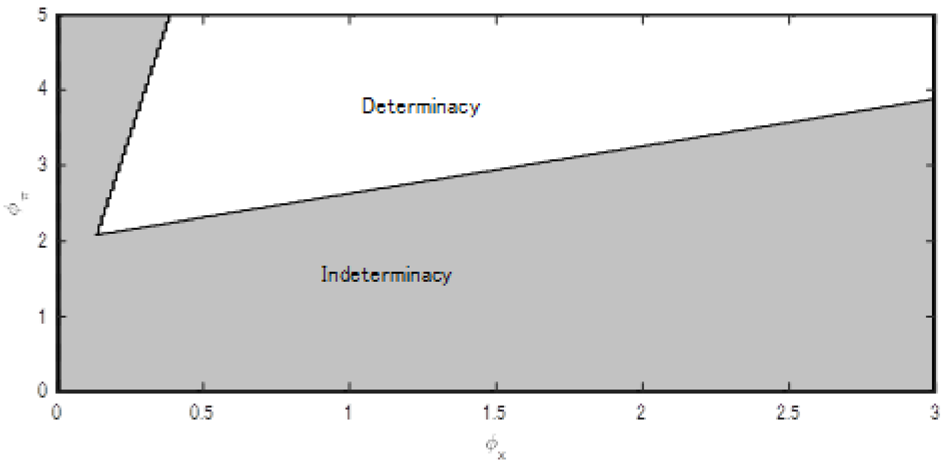
Figure 1: Determinacy and indeterminacy under a contemporaneous interest rate rule

(a) $\psi_D = 1.0$ (Standard new Keynesian model with a cost channel)



(b) $\psi_D = 0.5$ (Incomplete pass-through of deposit rates)



(c) $\psi_D = 1.5$ (Higher pass-through of deposit rates)

