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Loan rate pass-through, determinacy and monetary policy in a two-country model*

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Abstract

This paper examines the impact of an incomplete loan rate pass-through using a two-country model with nominal rigidities. We find that an incomplete loan rate pass-through affects the worldwide equilibrium determinacy. In particular, when the loan rate pass-through incompleteness is more severe in the foreign country, the global equilibrium indeterminacy drastically expands if home and foreign central banks employ a stronger response to endogenous variables such as inflation and the output gap. Furthermore, severe incomplete pass-through of the foreign loan rate crucially affects the home country's monetary policy transmission mechanism.

Keywords: Incomplete loan rate pass-through; Cost channel; Determinacy; Monetary policy; Two-country model;
JEL classification: E52; E58; F41

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1 Introduction

This paper studies the effects of loan rate pass-through incompleteness and monetary policy in a two-country model. It is assumed that financial market imperfections are associated with a cost channel whereby monetary tightening positively affects inflation by increasing a firm's working capital.[1] The severity of financial market imperfections may be often measured in terms of loan rate pass-through incompleteness (Chowdhury, Hoffman and Schabert, 2006; Kobayashi, 2008; Teranishi, 2015). In fact, several studies point out that pass-through of the policy rate to the loan rate is generally incomplete (e.g. Berger and Udell, 1992; Huelsewig et al., 2006; Henzel, et al., 2009).[2]

Such incompleteness of the loan rate pass-through is often associated with the presence of a cost channel. As shown by many studies on cost channels, incomplete pass-through of the loan rate can help explain inflation dynamics in developed countries (e.g. Ravenna and Walsh, 2006; Chowdhury, Hoffman and Schabert, 2006; Tillmann, 2008). Furthermore, several studies show the manner in which the presence of a cost channel affects equilibrium determinacy (Llosa and Tuesta, 2009; Surico, 2009; Pfajfar and Santoro, 2014).

Currently, it is evident that international trade and finance has rapidly expanded globalisation. Thus, as globalisation continues, economic shocks arising in one country are increasingly likely to affect macroeconomic variables in other countries. Clarida, Gali and Gertler (2002) develop a two-country economy model with sticky prices to examine international dimensions of optimal monetary policy. It naturally seems that financial market imperfections in one country spill-over into other countries, whereas their model abstracts the role of financial market imperfections.

Although the Taylor principle is required to satisfy the unique rational expectations

[1]This paper focuses on the role of the cost channel. A large number of papers construct a medium scale dynamic stochastic general equilibrium (DSGE) model with financial market frictions (e.g. Bernanke, Gertler and Gilchrist, 1999; Bernanke and Gertler, 2001; Gertler and Karadi, 2011; Aoki, Benigno and Kiyotaki, 2016).

[2]See also de Bondt (2005) and de Bondt et al. (2005).

equilibrium (REE) in a closed economy (Bullard and Mitra, 2002), this paper considers that the determinacy condition should be modified if an open economy effect is taken into account (Linnemann and Schabert, 2006; Bullard and Singh, 2008; Bullard and Schaling, 2009). Although those papers examine the equilibrium determinacy in an open economy, they all abstract the role of the cost channel. In a closed economy model, Llosa and Tuesta (2009) show that the presence of the cost channel makes the determinacy condition needed to achieve the unique REE more complicated. This naturally leads to an important question: how do central banks achieve determinacy of the global equilibrium when the cost channel matters in a two-country economy?

Many studies have examined the international transmission mechanism of structural shocks occurring in one country. Several have focused on the role of the credit channel or collateral channel in an open economy (Faia, 2008; Devereux and Yetman, 2010; Dedola and Lombardo, 2012). Kolsa and Lombardo (2011) analyse optimal monetary policy in an open economy with the credit channel. Other studies develop a two-country sticky price model with asset price fluctuations and show that the central bank should follow a monetary policy rule that includes asset price stabilisation (Di Giorgio and Nistico, 2007; Ida, 2011; Ida, 2013).[3]

