Research Institute

Discussion Paper Series

№.01

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2015 年 10 月

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http://www.andrew.ac.jp/soken/

Monetary policy in a two-country model with financial market imperfections

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This draft: October 21, 2015

Abstract

This paper examines whether financial market imperfections are important in a two-country economy with nominal price rigidities. The implication obtained in a standard open economy model is applicable to our model in the case of no financial friction in the foreign country. However, a foreign financial friction changes the prescription for monetary policy derived in a standard two-country model. The transmission mechanism of foreign structural shocks differs when a foreign financial friction exists. In such a case, even if the home country does not face a severe financial friction, a severe financial friction in the foreign country amplifies the impact of foreign shocks on the macro variables of home country. In addition, this paper finds the effectiveness of an output gap growth rule in a two-country economy with financial market imperfections. In sum, this paper suggests that financial market imperfections play a significant role in a two-country model.

Keywords: Financial market imperfections; Cost channel; Monetary policy rules; Two-country model

JEL classification: E52; E58; F41

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1. Introduction

It has been argued that the presence of financial market imperfections significantly affects the transmission mechanism of monetary policy. For instance, Bernanke, Gertler and Gilchrist (1999) incorporate financial market friction into the standard new Keynesian model and emphasise a financial accelerator effect, whereby changes of an external financial premium persistently influence the real economy.[1] In addition, financial market imperfections are associated with a cost channel that generates inflation through an increase in a firm's working capital after monetary tightening. Ravenna and Walsh (2006) investigate optimal monetary policy in an economy with a cost channel and reveal that the presence of a cost channel generates a wedge between stabilising inflation and the output gap. Chowdhury, Hoffman and Schabert (2006), Tillmann (2008), and Ida (2014) find that a cost channel can help explain inflation dynamics in the developed countries. Recently, Pfajfar and Santoro (2014) reveal that a monetary policy rule might contain the stabilisation of asset price fluctuations to attain the rational expectations equilibrium in a new Keynesian model in which a severe cost channel is present.

On the other hand, globalisation through international trade and finance has expanded rapidly. Thus, economic shocks that occur in one country are likely to increasingly affect macroeconomic variables in other countries as globalisation proceeds. Clarida, Gali and Gertler (2002) develop a two-country economy model with sticky prices to examine international dimensions of optimal monetary policy. However, their model abstracts the role of financial market imperfections. We observe that the financial turmoil that originated in the United States has led to severe economic stagnation in developed countries. Thus, financial market imperfections play a significant role in large countries. This is because financial market imperfections in one country spill-over into other countries. Accordingly, we require a model that considers the role of financial market imperfections in a two-country framework. As far as we know, however, very few studies have focused on monetary policy in an open economy model with financial market imperfections.

This paper examines whether financial market imperfections are important in a two-country sticky price model. In particular, we focus on the impact of a change in financial market imperfections in the foreign country on the home country. To do this, we incorporate financial market imperfections into a two-country sticky price model developed by Clarida, Gali and Gertler (2002).

Moreover, we employ the idea of Chowdhury, Hoffmann and Schabert (2006) to consider the role of financial market imperfections in an open economy. Chowdhury, Hoffmann and Schabert (2006) explore whether the presence of incomplete pass-through between lending and policy rates

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[1] Based on the framework of Bernanke, Gertler and Gilchrist (1999), Bernanke and Gertler (1999) examine whether the central bank should respond to asset prices when asset price bubbles are present.

explains inflation dynamics in developed countries. To drive such a wedge between lending and policy rates, they consider the adverse selection problem associated with asymmetric information in the credit market. However, their model does not provide a micro-foundation for such an incomplete interest rate pass-through.

In contrast to their model, Kobayashi (2008) and Teranishi (2008) present a micro foundation of imperfect lending rate pass-through by introducing staggered loan contracts in the canonical new Keynesian model. Instead of introducing a micro foundation of financial market imperfections, the idea of Chowdhury, Hoffmann and Schabert (2006) is simple and intuitively understandable. A notable feature of our model is its ability to examine how financial market imperfections amplify the transmission of structural shocks in a two-country framework. Therefore, this study provides significant implications for monetary policy analysis in an open economy model with financial market imperfections.

Is financial instability important in open economies? De Giorgio and Nistico (2007) develop a two-country sticky price model in which asset prices fluctuate in the foreign country. They show that the central bank should follow a monetary policy rule that includes the stabilisation of foreign asset prices. Fujiwara and Teranishi (2009) construct a two-country model with staggered loan contracts in both countries. According to their analysis, both domestic and foreign central banks should stabilise international financial shocks when staggered loan contracts are present in both countries. Hence, both central banks should consider international financial heterogeneity associated with staggered loan contracts in both countries when implementing optimal monetary policy.[2]

Ida (2011) also examines how a central bank should conduct its monetary policy when asset price fluctuations spill-over in both countries and reveals that an instrument rule that responds to both domestic and foreign asset prices leads to preferable outcomes compared with a simple rule that only reacts to the inflation rate. However, Ida (2011) does not examine how the degree of financial market imperfections affects the performance of asset price rules.

These studies stress the importance that the central bank cares about financial instability from the perspective of a global economy. It seems, however, that few studies explore the role of imperfect financial markets in transmitting structural shocks in a two-country economy.

We confirm that the implication obtained in a standard open economy model is applicable to our model in the case of no financial friction in the foreign country. However, a foreign financial friction changes the implication for monetary policy derived in a canonical two-country model. The transmission mechanism of foreign structural shocks differs in the case of financial friction in the foreign country. In such a case, even if the home country does not experience a severe financial friction, a severe financial friction in the foreign country makes the impact of foreign shocks on the

[2] Fujiwara and Teranishi (2009) investigate the effect of the presence of staggered loan contracts on monetary policy in a two-country economy with flexible prices.

macro variables of the home country large.

This paper also finds the effectiveness of an output gap growth rule in a two-country economy with financial market imperfections. This rule can achieve the smaller variances of inflation and the output gap. In particular, there are gains from employing this rule for a real shock. Intuitively, since a change of the output gap fluctuates the home terms of trade, changing the real exchange rate, a speed limit rule that smooths a change of the output gap can stabilise the real exchange rate.

On the other hand, an asset price target rule can attain the smallest variance of inflation of all policy regimes, whereas it produces the largest variances of the output gap. However, in the case of a foreign loan rate shock, an asset price rule can attain the preferable outcome. Thus, there might be gain from employing an asset price rule for a financial shock. Consider the case of an exogenous loan rate shock as a financial shock. There are two channels whereby a change in the lending rate fluctuates inflation. First, a change in the loan rate affects the real marginal cost, changing the inflation rate. Second, share prices cause fluctuations in the inflation rate through a change in dividends. An asset price rule can completely stabilise the second channel generated by financial shocks. This is the gain from employing an asset price rule when financial shocks matter.

The remainder of this study is constructed as follows. Section 2 describes our model. Section 3 derives the log-linearised system of the model. Section 4 calibrates the deep parameters. Section 5 reports our simulation results. Section 6 briefly concludes the study.

2. Model

We incorporate a simple financial market friction associated with a cost channel into a two-country framework developed by Clarida, Gali and Gertler (2002). Consider an economy with two large symmetric countries: home and foreign. The population sizes for home and foreign are $1-\gamma$ and γ, respectively. There are two production sectors in each country. Final goods sectors are characterized by perfect competition. The firms in intermediate goods sectors face monopolistic competition and Calvo (1983) type nominal price rigidity.

In addition, for intermediate firms to pay employee wages, they must borrow funds from financial intermediaries located in the home country. Following Ravenna and Walsh (2006) and Chowdhury, Hoffmann and Schabert (2006), we introduce the role of financial intermediaries into the model. Financial intermediaries receive deposits from domestic households and lend the funds to domestic firms. When financial intermediaries lend funds to intermediate goods producers, they incur a monitoring cost.

Our model assumes that there are complete markets in both countries and that households in both countries can trade a state-contingent bond domestically and internationally. Moreover, we assume that only final goods are traded. Finally, unless otherwise noted, analogous equations hold for the foreign country.

2.1. Households

The consumption index for the domestic country, C_t, is given by

$$C_t = \left[(1-\gamma)^{1/a} C_{H,t}^{(a-1)/a} + \gamma^{1/a} C_{F,t}^{(a-1)/a}\right]^{a/(a-1)}, \tag{1}$$

where $C_{H,t}$ denotes the consumption of domestic goods and $C_{F,t}$ denotes the consumption of foreign goods. The parameter a denotes the elasticity of substitution between domestic and foreign consumption goods.

First, households consider an intra-temporal cost minimisation problem and derive the demand function for each good:

$$C_{H,t} = (1-\gamma)\left(\frac{P_{H,t}}{P_t}\right)^{-a} C_t, \tag{2}$$

$$C_{F,t} = \gamma \left(\frac{P_{F,t}}{P_t}\right)^{-a} C_t, \tag{3}$$

where the price index in the home country is given by

$$P_t = \left[(1-\gamma) P_{H,t}^{1-a} + \gamma P_{F,t}^{1-a}\right]^{1/(1-a)}, \tag{4}$$

where $P_{H,t}$ is the price of domestic goods, and $P_{F,t}$ is the price of foreign goods.

Next, we consider the household's dynamic optimisation problem. The inter-temporal utility of an infinitely lived representative household is

$$U_t = E_t \sum_{j=0}^{\infty} \beta^j \left(\frac{C_{t+j}^{1-\sigma}}{1-\sigma} - \frac{N_{t+j}^{1+\phi}}{1+\phi} \right), \tag{5}$$

where N_t is the household's labour supply. The parameter β denotes the discount factor. In addition, σ and ϕ are positive parameters. The representative household faces the following budget constraint:

$$P_t C_t + P_t Q_t A_t + M_{t+1} + E_t \mu_{t,t+1} B_{t+1} + D_t = M_t + B_t + R_t^D D_t + P_t A_t \Gamma_t + \Pi_t(B) + W_t N_t + P_t Q_t A_{t-1} + P_t T_t, \tag{6}$$

where R_t^D denotes the gross nominal interest rate on deposits and D_t is the deposit in financial intermediaries. B_t is the nominal bond and $\mu_{t,t+1}$ is the stochastic discount factor, which denotes the bond price of in terms of home currency. W_t and Γ_t are the nominal wage and the dividend from intermediate goods firms. $\Pi_t(B)$ denotes the dividend from financial intermediaries and A_{t-1} denotes shares of stock that sell at price Q_t. The equities are owned by the ownership of firms. M_t is the nominal money stock and T_t denotes lump-sum transfers. In addition, the representative household faces a cash-in-advance constraint, which is given as follows:

$$P_t C_t \leq M_t - D_t + W_t N_t \,. \tag{7}$$

As in Ravenna and Walsh (2006), Equation (7) states that households enter period t with cash holdings of M_t. Before households enter goods and financial markets, they deposit the fund of D_t at financial intermediaries. Hence, remaining cash balances of households are subject to a cash-in-advance constraint (7).