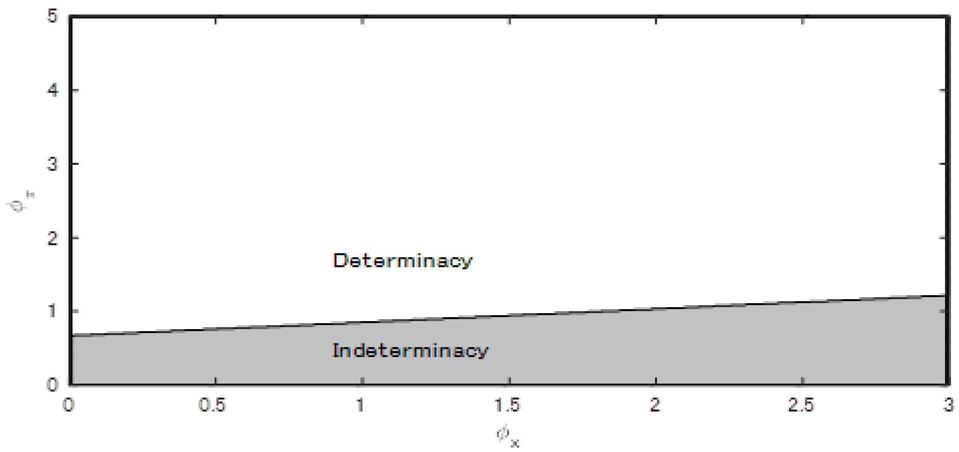
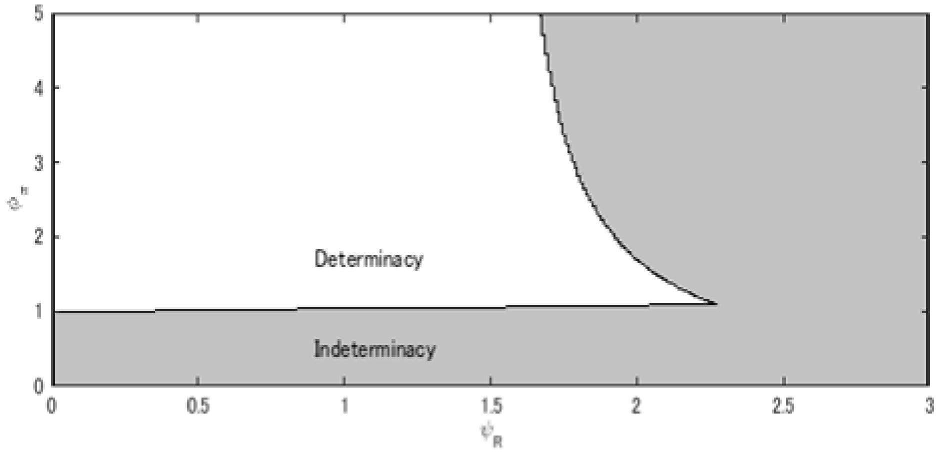
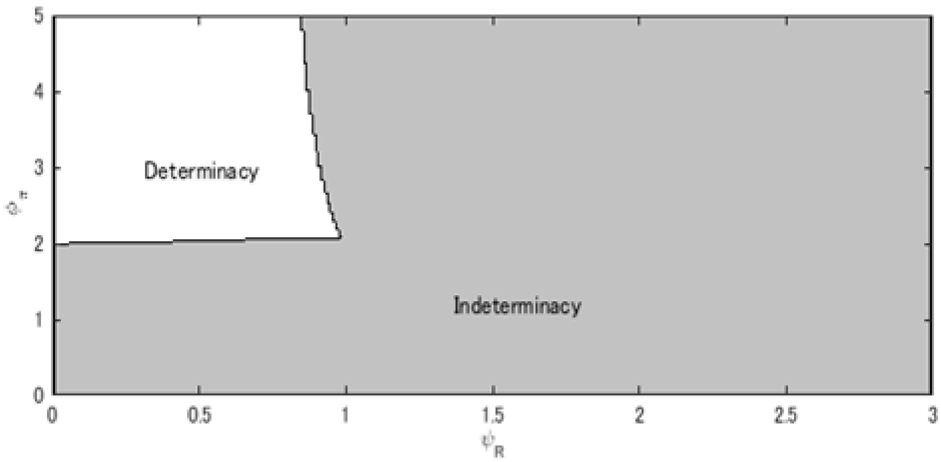


Figure 2. Determinacy and indeterminacy under a contemporaneous interest rate rule

(a) $\psi_D = 1.0$



(b) $\psi_D = 0.5$



(c) $\psi_D = 1.5$

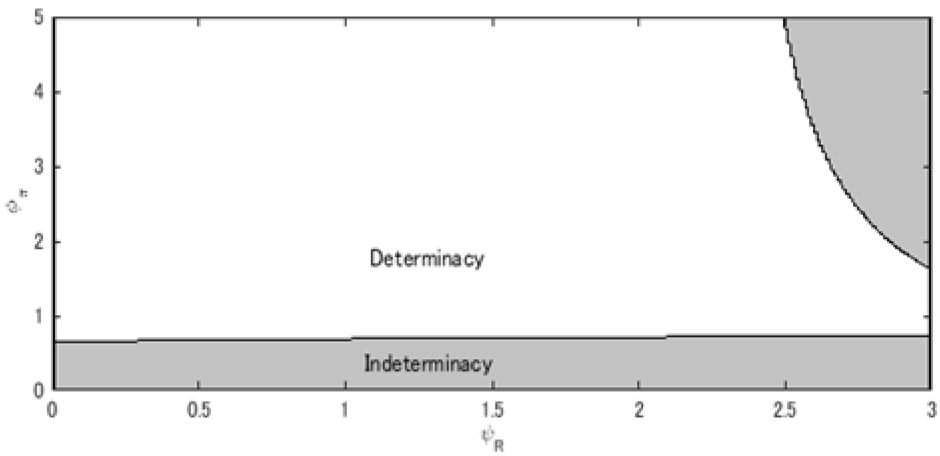


Figure 3: Determinacy and indeterminacy when the parameters ψ_R and ψ_D change: The case of a contemporaneous rule