These studies make significant contributions to the literature. However, the models considered in the above studies appear to be large-scale that therefore have more complicated structures. In contrast to these studies, this paper focuses on incomplete loan rate pass-through associated with the presence of a cost channel. The introduction of financial market imperfections is motivated by Chowehury, Hoffman and Schabart (2006). Of course, the proposed model recognises that this type of modelling is only a shortcut. However, instead of scarifying a strict derivation of financial market imperfections, such simplification makes the international transmission mechanism of structural shocks intuitively understandable. Thus, regardless of this shortcut, several important implications

[3]Di Giorgio and Nistico (2007) construct a model in which asset price fluctuations are observed in the only foreign country. Ida (2011, 2013) considers the role of a monetary policy rule that stabilises asset prices in a two-country model in which home and foreign asset prices fluctuate.

for international monetary policy analysis are identified in this paper.

Recently, several studies focus on the role of the cost channel in an open economy. Fujiwara and Teranishi (2009) construct a two-country model with staggered loan contracts in both countries and find that both domestic and foreign central banks should stabilise international financial shocks when staggered loan contracts are present in both countries. However, their study is based on the assumption of flexible prices. Ali and Anwar (2016) focus on the cost channel in the small open economy and show how the price puzzle, namely that monetary tightening generates an increase in inflation, is affected by an open economy. Palek and Schwanebeck (2017) investigate the effect of a cost channel on optimal monetary policy in a monetary union. Tae-Seok and Okano (2013) examine the role of the cost channel in a two-country model but do not focus on the degree of financial market imperfections. Ida (2015) also examines the performance of several monetary policy rules in a two-country model with imperfect loan rate-pass-through. However, he does not thoroughly explore the determinacy condition of monetary policy rules.

Different from those previous studies, this paper shows how the severity of incomplete loan rate pass-through changes the global determinacy condition. More concretely, it shows that a change in openness affects the worldwide determinacy condition in the presence of financial market imperfections in both countries. The present paper demonstrates that whether domestic and foreign goods are substitute or complements in the Pareto-Edgeworth sense will affect global determinacy conditions. When both goods are Pareto-Edgeworth substitutes, the worldwide equilibrium attains determinacy even in the presence of severe financial market imperfections in both countries. However, the determinacy regions of the global equilibrium shrink drastically when both goods are Pareto-Edgeworth complements.

Moreover, this paper explores how differences in inflation stabilisation between the two countries affects the global equilibrium determinacy in the presence of incomplete loan-rate pass-through. When there is no incomplete pass-through of the loan rate in the foreign country, home and foreign central banks can achieve the unique worldwide

REE if they respond more than one-for-one to inflation, i.e. follow the Taylor principle. This finding is consistent with previous studies, but it is overturned when the incomplete loan-rate pass-through is more severe in the foreign country. In particular, the worldwide equilibrium is always indeterminate unless the foreign central bank sets the inflation stabilisation in the policy rule to around 2.0. In contrast to Llosa and Tuesta (2009) and Surico (2008), the coefficient for the output gap in the Taylor rule is more restricted by an open economy effect when the foreign country has more severe loan rate pass-through incompleteness. In particular, both upper and lower bounds for the output gap stabilisation in the foreign policy rule are more restricted when loan-rate pass-through is more incomplete in the foreign country. Accordingly, an open economy increases the severity of the restriction on the output gap stabilisation if both central banks aim to attain determinacy of the world equilibrium.

Finally, we show how a change in foreign loan rate pass-through affects international transmission mechanism of foreign structural shocks. A foreign productivity shock leads to a decline in both inflation and output in the home country. Severe incomplete pass-through of the foreign loan rate induces a huge decline in home output, whereas home inflation is not subject to a change with foreign loan rate pass-through. On the other hand, a foreign loan rate shock results in a boom in the home country. This boom is amplified by a severe foreign loan rate pass-through. This paper finds that a change in foreign loan rate pass-through can significantly affect the welfare loss in the home country. Compared with the case of a foreign productivity shock, the home country welfare loss can be heightened by the severity of incomplete foreign loan rate pass-through for the case of a foreign loan rate shock.

The remainder of this study is constructed as follows. Section 2 describes a two-country model with nominal price rigidities in the presence of financial market imperfections. Section 3 derives the model's log-linearised system. Section 4 calibrates the deep parameters. Section 5 reports how the presence of financial market imperfections in both countries affect the worldwide REE. Section 6 explores how structural shocks in the foreign country affect the home country's macroeconomic dynamics. Section 7

concludes.