The household maximises its own utility, subject to Eqs. (6) and (7). If the nominal interest rate is positive, the first-order conditions of this optimisation problem are as follows:

$$C_t^{-\sigma} = \beta E_t \left(R_t C_{t+1}^{-\sigma} \frac{P_t}{P_{t+1}} \right), \tag{8}$$

$$\frac{N_t^{\phi}}{C_t^{-\sigma}} = \frac{W_t}{P_t}, \tag{9}$$

$$C_t^{-\sigma}(Q_t - \Gamma_t) = \beta E_t C_{t+1}^{-\sigma} Q_{t+1} \,. \tag{10}$$

Equation (8) represents an Euler equation for consumption. The left-hand side of Eq. (8) is the marginal utility in period t, whereas the right-hand side of Eq. (8) is the discounted marginal utility of consumption in period $t+1$. The Euler equation requires that in equilibrium, the marginal utility of consumption inter-temporally equalises through the adjustment of the real interest rate.[3] Equation (9) is the marginal rate of substitution between consumption and household labour supply. Equations (10) represents the dynamics of share prices Q_t.

2.2. Firms

There are two production sectors in each country. The first is the final goods sector, which produces final goods using intermediate goods and is characterised by perfect competition. The second is the intermediate goods sector in which firms face monopolistic competition and Calvo pricing. In addition, intermediate goods firms have to borrow funds from financial intermediaries to pay employee wages. As in Pfajfar and Santoro (2014), it is also assumed that firms are completely rationed on the equity market. This assumption enables the model to consider the case wherein firms

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[3] We checked that in competitive bond and deposit markets, the nominal interest rate on bonds is equal to the deposit rate through the arbitrage condition between bond and deposit markets.

borrow funds from financial intermediaries because financial gaps generated by the shortage of firm's internal funds exist.[4] Therefore, in this model, the intermediate firms borrow the funds from financial intermediaries while they also issue their own securities, which are held by domestic households.

2.2.1. The final goods sector

Each final goods firm employs the following CES technology:

$$Y_t = \left[\int_0^1 Y_t(i)^{\frac{\theta-1}{\theta}} di \right]^{\frac{\theta-1}{\theta}} . \quad (11)$$

where Y_t is aggregate output, $Y_t(i)$ denotes demand for intermediate goods produced by firm i. Also, the parameter θ is the elasticity of substitution for individual goods. This parameter satisfies $\theta > 1$.

The demand for intermediate goods is given as

$$Y_t(i) = \left(\frac{P_{H,t}(i)}{P_{H,t}} \right)^{-\theta} Y_t , \quad (12)$$

where $P_{H,t}(i)$ is the price for intermediate goods produced by firm i and the price index in this case is given by

$$P_{H,t} = \left[\int_0^1 P_{H,t}(i)^{1-\theta} di \right]^{\frac{1}{1-\theta}} . \quad (13)$$

2.2.2. Intermediate goods sector

The intermediate goods sector is characterised by monopolistic competition, and each firm produces a differentiated intermediate good. Firm i 's production function is given by

$$Y_t(i) = Z_t N_t(i) , \quad (14)$$

where Z_t denotes an aggregate productivity disturbance, which follows an AR (1) process given by $\log(Z_t) = \rho_z \log(Z_{t-1}) + \varepsilon_t^z$ with $0 \le \rho_z < 1$. ε_t^z is an i.i.d shock with constant variance σ_z^2.

Following Calvo (1983), we assume that price rigidity exists in the intermediate goods sector. Thus, a fraction $1-\omega$ of all firms adjusts their prices while the remaining fraction of firms ω do

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[4] See Pfajfar and Santoro (2014) for a detailed discussion of this problem.

not. When revising their prices, these firms take into account uncertainty concerning when they will be able to adjust prices next. As such, the intermediate firm's optimisation problem is given by

$$E_t \sum_{j=0}^{\infty} \omega^j \mu_{t,t+j} \left[\left(\frac{P_{H,t}^{opt}}{P_{H,t+j}} \right)^{1-\theta} - \varphi_{t+j} \left(\frac{P_{H,t}^{opt}}{P_{H,t+j}} \right)^{-\theta} \right] Y_{t+j} , \tag{15}$$

where $\mu_{t,t+j}$ is again the stochastic discount factor, which is given by $\beta^j (C_{t+j} / C_t)^{-\sigma}$. Also φ_t denotes the real marginal cost and $P_{H,t}^{opt}$ is the optimal price index in period t.

The first order condition of this optimisation problem is as follows:

$$E_t \sum_{j=0}^{\infty} (\omega\beta)^j \left(\frac{C_{t+j}}{C_t} \right)^{-\sigma} \left(\frac{P_{H,t}^{opt}}{P_{H,t+j}} - \frac{\theta}{\theta - 1} \varphi_{t+j} \right) \left(\frac{P_{H,t}^{opt}}{P_{H,t+j}} \right)^{-\theta} \frac{1}{P_{H,t}^{opt}} Y_{t+j} = 0 . \tag{16}$$

We assume that in order for intermediate firms to pay employee wages, they have to borrow the funds $W_t N_t$ from domestic financial intermediaries at the gross lending rate R_t^L. Intermediate firms face the following cost minimisation problem:

$$R_t^L \frac{W_t}{P_{H,t}} N_t - \varphi_t (Z_t N_t - Y_t) . \tag{17}$$

Cost minimisation leads to

$$\varphi_t = \frac{1}{Z_t} \frac{W_t}{P_{H,t}} R_t^L . \tag{18}$$

In contrast to the standard new Keynesian analysis, as intermediate firms have to borrow funds from financial intermediaries under the assumption of the cost channel, their real marginal costs also depend on the lending rate. When the central bank raises the nominal interest rate, intermediate firm i's working capital increases because monetary tightening induces an increase in the lending rate. This indicates that a monetary tightening policy directly increases the real marginal cost.

Finally, as employed in the framework of Pfajfar and Santoro (2014), we assume that firms fully transfer their profits through dividends to the shareholders. In this case, the dividends to the shareholders are given as follows:

$$\Gamma_t = Y_t - R_t^L \frac{W_t}{P_{H,t}} N_t = (1 - \varphi_t) Y_t . \tag{19}$$

In contrast to the case of no cost channel, the lending rate affects the dividends to stockholders. Hence, it follows from Eq. (10) that the lending rate influences the dynamics of stock prices.

2.3. Financial intermediaries

Domestic financial intermediaries provide deposit services to domestic households. If a domestic household deposits an amount of D_t in period t, it will receive a deposit of $R_t D_t$ at the end of the period. In turn, the financial intermediaries receive deposits from domestic households and lend the funds to domestic firms.

When financial intermediaries lend funds to intermediate goods producers, they incur a monitoring cost, $\Psi(R_t)$. One possible interpretation of the monitoring cost $\Psi(R_t)$ is as follows. The monitoring cost $\Psi(R_t)$ could arise due to adverse selection between financial intermediaries and firms. When the adverse selection problem is present, financial intermediaries incur a monitoring cost during the selection of good borrowers in the credit market. Financial intermediaries set their loan rates higher than market rates because they face a risk of default by firms. The borrowers who have the opportunity to invest in good projects cannot negotiate loan contracts with financial intermediaries as long as the lending rate is higher than the short-term nominal interest rate. As a result, there only exist borrowers who have the opportunity to invest in bad projects. In this situation, the financial intermediaries' profit decreases as the nominal interest rate increases. Hence, the monitoring cost function depends on a change in the nominal interest rate. To capture this argument in the model, following Chowdhury, Hoffmann, and Schabert (2006), we assume that this monitoring cost is differentiable and satisfies the following properties: $\Psi'(R_t) \geq 0$ and $\Psi''(R_t) \geq 0$.

Financial intermediaries face the following profit maximisation problem:

$$\Pi_t(B) = R_t^L (1 - \psi(R_t) e^{\nu_t}) L_t - R_t D_t - k L_t, \tag{20}$$

subject to $L_t = D_t$, where L_t denotes loans for the firm. The parameter k represents the management cost, which is constant. Also, we incorporate a financial market shock ν_t into the model. We interpret this disturbance as an exogenous risk premium shock. The financial market disturbance ν_t follows an AR (1) process given by $\nu_t = \rho_\nu \nu_{t-1} + \varepsilon_t^\nu$ with $0 \leq \rho_\nu < 1$. ε_t^ν is an i.i.d shock with constant variance σ_ν^2. The equilibrium for the lending market is $D_t = W_t N_t^d$, where N_t^d denotes the demand for labour.

2.4. Equilibrium

The clearing conditions for the goods market in home and foreign countries are

$$Y_t = C_{H,t} + C_{H,t}^*, \tag{21}$$

$$Y_t^* = C_{F,t} + C_{F,t}^*, \tag{22}$$

where asterisks denote foreign variables.

Substituting Equation (2) and the corresponding equation in the foreign country into Equation

(21), we obtain

$$Y_t = (1-\gamma)[(1-\gamma)+\gamma\Delta_t^{1-a}]^{a/(1-a)} C_t + \gamma[\gamma + (1-\gamma)(\Delta_t^*)^{a-1}]^{a/(1-a)} C_t^*, \tag{23}$$

where $\Delta_t \equiv P_{F,t} / P_{H,t}$ denotes the home terms of trade.