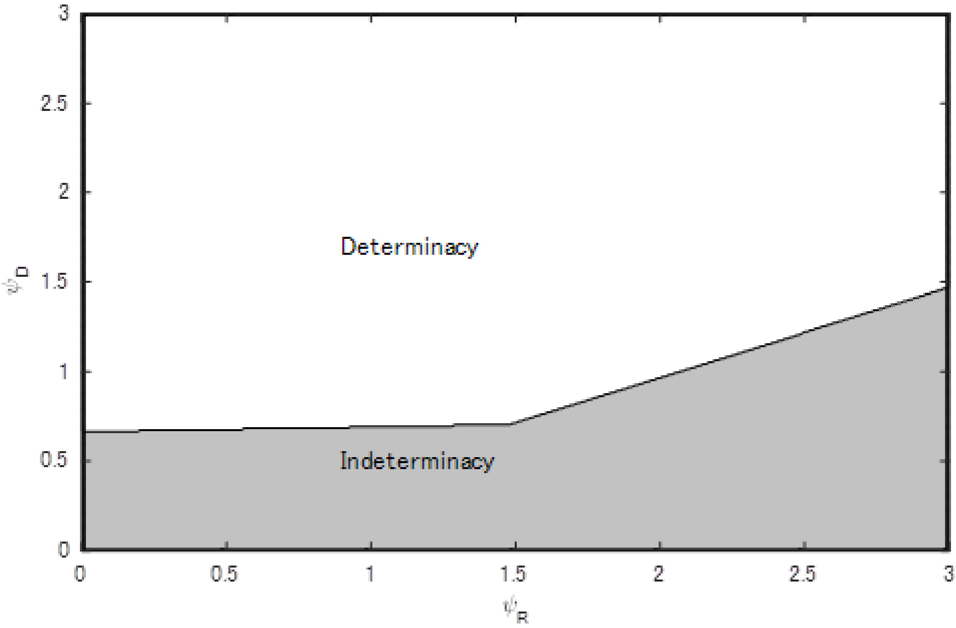
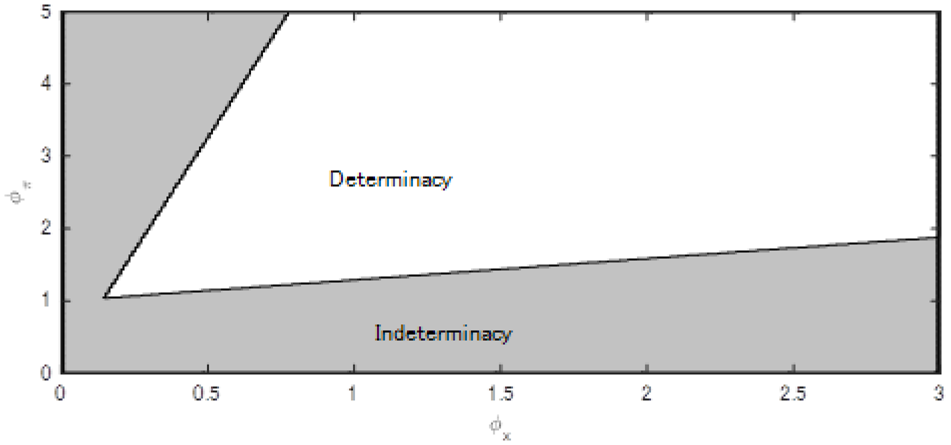
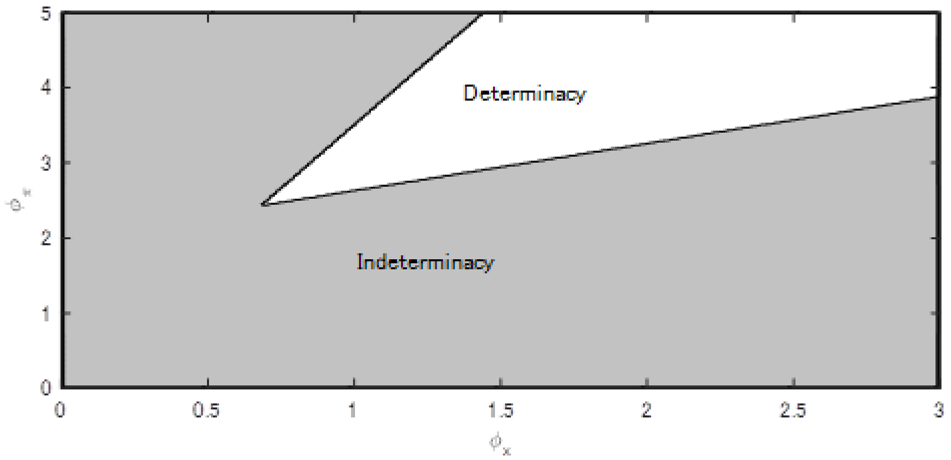