2 Model

This paper incorporates simple financial market friction associated with a cost channel into the two-country framework.[4] The model is based on the framework developed by Ida (2015). Consider an economy with two large symmetric countries: home and foreign. Each country has two production sectors. The final goods sectors are characterised by perfect competition, whereas firms in intermediate goods sectors face monopolistic competition and Calvo (1983) type nominal price rigidity.

In addition, in order to pay employee wages, intermediate goods firms must borrow funds from financial intermediaries located in the home country. Following Ravenna and Walsh (2006) and Chowdhury, Hoffman and Schabert (2006), this paper introduces the role of financial intermediaries into the model. Financial intermediaries receive deposits from domestic households and lend funds to domestic firms. When lending funds to intermediate goods producers, these financial intermediaries incur a monitoring cost.

Our model assumes that both countries have complete markets and that households in both countries can trade a state-contingent bond both domestically and internationally. Moreover, this paper presumes 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

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

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

[4] Tae-Seok and Okano (2013) examined the effect of a cost channel in a two-country model. However, as noted earlier, they do not focus on the degree of financial market imperfections.

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 home country's price index is given by

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

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

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

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

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

where R_t^D denotes the gross nominal interest rate on deposits, D_t is the deposit in financial intermediaries, B_t is the nominal bond, $\mu_{t,t+1}$ is the stochastic discount factor, which denotes the bond price of in terms of home currency. W_t, 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 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 the following cash-in-advance constraint:

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

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 funds D_t with financial intermediaries. Hence, household's remaining cash balances 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

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

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

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

Equation (8) represents an Euler equation for consumption.[5] 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 will inter-temporally equalise through real interest rate adjustments. Equation (9) gives the marginal rate of substitution between consumption and a household's labour supply. Equations (10) represents the dynamics of share prices Q_t.

2.2 Firms

Each country has two production sectors. (i) the final goods sector, which produces final goods using intermediate goods and is characterised by perfect competition, and (ii) the intermediate goods sector, in which firms face monopolistic competition and Calvo pricing. In addition, intermediate goods firms have to borrow funds from only home financial intermediaries to pay employee wages. Following Pfajfar and Santoro (2014), it is assumed that firms are completely rationed on the equity market located in the home country; this assumption allows the model to consider the case wherein firms borrow

[5] 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.

funds from home financial intermediaries due to the existence of financial gaps generated by firms facing a shortage of internal funds.[6] Therefore, in this model, intermediate firms borrow funds from financial intermediaries and 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 constant elasticity of substitution (CES) technology:

$$Y_t = \left[\int_0^1 Y_t(i)^{(\theta-1)/\theta} di \right]^{\theta/(\theta-1)}, \tag{11}$$

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

The demand for intermediate goods is

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

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

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

2.2.2 The 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

$$Y_t(i) = Z_t N_t(i), \tag{14}$$

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

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

Following Calvo (1983), price rigidity is assumed to exist in the intermediate goods sector. Thus, a fraction $1-\omega$ of all firms adjusts their prices, whereas the remaining fraction of firms ω do not. When revising their prices, these firms take into account uncertainty concerning their next potential opportunity to adjust prices. As such, the intermediate firm's optimisation problem is given by

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

where $\mu_{t,t+j}$ is the stochastic discount factor, which is given by $\beta^j (C_{t+j}/C_t)^{-\sigma}$. 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:

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

This paper assumes that intermediate firms must borrow the funds $W_t N_t$ from domestic financial intermediaries at the gross lending rate R_t^L in order to pay employee wage.[7] 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, because 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 a rise in the lending rate. This indicates that a monetary tightening policy directly increases the real marginal cost.

[7]This paper does not postulate that firms located in home country firms do not lend the funds from foreign financial intermediaries. Thus, it does not assume that financial intermediaries in one country lends their funds for firms only lend to firms located in the home country.