The clearing condition of stock market in each country is $A_t = 1$. Also, the clearing condition of international bond market is given as follows:

$$B_t + B_t^* = 0.$$

Next, we consider a risk sharing condition between countries. The Euler equation for foreign consumption denominated in domestic currency is given by

$$\frac{1}{R_t^*} = \beta E_t\left[\left(\frac{C_{t+1}^*}{C_t^*}\right)^{-\sigma} \frac{P_t^*}{P_{t+1}^*}\frac{e_t}{e_{t+1}}\right], \tag{24}$$

where e_t denotes the nominal exchange rate. Given the assumption that there are state-contingent bonds that both domestic and foreign households can trade internationally, combining Eq. (24) with the Euler equation for domestic consumption and using the definition of the real exchange rate $S_t = e_t P_t^* / P_t$, the real exchange rate becomes

$$S_t = \tau\left(\frac{C_t}{C_t^*}\right)^{\sigma}, \tag{25}$$

where τ is a constant term. Equation (25) states that the real exchange rate adjusts the difference between domestic and foreign consumption.

Finally, the fiscal authority satisfies the following budget constraint:

$$P_t T_t = M_{t+1} - M_t + B_{t+1} - R_t B_t. \tag{26}$$

3. Log-linearisation

This section provides the log-linearisation of the system around the steady state. A log-linearised variable around the steady state is expressed by $\hat{H}_t = \log(H_t / \overline{H})$, where $\overline{H}$ represents a steady-state value.

First, log-linearisation of Equation (23), we obtain

$$\hat{Y}_t = \hat{C}_t + \gamma[2(1-\gamma)a - \sigma^{-1}(1-2\gamma)]\hat{\Delta}_t. \tag{27}$$

Also, the corresponding equation in the foreign country is given by

$$\hat{Y}_t^* = \hat{C}_t^* - \gamma[2(1-\gamma)a - \sigma^{-1}(1-2\gamma)]\hat{\Delta}_t . \tag{28}$$

Subtracting Equation (28) from Equation (27), we obtain the following log-linearised relationship between terms of trade and the relative output:

$$\hat{\Delta}_t = \sigma\Omega^{-1}(\hat{Y}_t - \hat{Y}_t^*) , \tag{29}$$

where $\Omega \equiv 4\gamma(1-\gamma)(\sigma\ a-1)+1$.

Log-linearisation of the Euler equation for consumption is given by

$$\hat{C}_t = E_t\hat{C}_{t+1} - \sigma^{-1}[\hat{R}_t - E_t\pi_{t+1}] , \tag{30}$$

where $\pi_t \equiv \log(P_t / P_{t-1})$ denotes consumer price index (CPI) inflation.

To express in terms of log-deviation from their flexible price equilibrium counterparts, we introduce the following notations:

$$q_t = \hat{Q}_t - \hat{Q}_t^f ,\ \ y_t = \hat{Y}_t - \hat{Y}_t^f ,\ \ \eta_t = \hat{\Gamma}_t - \hat{\Gamma}_t^f ,$$

where the superscript f denotes the log-deviation of the natural level.

The log-linearised Euler equation for stock prices is given as follows:

$$q_t = (1-\beta)\eta_t + \beta E_t q_{t+1} - \beta(\hat{R}_t - E_t\pi_{t+1}) , \tag{31}$$

The second term on the right hand side indicates that future stock prices affects stock prices in period t. The third term of the right hand side of Eq. (31) is the real interest rate. An increase in the real interest rate decreases stock prices. As we will show, stock prices in the home country are indirectly influenced by the movements in the foreign output gap through the domestic dividends.

Using Equations (27), (28), (29), and the definition of the output gap, the real marginal cost in an open economy is given as follows:

$$\hat{\varphi}_t = \hat{R}_t^L + (\sigma + \phi - \chi)y_t + \chi\ y_t^* , \tag{32}$$

where $\chi \equiv \Theta\Omega^{-1}$ and $\Theta \equiv 2\gamma(1-\gamma)(\sigma\ a-1)$.

As shown in Ravenna and Walsh (2006) and Chowdhury, Hoffmann and Schabert (2006), the real marginal cost depends on the lending rate in an economy with a cost channel. Moreover, the foreign output gap affects the real marginal cost through the terms of trade and consumption risk sharing in an open economy. For instance, as discussed in Clarida, Gali and Gertler (2002) and Pappa (2004), there exist externalities associated with an open economy as long as the parameter $\sigma\ a$ is not unity.

If $\sigma\ a > 1$, domestic and foreign goods are substitute in the Pareto-Edgeworth sense. When the parameter $\sigma\ a$ takes a value above one, domestic inflation increases in response to an increase in the foreign output gap. This is because a positive output gap in the foreign country induces an increase in the domestic real marginal cost. On the other hand, if $\sigma a < 1$, two goods are complements. In the case where the parameter σa takes a value less than unity, the domestic inflation rate declines because a positive foreign output gap reduces the domestic marginal cost. As mentioned earlier, these effects cancel out when the parameter σa takes unity.

A log-linearisation of the dividends from the firms to the stockholders is as follows:

$$\hat{\Gamma}_t = \hat{Y}_t - (\theta - 1)\hat{\varphi}_t .$$

Using the definition of the dividend gap and substituting the real marginal cost into the above equation, we obtain

$$\eta_t = [1 - (\theta - 1)(\sigma + \phi - \chi)]y_t - (\theta - 1)\chi y_t^* - (\theta - 1)\hat{R}_t^L . \quad (33)$$

Equation (29) indicates that the lending rate negatively affects stock prices through firm's dividends to stockholders in the home country. In contrast to the framework of Pfajfar and Santoro (2014), there is a spill-over effect of an open economy on firm's dividends to the domestic stockholders. This effect is captured by the second term of the right hand side. Thus, it follows from Eq. (33) that the foreign output gap influences the domestic dividends through the terms of trade and through consumption risk sharing. For instance, the foreign output gap reduces the domestic dividends when the parameter σa takes a value above unity. The foreign output gap increases the domestic dividends when the parameter σa takes a value less than unity. These effects disappear when the parameter σa takes unity. Thus, the foreign output gap affects the domestic stock prices through the domestic dividends as long as the parameter σa is not unity.

The relationship between the real exchange rate and the terms of trade is given by

$$\hat{S}_t = (1 - 2\gamma)\hat{\Delta}_t . \quad (34)$$

Using Equation (29), the real exchange rate can be expressed as follows:

$$\hat{S}_t = \frac{(1 - 2\gamma)\sigma}{\Omega}(\hat{Y}_t - \hat{Y}_t^*) . \quad (35)$$

Thus, if foreign output is constant, an increase in output in the home country depreciates the real exchange rate.

Next, the log-linearised lending rate is given as follows:

$$\hat{R}_t^L = (1 + \psi_R)\hat{R}_t + \nu_t , \quad (36)$$

where ψ_R represents the degree of lending rate pass-through.[5] It follows from Eq. (36) that the lending rate deviates from the policy rate as pass-through of the lending rate becomes incomplete: the higher value of the parameter ψ_R, the more incomplete interest rate pass-through is. As

[5] See Chowdhury et al. (2006) for a detailed discussion of Eq. (36).

indicated in a closed economy model, it is possible that when the economy faces severe financial market imperfections, monetary tightening easily increases the inflation rate through the supply side effect of monetary policy. Note that as in Ravenna and Walsh (2006), a wedge between the lending rate and the policy rate disappears when $\psi_R = 0$ if an exogenous credit market shock is not present.

Inflation adjustment is depicted by the new Keynesian Phillips curve (NKPC), which plays an important role in inflation dynamics. An open-economy NKPC expressed in terms of the real marginal cost is given by

$$\pi_{H,t} = \beta E_t \pi_{H,t+1} + \kappa \hat{\varphi}_t , \tag{37}$$

where $\kappa \equiv (1-\omega)(1-\omega\beta)/\omega$ and $\pi_{H,t}$ is producer price inflation (PPI).

Substituting Eq. (32) into Eq. (37), an open-economy NKPC expressed in terms of the output gap is derived as follows:

$$\pi_{H,t} = \beta E_t \pi_{H,t+1} + \kappa(\sigma + \phi - \chi) y_t + \kappa\chi\, y_t^* + \kappa \hat{R}_t^L . \tag{38}$$

The dynamic IS curve, which is derived from the representative household's Euler equation for optimal consumption, is given by

$$y_t = E_t y_{t+1} + \vartheta(E_t y_{t+1}^* - y_t^*) - \sigma_0^{-1}(\hat{R}_t - E_t \pi_{H,t+1}) + \zeta_t , \tag{39}$$

where ζ_t represents the demand disturbance term. Also,

$\vartheta \equiv \dfrac{\sigma\Theta}{\Omega}$ and $\sigma_0 \equiv \dfrac{\sigma(1+\Theta)}{\Omega}$.

The set of variables under flexible price equilibrium is given as follows:

$$\hat{R}_t^f = \sigma_0 \vartheta (E_t \hat{Y}_{t+1}^{f*} - \hat{Y}_t^{f*}) + \sigma_0 (E_t \hat{Y}_{t+1}^f - \hat{Y}_t^f) , \tag{40}$$

$$\hat{Q}_t^f = (1-\beta)\hat{\Gamma}_t^f + \beta(E_t \hat{Q}_{t+1}^f - \hat{R}_t^f) , \tag{41}$$

$$\hat{\Gamma}_t^f = \hat{Y}_t^f , \tag{42}$$

$$(\sigma + \phi - \chi)\hat{Y}_t^f + \chi \hat{Y}_t^{f*} + \hat{R}_t^f = (1+\phi) Z_t . \tag{43}$$

Equation (40) represents the open-economy natural rate of interest that holds the real interest rate under flexible price equilibrium. Eqs (41) and (42) are the stock prices and the dividends under flexible price equilibrium. Eq. (43) describes the natural rate of output in an open economy model. In contrast to the natural rate of output shown in Clarida, Gali and Gertler (2002), the natural rate of output in the home country depends on the natural level of the lending rate.

Under the case where both domestic and foreign households can trade Arrow–Debrew securities both domestically and internationally, the following uncovered interest rate parity (UIP) holds:

$$\hat{R}_t - \hat{R}_t^* = E_t \hat{e}_{t+1} - \hat{e}_t \, . \tag{44}$$

To close the model, we now describe the monetary policy rules used in this study. This study employs the standard monetary policy rule suggested by Taylor (1993). We specify a log-linearized monetary policy rule as follows:

$$\hat{R}_t = \phi_\pi \pi_{H,t} + \phi_y y_t \, , \tag{45}$$

where ϕ_π is the coefficient of the rate of inflation, and ϕ_y is the coefficient of the output gap. We refer to this monetary policy rule as a benchmark rule. The next section compares the performance of this rule with that under several alternative specifications of a monetary policy rule.