Figure 4: Determinacy and indeterminacy under a forward-looking interest rate rule

(a) $\psi_D = 1.0$ (Standard new Keynesian model with a cost channel)



(b) $\psi_D = 0.5$ (Incomplete pass-through of deposit rates)



(c) $\psi_D = 1.5$ (Higher pass-through of deposit rates)

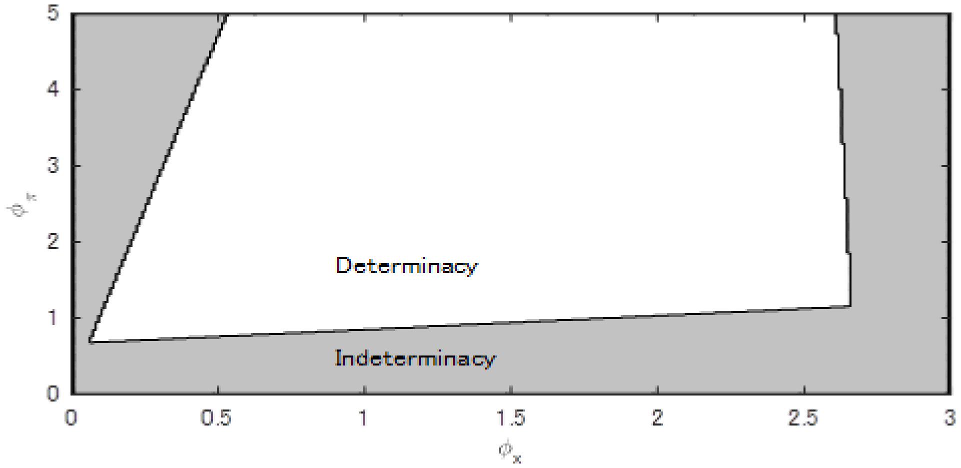
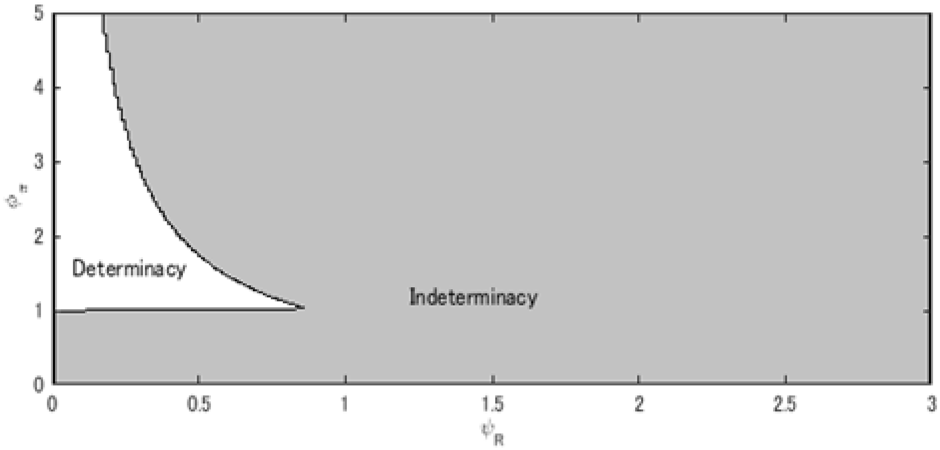
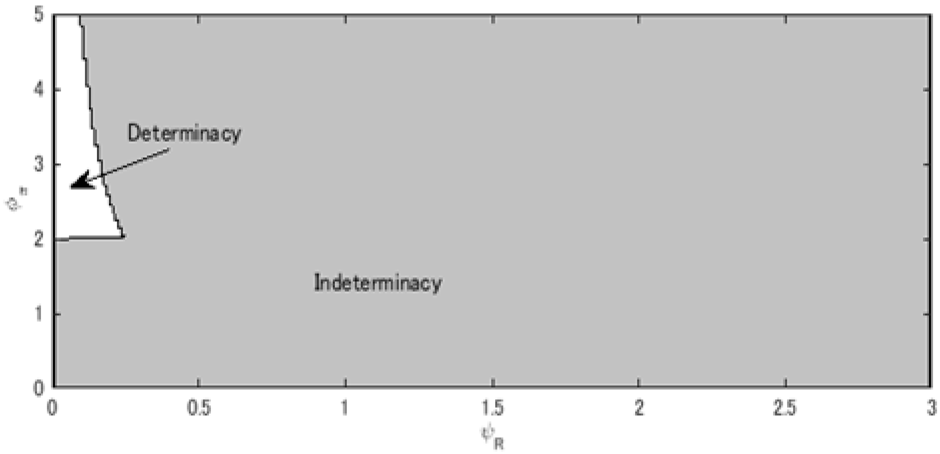