Finally, as employed in the framework of Pfajfar and Santoro (2014), this paper assumes that firms fully transfer their profits through dividends to shareholders. In this case, dividends to 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 the amount of D_t in period t, it will receive the amount of $R_t D_t$ at the end of the period. In turn, the financial intermediaries receive deposits from domestic households and lend these funds to domestic firms.

Following Chowdhury, Hoffman and Schabert (2006), financial intermediaries incurs a monitoring cost, $\Psi(R_t)$ when lending funds to intermediate goods producers. As mentioned earlier, this monitoring cost seems to serve as a shortcut to create incompleteness of loan rate pass-through. For the sake of strictly deriving the loan rate curve with a micro-foundation, this simplification makes the model description and model solution simple and intuitively understandable. To capture this argument in the model, following Chowdhury, Hoffman and Schabert (2006), it is here assumed 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 to a firm. The parameter k represents the management cost, which is constant. In addition, an exogenous loan rate shock ν_t is incorporated into the model. The financial market disturbance ν_t follows an AR (1) process given by $\nu_t = \rho_\nu \nu_{t-1} + \epsilon_t^\nu$ with $0 \leq \rho_\nu < 1$, where 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 Market clearing and international risk-sharing condition

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

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

where $\Delta_t = P_{F,t}/P_{H,t}$ denotes the home terms of trade. The stock market clearing condition in each country is $A_t = 1$, and the clearing condition of the international bond market is given by $B_t + B_t^* = 0$.

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

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

where e_t denotes the nominal exchange rate. By assuming that there exist state-contingent bonds that allow both domestic and foreign households to trade internationally, combining Eq. (24) with the Euler equation for domestic consumption and 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 for the difference between domestic and foreign consumption.

3 Log-linearised two country model

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

First, log-linearisation of Equation (23) yields

$$\hat{Y}_t = \hat{C}_t + \gamma[2(1-\gamma)a - \sigma^{-1}(1-2\gamma)]\hat{\Delta}_t, \tag{26}$$

The corresponding equation in the foreign country is

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

Subtracting Equation (27) from Equation (26) yields the following log-linearised relationship between terms of trade and relative output:

$$\hat{\Delta}_t = \sigma\Omega^{-1}(\hat{Y}_t - \hat{Y}_t^*), \tag{28}$$

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

Log-linearisation of the Euler equation for consumption is

$$\hat{C}_t = E_t\hat{C}_{t+1} - \sigma^{-1}(\hat{R}_t - E_t\pi_{t+1}), \tag{29}$$

where $\pi_t = \log(P_t/P_{t-1})$ denotes consumer price index 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 log-deviation of the natural level. The log-linearised Euler equation for stock prices is

$$q_t = (1-\beta)\eta_t + \beta E_t q_{t+1} - \beta(\hat{R}_t - E_t\pi_{t+1}), \tag{30}$$

The second term on the right-hand side indicates that future stock prices affect stock prices in period t. The third term of the right-hand side of Eq. (30) is the real interest

rate. An increase in the real interest rate decreases stock prices. As will be shown, stock prices in the home country are indirectly influenced by movements in the foreign output gap through domestic dividends. Ida (2019) examines the role of asset price stabilisation in monetary policy rules in a two country model developed by the present paper.

Using Equations (26), (27), (28), and the definition of the output gap, the real marginal cost in an open economy is given as follows:

$$\hat{\varphi}_t = \hat{R}_t^L + (\sigma + \phi - \chi)y_t + \chi y_t^*, \tag{31}$$

where $\chi = \vartheta\Omega^{-1}$ and $\vartheta = 2\gamma(1-\gamma)(\sigma a - 1)$. As shown by 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 terms of trade and consumption risk-sharing in an open economy.

As discussed in Clarida, Gali and Gertler (2002) and Pappa (2004), externalities associated with an open economy exist as long as the parameter σa is not unity. If $\sigma a > 1$, then domestic and foreign goods are substitutes in the Pareto-Edgeworth sense. In such a case, domestic inflation increases in response to an increase in the foreign output gap. This occurs because a positive output gap in the foreign country induces an increase in the domestic real marginal cost. In contrast, if $\sigma a < 1$, the two goods are complements. This implies that the domestic inflation rate declines because a positive foreign output gap will reduce the domestic marginal cost. As mentioned earlier, these effects cancel out when the parameter σa takes unity.