4. Calibration

This section describes the parameters used in this study. We set the degree of price rigidity ω to 0.75 based on Pappa (2004). Following previous studies in the new Keynesian literature, the discount factor β is set to 0.99. Following Pappa (2004), we use a value of 2.0 for the risk aversion coefficient, σ. The elasticity of household labour supply ϕ is set to 1.0. The elasticity of substitution between domestic and foreign consumption goods a is set to 1.5. With regard to the degree of openness, following Pappa (2004), we set γ to 0.2. The elasticity of substitution for individual goods is set to 5.0, based on the value calibrated in the existing literature.

Several studies report the value of the degree of financial market imperfection ψ_R. Ravenna and Walsh (2006) report that the value of the parameter ψ_R is 0.276. Also, Chowdhury, Hoffman and Schabert (2006) also estimate the value of financial market imperfection of 0.32 for the United States. Castelnuovo (2007) use the values $\psi_R \in \{0.5,\ 1.7\}$.[6] Therefore, we use the values $\psi_R \in \{0,\ 1.5\}$. In this paper, we focus on how the degree of financial market imperfections in the foreign country affects the home country. Therefore, the degree of financial market imperfections in the home country is set to 0.276 based on the estimation value obtained in the study by Ravenna and Walsh (2006), whereas we set several values calibrated in above studies to that of the foreign countries.

We now describe the parameters for the monetary policy rule. As a benchmark, we choose 1.5 and 0.5 for ϕ_π and ϕ_y. Finally, with regard to the standard deviation of economic shocks, we assume that σ_ν, σ_ζ, and σ_z are set to 0.01, respectively. Also, we assume that the parameters

[6] Castelnuovo (2007) points out that a larger value of the parameter ψ_R is likely to generate the price puzzle that an increase in the policy rate increases inflation in the closed economy model.

ρ_v, ρ_ζ, and ρ_z are set to 0.8, 0.8, and 0.8, respectively. Table 1 summarises the deep parameters calibrated in this study.

[Table 1 around here]

5. The role of financial market imperfections in a two-country economy

This section reports main simulation results obtained in the model. First, Section 5.1 provides the results of the impulse response analysis. We explain that the impulse response function obtained in the case of financial market imperfections in the foreign country differs from that in the case of no financial friction. In addition, we consider how the presence of a foreign financial friction influences social welfare in the home country as the degree of openness increases. Second, Section 5.2 shows how a change in financial market imperfections in the foreign country spills over to the home country. Finally, Section 5.3 shows how the home central bank should conduct its monetary policy in the case where financial market imperfections are severe in the foreign country. Concretely, we compare several alternative policy rules using the benchmark Taylor rule.

5.1. Benchmark results

Figure 1 displays the impulse response to a foreign positive productivity shock. The solid line indicates the impulse response when financial market imperfections are absent in the foreign country. The foreign productivity shock expands foreign output, but it reduces the foreign inflation rate. Therefore, the foreign central bank cuts the policy rate down in accordance with a decline in the inflation rate. On the other hand, after the foreign productivity shock, a decline in the home terms of trade reduces home output, decreasing home inflation through a decline in the real marginal cost. Accordingly, the home central bank implements a reduction of the policy rate, reducing the home lending rate. Consequently, the domestic stock price increases because a decline in the home lending rate creates a boom in the home dividend.

[Figure 1 around here]

The above result is not applicable in the case of the presence of financial market imperfections in the foreign country. The line with an asterisk represents the impulse response when financial market imperfections are present in the foreign country. A foreign productivity shock considerably reduces both home inflation and output. Hence, the home central bank more aggressively cuts its policy rate. Thus, the home central bank needs to conduct its monetary policy considering a foreign financial friction.

[Figure 2 around here]

Figure 2 shows the impulse response when the lending rate exogenously increases in the foreign country. In the case of no financial friction in the foreign country, the foreign loan rate shock does not impact the home country. On the other hand, when financial market imperfections are present, the foreign loan rate shock generates a tradeoff between inflation and output in the foreign country. In addition, the exogenous loan rate shock increases the foreign policy rate, resulting in a depreciation of the real exchange rate in terms of home currency. Therefore, an improvement of the home terms of trade increases both output and inflation in the home country. In other words, the foreign loan rate shock produces a boom in the home country. Home share prices also increase through a rise in the home dividend derived from an upsurge in home output and a decline in foreign output. Consequently, the home central bank raises its policy rate.

Summing up, the foreign productivity shock leads to a recession in the home country, whereas the foreign loan rate shock creates a boom in the home country.

Figure 3 illustrates the impulse response to a foreign natural rate shock. Interestingly, the impulse response when a foreign financial friction exists differs from that when a financial friction is absent in the foreign country. First, in the case of no financial friction in the foreign country, the foreign natural rate shock worsens the home terms of trade, resulting in a decline in both inflation and output in the home country. Hence, the home central bank cuts its policy rate in response to a recession of the home country.

[Figure 3 around here]

On the other hand, when a financial friction is present in the foreign country, the foreign natural rate shock can improve the home terms of trade. As a result, such an improvement of the home country’s terms of trade produces a boom in home output, increasing the home inflation rate. The home central bank raises its policy rate in accordance with such responses of home country macro variables. Compared with the case of no financial friction in the foreign country, the responses of both inflation and output are asymmetric when a financial friction exists in the foreign country.

The results obtained by the above impulse response analysis reveal that the presence of financial market imperfections in the foreign country is never negligible. How then does the degree of a foreign financial friction affect home social welfare? To answer this question, we calculate home social welfare. This paper assumes that the home loss function is given as follows:

$$L_{H,t} = (1-\beta)E_0 \sum_{t=0}^{\infty} \beta^t (\pi_{H,t}^2 + \alpha y_t^2) \,. \tag{46}$$

The parameter α represents the weight on the output gap relative to inflation stabilisation. As explained in Walsh (2005), this criterion may lead to misguiding results. However, the reason that we must employ the traditional loss function is as follows. In the two-country model, Clarida, Gali and Gertler (2002) derive the central bank's loss function in cases of both policy coordination and no policy coordination.

However, this paper has difficulty in assessing home social welfare using second-order approximation of the household's utility function. Clarida, Gali and Gertler (2002) assume that the optimal subsidies to make the steady state efficient in the case of policy coordination differ from those in the case of no policy coordination. In this paper, this difference is not crucial. The crucial point is that the derivation of the loss function under policy coordination differs in that under no policy coordination. The welfare criterion under no policy coordination is related to the home loss function. Such a criterion is derived under the presumption that the home country treats foreign variables as given. However, this paper cannot assume that foreign variables are given. In contrast, the worldwide loss function is derived under policy coordination, but such a criterion is not suitable for our purpose. Hence, we use the traditional loss function to evaluate home social welfare.[7] We note that Equation (41) resembles the loss function derived under the assumption of no policy coordination in Clarida, Gali, and Gertler (2002).

[Figure 4 around here]

Figure 4 shows the home welfare loss when the degrees of both foreign financial friction and openness change.[8] When the degree of openness is close to zero, a foreign financial friction never affects the home welfare loss. As the degree of openness increases, the presence of financial market imperfections in the foreign country influences home social welfare. In particular, a predominately higher value of the parameter ψ_R^* worsens the home welfare loss as the degree of openness increases. As shown in Figures 1–3, compared with the case of no foreign financial friction, foreign shocks generate a large fluctuation of home variables when financial market imperfections are present in the foreign country. The home central bank should respond aggressively to such a response of home variables that are fluctuated by the presence of a foreign financial friction. Therefore, the presence of foreign financial friction worsens home social welfare.

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7 We might be able to strictly assess social welfare by solving a Ramsey policy. We would like to consider this issue as a future work.

8 The parameter α is set to 0.25 based on the existing literature in the new Keynesian model.

5.2. The impact of foreign financial market imperfections on the home country

In Section 5.1, the presence of a foreign financial friction worsens home social welfare. This is because such a foreign financial friction amplifies foreign shocks, which generates a large fluctuation of home country macro variables. More concretely, how do foreign structural shocks affect home country macro variables as foreign financial friction becomes severe? In this section, we examine how a change of a foreign financial friction leads to a fluctuation of home country macro variables.

Figure 5 shows the impulse response to a foreign positive productivity shock under several values of the parameter ψ_R^*. For a larger value of ψ_R^*, both home inflation and output drastically decrease after the foreign productivity shock occurred. The home central bank should aggressively cut its policy rate down in response to such a large drop in both inflation and output. In addition, the foreign country where the productivity shock occurred experiences a large drop in the inflation rate and an increase in the output gap. Consequently, the foreign monetary authority also reduces the nominal interest rate.

[Figure 5 around here]

Figure 6 illustrates the impulse response to a foreign exogenous loan rate shock under several values of the parameter ψ_R^*. A larger value of ψ_R^* amplifies the effect of the loan rate shock on the real economy. As shown in Figure 2, the foreign loan rate shock creates a tradeoff between inflation and output in the foreign country. It follows from Figure 6 that such a tradeoff is more severe as the parameter ψ_R^* takes a larger value. On the other hand, for the home country, the foreign loan rate shock improves the home terms of trade, inducing an appreciation of the real exchange rate. Accordingly, the home country experiences a boom in the output and an increase in home inflation. Such a boom is accelerated by a larger value of the parameter ψ_R^*.

[Figure 6 around here]

These results are summarised as follows. In the case of no financial friction in the foreign country, the policy suggestion obtained in Clarida, Gali, and Gertler (2002) is applicable to our model. However, the presence of a foreign financial friction changes the implication for monetary policy derived in a two-country model. The transmission mechanism of foreign structural shocks differs in the presence of a financial friction in the foreign country. In such a case, even if the home country does not face a severe financial friction, a severe financial friction in the foreign country amplifies the impact of foreign shocks on the macro variables of the home country.

5.3. Monetary policy rules in a two-country economy with financial market imperfections

5.3.1. Alternative monetary policy rules

We now examine how the central bank should implement monetary policy in an economy with financial instability. This study considers three alternative policy rules: an output gap change rule, a stock price rule and an exchange rate rule. The first rule is an output gap growth rule suggested by Walsh (2003). More specifically, we introduce an output gap change rule as follows:

$$\hat{R}_t = \phi_\pi \pi_{H,t} + \phi_y y_t + \phi_{slp}(y_t - y_{t-1}) . \qquad (47)$$

It follows from Eq. (42) that the central bank sets its policy rate in response to a change in the output gap. Walsh (2003) shows that a gap change target can achieve preferable outcomes to a pure discretionary policy when the central bank cannot commit its monetary policy. This is because an introduction of a gap change target in the monetary policy rule generates policy inertia. Therefore, in a forward-looking economy, the central bank can implement its monetary policy through the management of private expectations (Woodford, 2003).