Figure 5. Determinacy and indeterminacy under a forward-looking interest rate rule

(a) $\psi_D = 1.0$



(b) $\psi_D = 0.5$



(c) $\psi_D = 1.5$

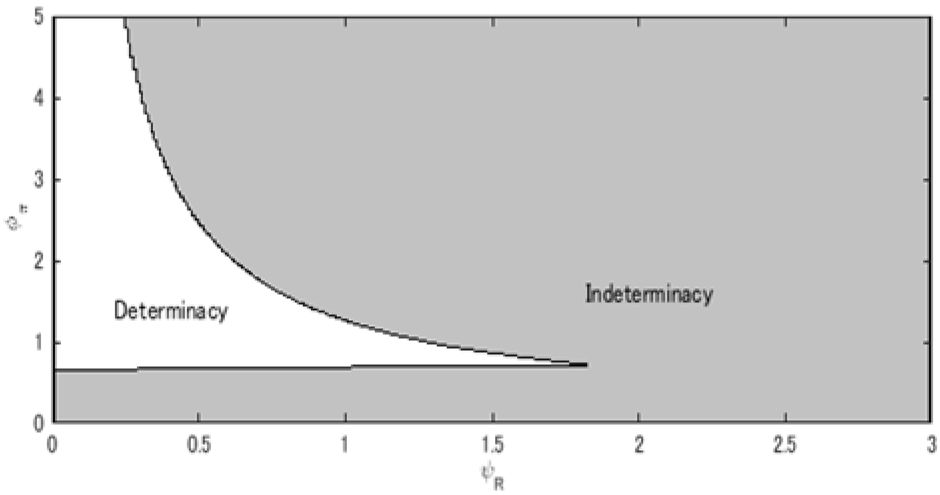


Figure 6: Determinacy and indeterminacy when the parameters ψ_R and ψ_D change: The case of a forward-looking rule