Log-linearisation of the dividends from the firms to the stockholders yields:

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

Using the definition of the dividend gap and substituting the real marginal cost into the above equation produces

$$\eta_t = [1 - (\theta - 1)(\sigma + \phi - \chi)]y_t - (\theta - 1)\chi y_t^* - (\theta - 1)\hat{R}_t^L. \tag{32}$$

Equation (28) indicates that the lending rate can negatively affect stock prices through a firm's dividends to stockholders in the home country. In contrast to the framework

of Pfajfar and Santoro (2014), a spill-over effect exists from an open economy on firm's dividends to domestic stockholders. This effect is captured by the second term of the right hand side. Thus, it follows from Eq. (32) that the foreign output gap influences domestic dividends through both terms of trade and consumption risk-sharing. For instance, the foreign output gap reduces domestic dividends when parameter σa takes a value above unity, but increases 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 domestic dividends as long as the parameter σa is not unity.

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

$$\hat{S}_t = (1 - 2\gamma)\hat{\Delta}_t. \tag{33}$$

Using Equation (28), the real exchange rate and terms of trade can be determined by

$$\hat{S}_t = \frac{(1 - 2\gamma)\sigma}{\Omega}(\hat{Y}_t - \hat{Y}_t^*). \tag{34}$$

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

The log-linearised lending rate is

$$\hat{R}_t^L = (1 + \psi_r)\hat{R}_t + \nu_t, \tag{35}$$

where ψ_r represents the degree of lending rate pass-through.[8] It follows from Eq. (35) that the lending rate deviates from the policy rate as the lending rate pass-through becomes incomplete: the higher value of the parameter ψ_r, the more incomplete interest rate pass-through. It has been found that in a closed economy model, when the economy faces severe financial market imperfections, it is possible that monetary tightening easily increases the inflation rate through the supply-side effect of monetary policy. Note that as in Ravenna and Walsh (2006), if an exogenous loan rate shock is not present, the wedge between the lending rate and the policy rate disappears when $\psi_r = 0$.

[8]See Chowdhury, Hoffman and Schabert (2006) for a detailed discussion of Eq. (35).

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

$$\pi_{H,t} = \beta E_t \pi_{H,t+1} + \kappa \hat{\varphi}_t, \tag{36}$$

where $\kappa = (1-\omega)(1-\omega\beta)/\omega$ and $\pi_{H,t}$ is producer price inflation. Substituting Eq. (32) into Eq. (37), an open-economy NKPC expressed in terms of the output gap is derived as follows:

$$\pi_{H,t} = \beta E_t \pi_{H,t+1} + \kappa[\hat{R}_t^L + (\sigma + \phi - \chi) y_t + \chi y_t^*], \tag{37}$$

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

$$y_t = E_t y_{t+1} + \zeta(E_t y_{t+1}^* - y_t^*) - \sigma_0^{-1}(\hat{R}_t - E_t \pi_{H,t+1} - \hat{R}_t^f), \tag{38}$$

where $\zeta = \sigma\vartheta/\Omega$ and $\sigma_0 = \sigma(1+\vartheta)/\Omega$.

The variables under flexible price equilibrium are as follows:

$$\hat{R}_t^f = \sigma_0 \vartheta (E_t \hat{Y}_{t+1}^{f*} - \hat{Y}_t^{f*}) + \sigma_0 (E_t \hat{Y}_{t+1}^f - \hat{Y}_t^f), \tag{39}$$

$$\hat{Q}_t^f = (1-\beta)\hat{\Gamma}_t^f + \beta(E_t \hat{Q}_{t+1}^f - \hat{R}_t^f), \tag{40}$$

$$\hat{\Gamma}_t^f = \hat{Y}_t^f, \tag{41}$$

$$(\sigma + \phi - \chi)\hat{Y}_t^f + \chi \hat{Y}_t^{f*} + \hat{R}_t^f = (1+\phi) Z_t. \tag{42}$$