Next, we examine the performance of an asset price rule, which is given by

$$\hat{R}_t = \phi_\pi \pi_{H,t} + \phi_y y_t + \phi_q(q_t - q_{t-1}) . \qquad (48)$$

As suggested in De Giorgio and Nistico (2007) and Ida (2011), a monetary policy rule that contains the stabilisation of asset prices might lead to preferable outcomes to a standard monetary policy rule.[9] Pfajfar and Santoro (2014) also argue that a stock price rule can produce preferable outcomes when a strong cost channel is introduced into the economy.[10]

Finally, based on the idea of Taylor (2001), we also check the performance of a real exchange rate rule. Specifically, this paper assumes that a real exchange rate rule is given as follows:

$$\hat{R}_t = \phi_\pi \pi_{H,t} + \phi_y y_t + \phi_S(\hat{S}_t - \hat{S}_{t-1}) . \qquad (49)$$

This regime might create a desirable outcome. The reason is that the central bank imparts policy inertia through this rule because the real exchange rate is affected by a change of the terms of trade that depends on home output.

Finally, this paper assumes that the home central bank employs these alternative policy rules,

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9 Carstrom and Furest (2007) show that in the case of no cost channel, a policy rule that aimed at stabilising a fluctuation of asset prices leads to equilibrium indeterminacy.

10 Ida (2011) findsthat a monetary policy rules that contains both domestic and foreign asset prices leads to preferable outcomes. However, he does not consider whether the degree of financial market imperfections in the foreign country affects the performance of an asset price rule.

whereas the foreign central bank conducts its monetary policy rule by following the standard Taylor rule that contains the stabilisation of inflation and the output gap.

5.3.2. Performance of alternative policy rules

Table 1 calculates second moments of several home macro variables under several alternative monetary policy rules.[11] First, for a monetary policy rule that reacts to an asset price growth, it produces the smallest variance of inflation. On the other hand, the stock price rule leads to the largest variance of the output gap. This rule naturally achieves the smallest variance of stock prices. Thus, a stock price rule can stabilize the inflation rate, whereas it generates the largest fluctuation of the output gap. In sum, the home central bank that responds to asset prices faces a severe tradeoff between inflation and the output gap.

[Table 2 around here]

Next, consider the performance of the output gap growth rule. Under this rule, the central bank can attain the smallest variances of both inflation and the output gap. This rule also can avoid a fluctuation of the real exchange rate. Intuitively, since a change of the output gap causes a fluctuation of the home terms of trade, which changes the real exchange rate, a speed limit rule that smooths a change of the output gap can stabilise the real exchange rate.

Finally, we check the performance of a real exchange rate rule. This rule succeeds in reproducing the almost same results obtained from the speed limit rule. As we mentioned above, this is because the real exchange rate rule can stabilise the output gap because the terms of trade through a change of home output affects the real exchange rate.

[Figure 7 around here]
[Figure 8 around here]

Figures 7 and 8 display the impulse response under several alternative rules. Figure 7 shows the impulse response to the foreign positive productivity shock. It turns out that the result of the impulse response analysis is consistent with that of Table 1. Though an asset price rule can stabilise a fluctuation of both stock prices and inflation, it produces a larger fluctuation of the output gap. On the other hand, a speed limit rule and a real exchange rate rule can stabilise inflation and the output gap. Indeed, Table 3(i) reveals that the speed limit policy outperforms in that it succeeds in stabilising both inflation and the output gap. Therefore, this result indicates that if structural shocks

[11] This paper assumes that $\phi_{slp} = \phi_q = \phi_S = 0.5$.

are generated by a real factor, then it is desirable that the home central bank employs an output gap change rule or a real exchange rate rule.

Figure 8 illustrates the impulse response to a foreign loan rate shock. In the case where structural shocks are derived from a financial factor, if the home central bank sets its policy rate by following an asset price rule, then it can restrain fluctuation of home macro variables. Hence, there are gains from employing a stock price rule if structural shocks are related to financial factors.

Indeed, Table 3(ii) shows that for a foreign loan rate shock, an asset price rule can achieve preferable outcomes to alternative policy rules. There are two channels that a change in the lending rate leads to a fluctuation of inflation. First, a fluctuation of the loan rate affects the real marginal cost, changing the inflation rate. The second channel is that it affects share prices, which fluctuates the inflation rate through dividend change. An asset price rule can completely stabilise the second channel generated by financial shocks. Thus, it is possible that an asset price rule outperforms in the case where the resource of structural shocks are associated with financial factors.

6. Concluding remarks

This study examined whether financial market imperfections matter in a two-country economy. The result revealed that a cost channel associated with the presence of financial market imperfections plays an important role in a two-country framework. In the case of no financial friction in the foreign country, the implication obtained in a standard open economy model is applicable to our model. However, the presence of a foreign financial friction changes the implication for monetary policy derived in a standard two-country model. The transmission mechanism of foreign structural shocks is quite different in the presence of a financial friction in the foreign country. In such a case, even if the home country does not face a severe financial friction, a severe financial friction in the foreign country amplifies the impact of foreign shocks on the home country macro variables.

This paper also addressed the effectiveness of an output gap growth rule in a two-country economy with financial market imperfections. This rule can achieve the smaller variances of inflation and the output gap. In particular, for a real shock, there are gains from employing this rule. On the other hand, an asset price target rule can attain the smallest variance of inflation of all policy regimes, whereas it produces the largest variances of the output gap. However, in the case of the foreign loan rate shock, an asset price rule can attain the preferable outcome. Thus, for a financial shock, there might be gain from employing an asset price rule.

Finally, there are possible future extensions of the work in this study. We assumed that the exchange rate pass-through is perfectly complete. Thus, the law of one price holds in this model. However, as argued in Corsetti and Pesenti (2001), Monacelli (2005) and Engel (2009), exchange rate pass-through would be incomplete if firms set their export prices based on local currency pricing (LOP). It is interesting how financial market imperfection affects an open macroeconomic model in which incomplete exchange rate pass-through is present.

It is also worth investigating optimal monetary policy in a two-country economy with financial market imperfections. It is interesting how optimal monetary policy changes when financial market imperfections are present in a two-country economy. In particular, it is worth examining whether a domestic central bank coordinates a foreign central bank when financial market imperfections play a significant role in both countries.

Acknowledgements

This paper was circulated as "Financial market imperfections in an open economy". I would like to thank Kosuke Aoki, Kojiro Dohwa, Eiji Fujii, Kenji Fujiwara, Shigeto Kitano, Yutaka Kurihara, Toshihiro Okada, Mitsuhiro Okano, Kenya Takaku and Yohei Tenryu for helpful comments and suggestions. In addition, this study has been greatly improved by the helpful comments and suggestions made by seminar participants at Keio University, Kwansei Gakuin University, Osaka University, University of Kitakyusyu and University of Hyogo. All remaining errors are my own.

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Table 1: Baseline parameters

Parameter	Description	Value
ω	Degree of price stickiness	0.75
β	Discount factor	0.99
σ	Relative risk aversion coefficient	2.0
ϕ	Elasticity of labor supply	1.0
γ	Degree of openness	0.2
θ	Elasticity of substitution	5.0
a	Elasticity of substitution between domestic and foreign goods	1.5
ϕ_π	Coefficient for inflation stabilization	1.5
ϕ_y	Coefficient for the stabilization of the output gap	0.5
σ_v	Standard deviation of credit shock	0.01
σ_ζ	Standard deviation of demand shock	0.01
σ_z	Standard deviation of productivity shock	0.01
ρ_v	Auto-regression coefficient for credit shock	0.8
ρ_ζ	Auto-regression coefficient for demand shock	0.8
ρ_z	Auto-regression coefficient for productivity shock	0.8

Table 2: Second moment properties in the home country under alternative monetary policy rules

(i) $\psi_R^* = 0.5$

	Inflation	Output gap	Asset prices	Real exchange rate
Benchmark	0.071	0.013	5.870	0.016
Output gap growth	0.069	0.008	5.794	0.011
Asset price growth	0.017	0.281	1.592	0.133
Real exchange rate growth	0.075	0.007	5.855	0.009

(ii) $\psi_R^* = 1.5$

	Inflation	Output gap	Asset prices	Real exchange rate
Benchmark	0.073	0.020	6.054	0.048
Output gap growth	0.072	0.011	5.924	0.040
Asset price growth	0.021	0.248	1.540	0.120
Real exchange rate growth	0.078	0.010	5.942	0.031

Table 3: Second moment properties of the home country under several alternative rules when $\psi_R^* = 1.5$