Equation (39) represents the open-economy natural rate of interest that holds the real interest rate under flexible price equilibrium. Eqs (40) and (41) are the stock prices and dividends under the flexible price equilibrium. Eq. (42) describes the natural rate of output in an open economy model. In contrast to the natural rate of output found by 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:

$$\hat{R}_t - \hat{R}_t^* = E_t \hat{e}_{t+1} - \hat{e}_t. \tag{43}$$

To close the model, the monetary policy rule used in this study. This study employs the standard monetary policy rule suggested by Taylor (1993), which specifies a log-linearised monetary policy rule as follows:

$$\hat{R}_t = \phi_\pi \pi_{H,t} + \phi_y y_t + u_t, \tag{44}$$

where ϕ_π is the coefficient of the rate of inflation, and ϕ_y is the coefficient of the output gap, and u_t is a monetary policy shock.

4 Calibration

This section describes the parameters used in this study. The degree of price rigidity ω is set 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), a value of 2.0 is used 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), the value of γ is set to 0.2. The elasticity of substitution for individual goods θ is set to 5.0, based on the value calibrated in the existing literature.

Several studies have reported the degree of financial market imperfection ψ_r. Ravenna and Walsh (2006) report that the value of the parameter ψ_r is 0.276. Chowdhury, Hoffmann and Schabert (2006) estimate a value of financial market imperfection of 0.32 for the United States. Castelnuovo (2007) uses the values $\psi_r \in \{0.5, 1.7\}$.[9] Therefore, this paper uses the values $\psi_r \in \{0, 3\}$. This slightly larger value of ψ_r than previous studies is used in order to examine how more severe financial imperfections change the international transmission mechanism of structural shocks in one country. This paper

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

mainly focuses 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 0.25 based on the estimation value obtained by Ravenna and Walsh (2006), and several values calibrated in the aforementioned studies are assigned to the foreign countries.

The parameters for the monetary policy rule are as follows As a benchmark, 1.5 and 0.5are used for ϕ_π and ϕ_y for each country. Finally, with regard to the standard deviation of economic shocks, this paper assumes that σ_ν, σ_z, and σ_u are all set to 0.01. This paper assumes that the parameters ρ_ν, ρ_z, and ρ_u are set to 0.8, 0.8 and 0.5, respectively. Table 1 summarises the deep parameters calibrated in this study.

[Table 1 around here]

5 Worldwide equilibrium determinacy under incomplete loan rate pass-through

This section explores how the presence of incomplete loan rate pass-through of affects determinacy of the global equilibrium. First, Figure 1 plots how the degree of loan rate pass-through changes the worldwide determinacy regions under several parameterisations of γ.

[Figure 1 around here]

According to this figure, a larger value of γ expands the determinacy regions for a larger values for ψ_r and ψ_r^*. A smaller value of γ implies that one country is closed to the closed economy. This is the extreme case of $\gamma = 0.01$. On the other hand, when $\gamma = 0.4$, even severe incompleteness of loan rate pass-through in one country makes the worldwide REE determinate as long as it takes a smaller value in another country. Indeed, if ψ_r is less than 0.5, the global REE is determinate even if ψ_r^* takes a value of 3.0, although this seems to be the gain created by an open economy effect. Bullard and Scaling (2009) show the worldwide determinacy condition based on Clarida, Gali

and Gertler (2002), but they abstract the role of financial market imperfections. This paper demonstrates how a change of γ affects the worldwide determinacy condition in the presence of financial market imperfections in both countries.

[Figure 2 around here]

Second, this paper examines how the degree of σa affects the determinacy condition of the worldwide equilibrium. Figure 2 shows how a combination of ψ_r and ψ_r^* changes the worldwide determinacy condition under several parameterisations of σa. $\sigma a = 1$, a larger value of $\sigma a > 1$ can expand the worldwide determinacy regions for larger values of ψ_r and ψ_r^*. Thus, $\sigma a > 1$ can expand the worldwide determinacy regions, whereas, conversely, an extremely larger value of it conversely shrinks the worldwide REE. Indeed, when $\sigma a = 10$, the region of the worldwide REE is smaller than in the case of $\sigma a = 4$. Interestingly, the worldwide REE is drastically reduced when σa is less than unity. In particular, in the extreme case of $\sigma a = 0.2$, both countries can achieve the worldwide REE only for a much smaller value of both ψ_r and ψ_r^*.