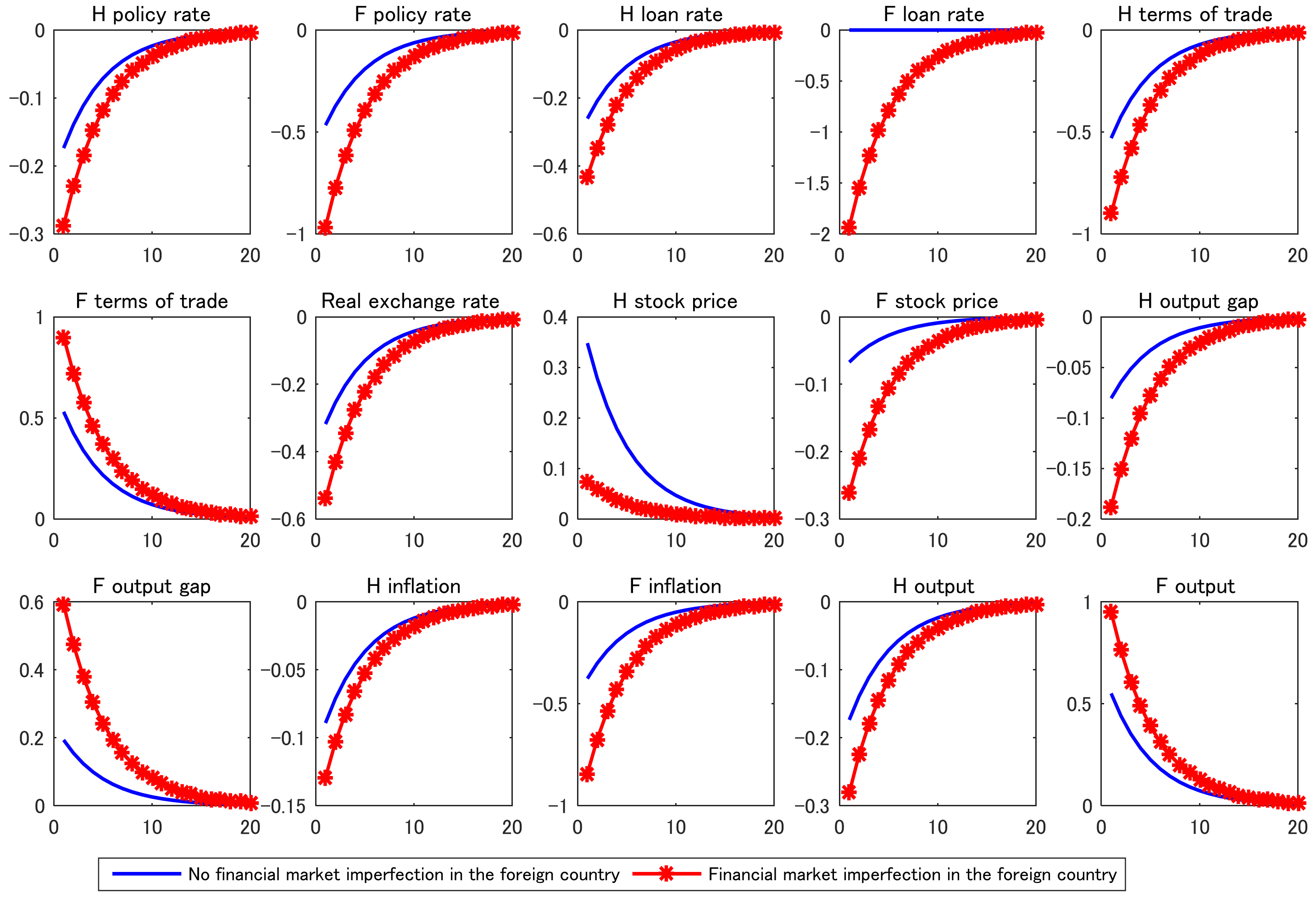
(i) Foreign productivity shock

	Output gap	Inflation	Stock price	Real exchange rate
Benchmark	0.001929	0.000689	0.000392	0.01352
Speed limit rule	0.001129	0.000889	0.000204	0.011771
Asset price rule	0.001633	0.000752	0.000104	0.012963
Real exchange rate rule	0.000696	0.000904	0.002581	0.008801

(ii) Foreign loan rate shock

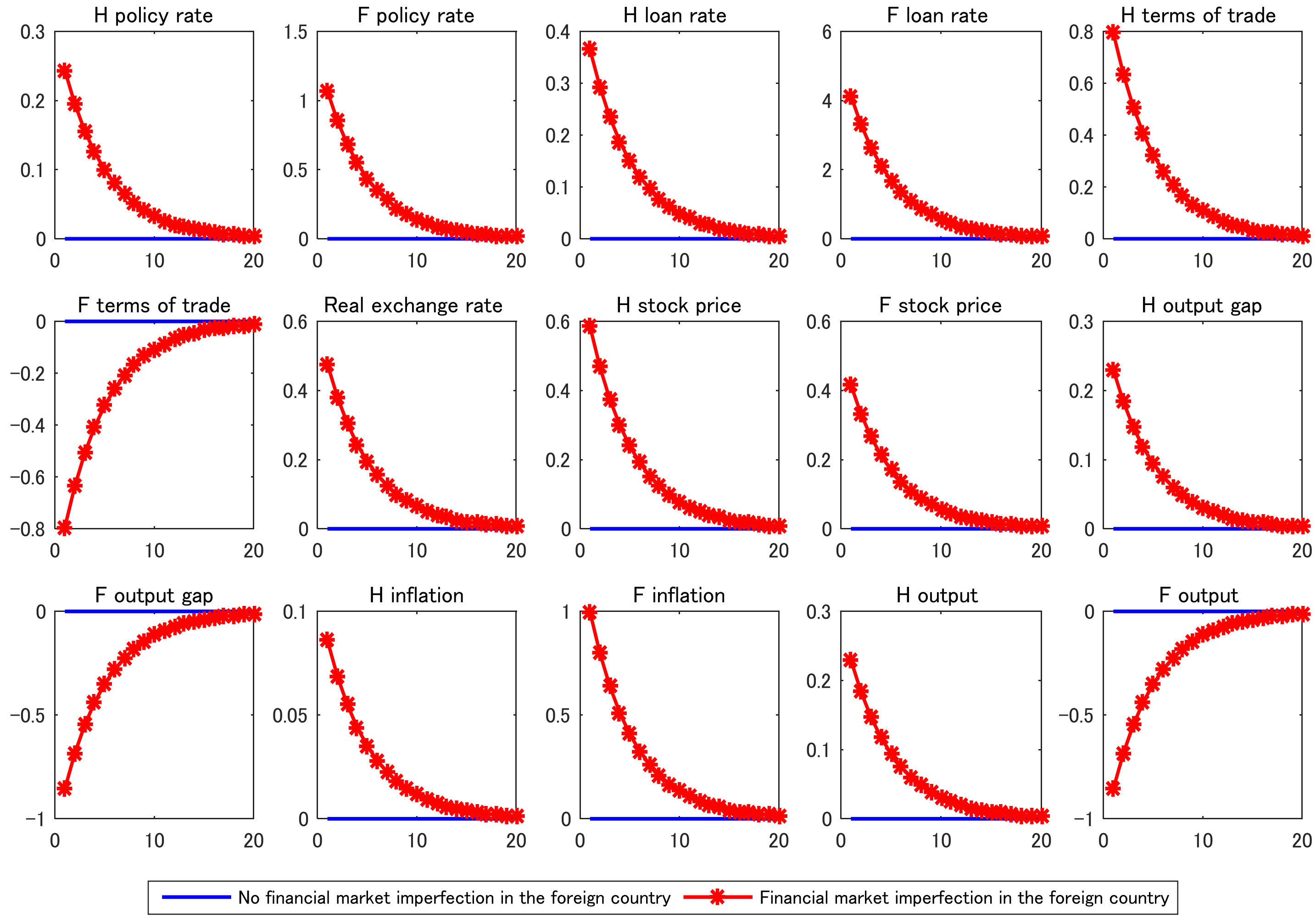
	Output gap	Inflation	Stock price	Real exchange rate
Benchmark	0.004259	0.000596	0.027709	0.018319
Spped limit rule	0.002493	0.000883	0.016095	0.015338
Asset price rule	0.000256	0.000187	0.001168	0.002139
Real exchange rate rule	0.001692	0.001271	0.009114	0.012373

Figure 1: Foreign positive productivity shock



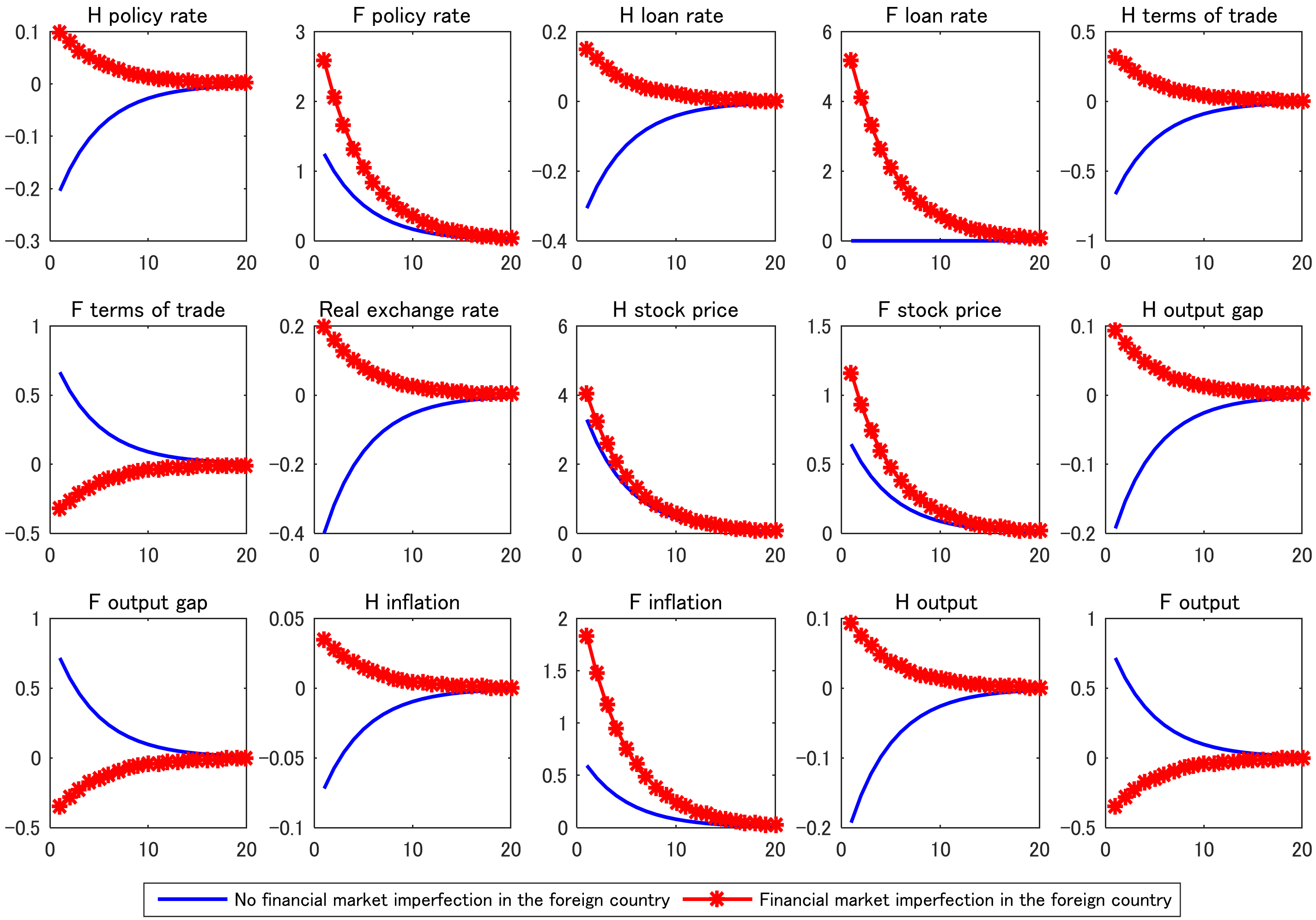
Note: H denotes the impulse response of domestic variables. F represents the impulse response of foreign variables.

Figure 2: Foreign exogenous loan rate shock



Note: H denotes the impulse response of domestic variables. F represents the impulse response of foreign variables.

Figure 3: Foreign natural interest rate shock



Note: H denotes the impulse response of domestic variables. F represents the impulse response of foreign variables.

Figure 4: Home welfare loss when the parameters ψ_R^* and γ change

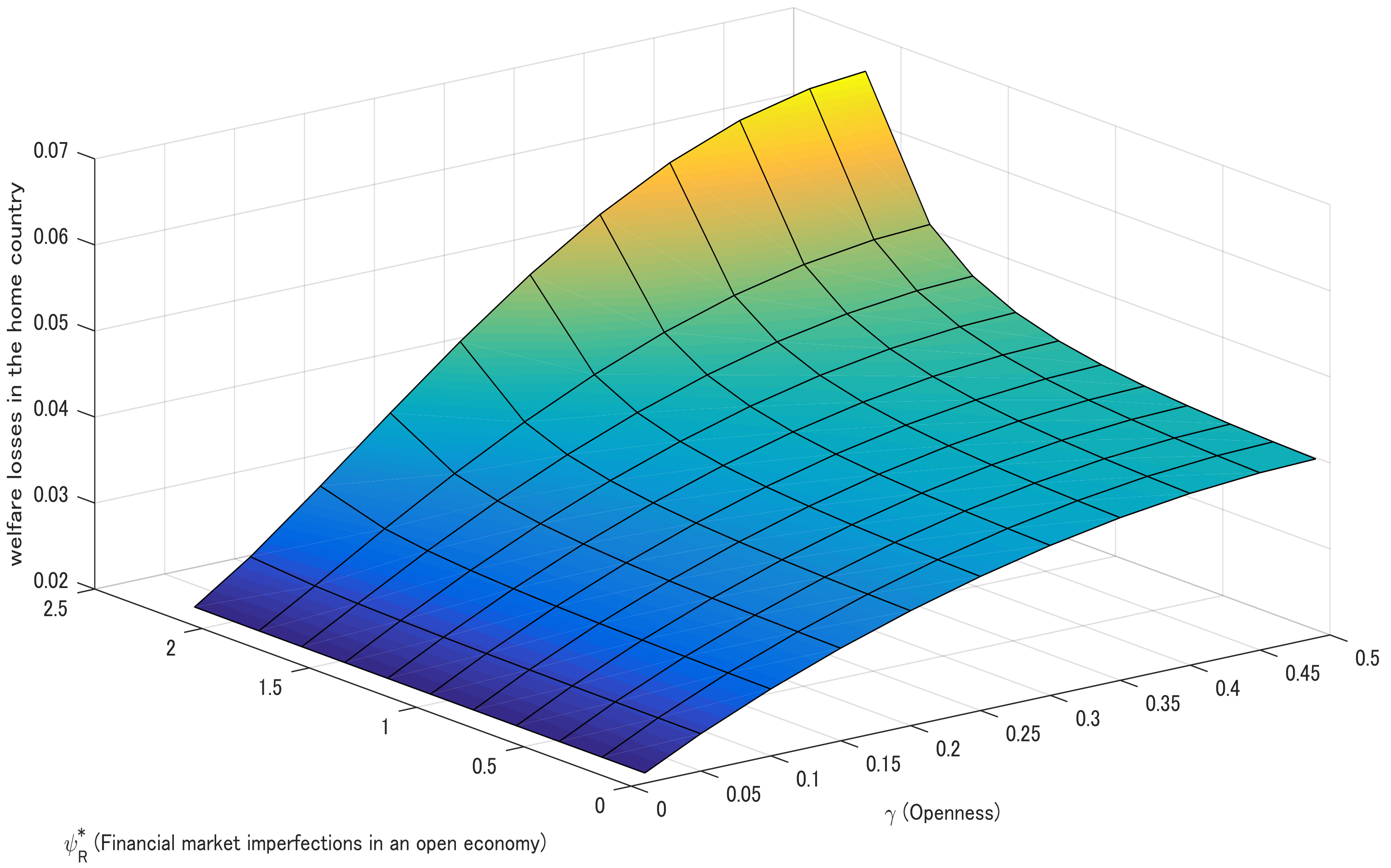
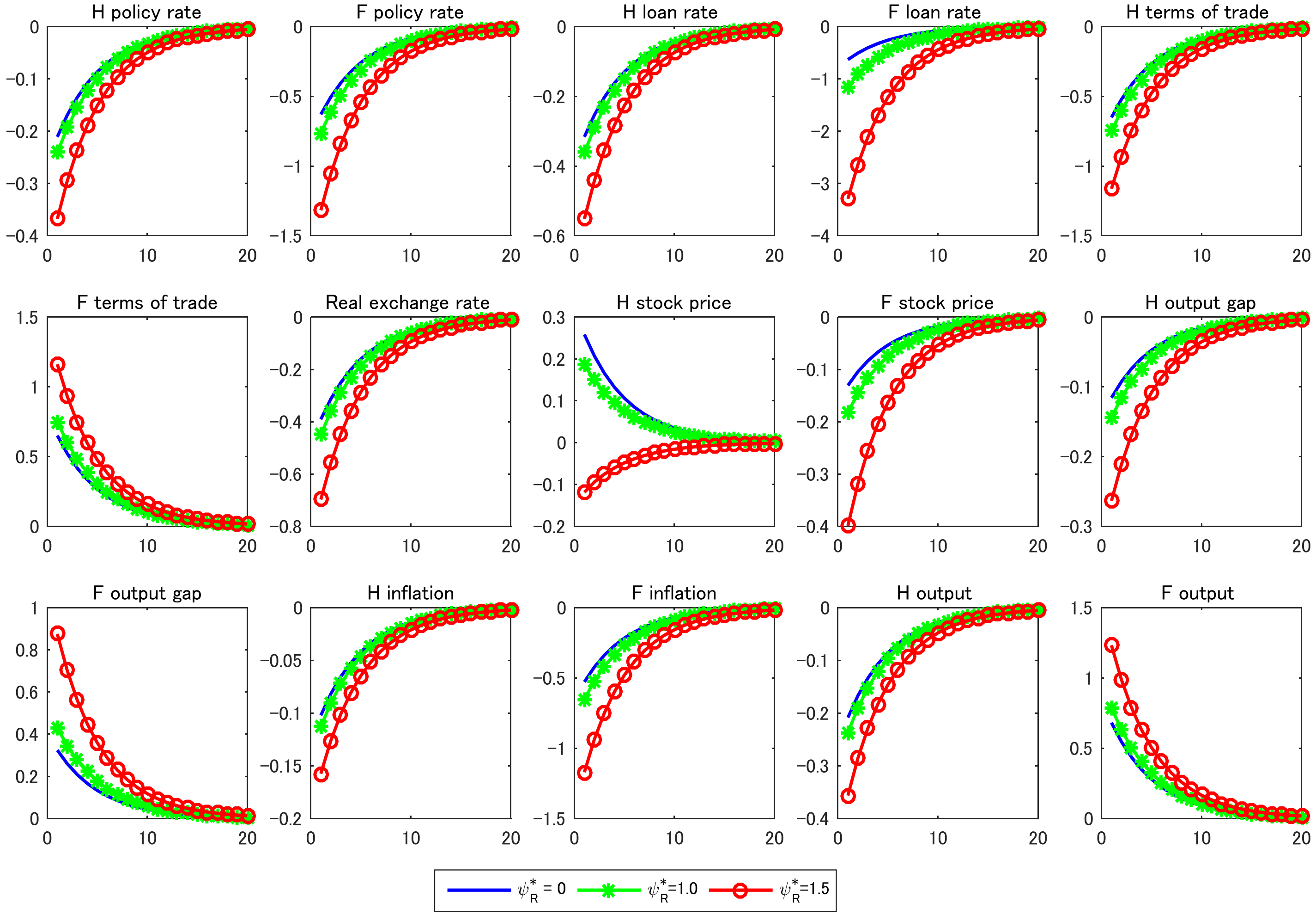
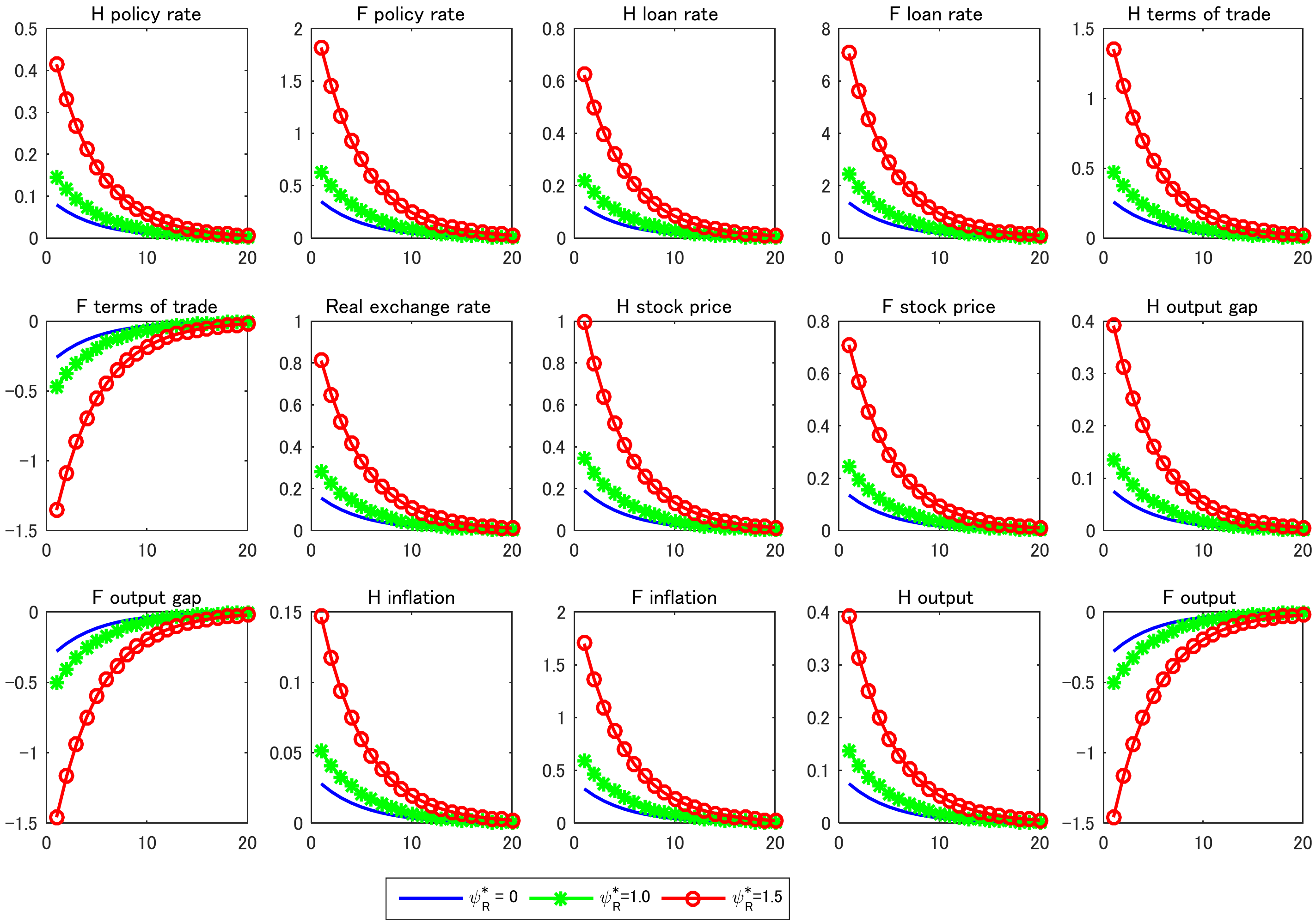


Figure 5: Foreign positive productivity shock under several values of parameter ψ_R^*



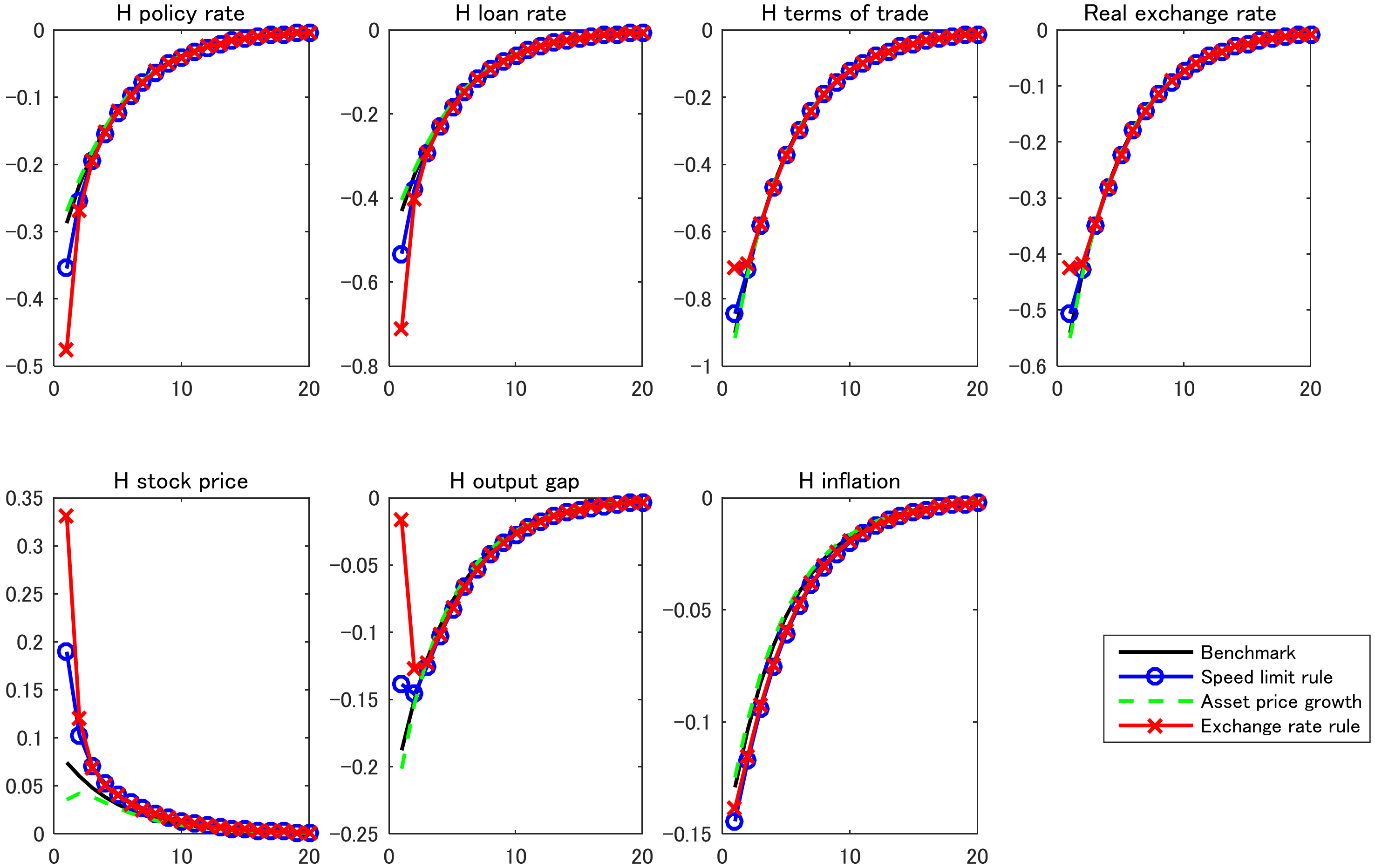
Note: H denotes the impulse response of domestic variables. F represents the impulse response of foreign variables.

Figure6: Foreign exogenous loan rate shock under several values of parameter ψ_R^*



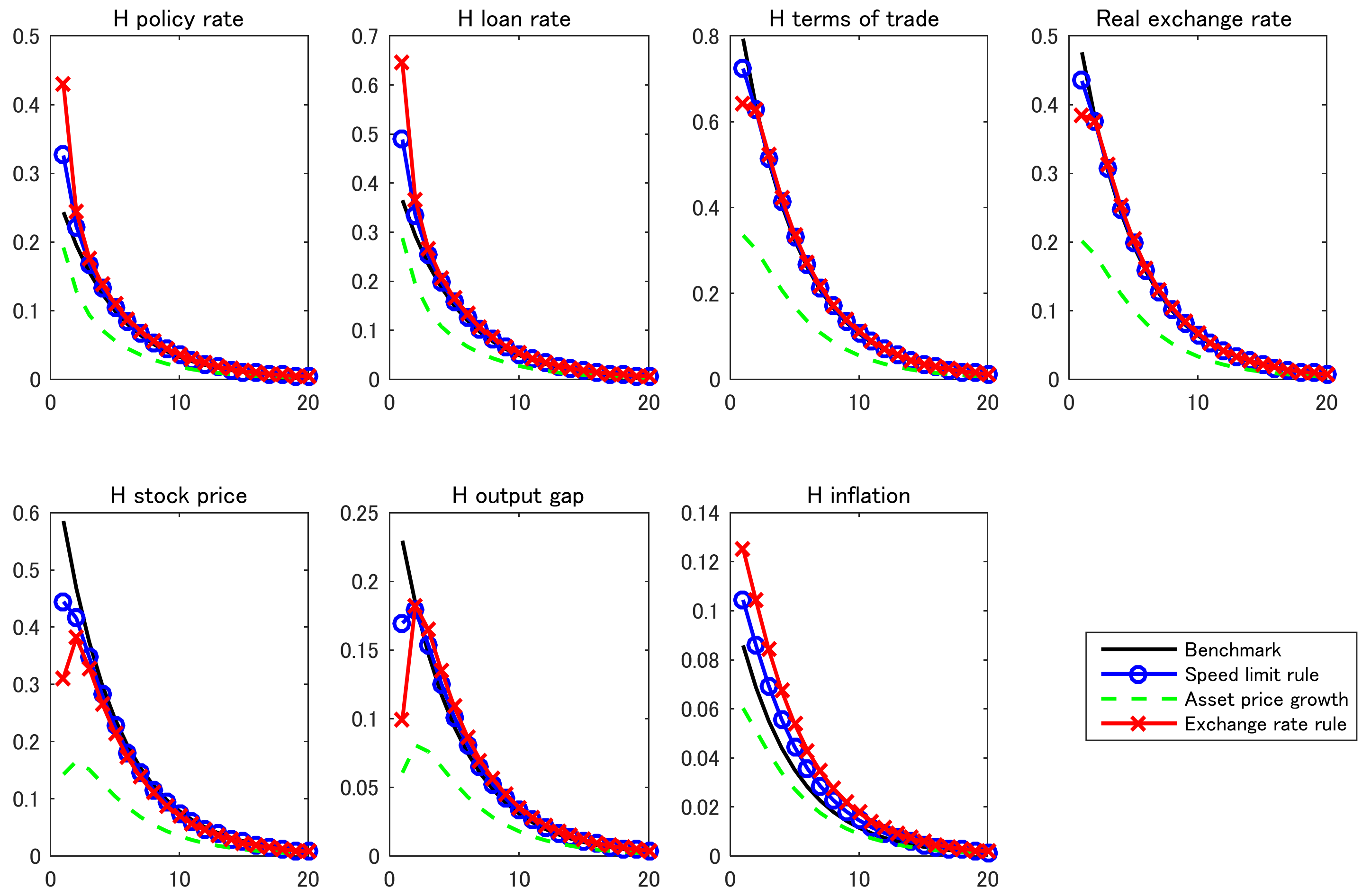
Note: H denotes the impulse response of domestic variables. F represents the impulse response of foreign variables.

Figure 7: The performance of alternative monetary policy rule: The case of foreign positive productivity shock



Note: H denotes the impulse response of domestic variables.

Figure 8: The performance of alternative monetary policy rules: The case of foreign exogenous loan rate shock



Note: H denotes the impulse response of domestic variables.