The intuition of these results is as follows. The interdependence exists between two countries unless $\gamma \neq 0$ or $\gamma = 1$. Suppose that a sunspot shock occurs in the foreign country that increases both inflation and the output gap. In the case of $\sigma a > 1$, such a foreign sunspot shock causes an appreciation of the home terms of trade, creating a deflationary pressure on the home country. Thanks to the presence of incomplete loan rate pass-through in the home country, the home central bank can alleviate such deflationary pressure by aggressively cutting its policy rate. Put differently, the home central bank can prevent a sunspot deflationary equilibrium originating from a foreign sunspot shock. This gain is associated with interdependence between two countries through an open economy.

In the case of $\sigma a < 1$, however, a foreign sunspot shock generates an inflationary pressure on the home country through a depreciation of the home terms of trade. As Llosa and Tuesta (2009) and Surico (2008) show, the presence of the cost channel requires there to be an upper bound for the response to inflation in the policy rule. Therefore, the home central bank may not stabilise a fluctuation in home inflation caused by a foreign

sunspot shock in the case of a larger value of ψ_r. Accordingly, a foreign sunspot shock renders the equilibrium in the home country unstable.

[Figure 3 around here]

Next, how the difference in inflation stabilisation in both countries affects the global equilibrium determinacy condition in the presence of incomplete loan rate pass-through will be analysed. Figure 3 portrays determinacy of the world equilibrium under several parameterisations of ϕ_π and ϕ^*_π.[10] In the case of no incomplete loan rate pass-through in the foreign country, both central banks can achieve the unique worldwide REE if they respond more than one for one to inflation, namely the Taylor principle. This is consistent with previous studies.

This result is overturned, however, when ψ^*_r is above unity. When $\psi^*_r = 1.5$, both central banks need to satisfy the Taylor principle, and upper bounds exist for both ϕ_π and ϕ^*_π. For instance, regardless of whether the parameter ϕ^*_π satisfies the Taylor principle, the home central bank that sets ϕ_π to above 4.0 can make the world equilibrium indeterminate. This is more severe in the case of a larger value of ψ^*_r. In particular, when $\psi^*_r = 3.0$, the worldwide equilibrium is always indeterminate unless the foreign central bank sets ϕ^*_π to a value around 2.0. In contrast to the case discussed by Llosa and Tuesta (2009), this paper stresses that this result is specific to the case of an open economy framework. Put differently, the result of Figure 3 implies that more severe conditions are needed to achieve the REE than argued by Llosa and Tuesta (2009).

[Figure 4 around here]

Finally, it will be explored how the difference in stabilisation of the output gap in both countries affects the worldwide REE. As shown by Surico (2008) and Llosa and Tuesta (2009), in a model with the cost channel, a larger value of the output gap stabilisation in the Taylor rule is likely to induce equilibrium indeterminacy. This paper explores whether their results hold in the case of a two-country model.

[10] I maintain $\psi_r = 0.25$ in this simulation.

Figure 4 illustrates the determinacy regions when ϕ_x and ϕ_x^* change. It can be seen that when the loan rate pass-through is complete in the foreign economy, the worldwide unique REE is achieved as long as ϕ_x and ϕ_x^* take a larger value. For instance, even in the case of $\phi_x = 2.0$ and $\phi_x^* = 2.0$, both central banks could attain the worldwide unique REE. On the contrary, as the incompleteness of loan rate pass-through becomes more severe, a combination of smaller values of both ϕ_x and ϕ_x^* can make the worldwide REE determinate. Interestingly, when the parameter ψ_r^* is above unity, a combination of ϕ_x and ϕ_x^* is more restricted by a lower bound on these parameters. As Figure 4 shows, this restriction on parameters ϕ_x and ϕ_x^* is more severe when ψ_r^* takes a larger value. In particular, both upper and lower bounds for ϕ_x^* are very restrictive when $\psi_r^* = 3.0$. Accordingly, in contrast to the case of Llosa and Tuesta (2009) and Surico (2008), the open economy forces the restriction on the stabilisation of the output gap to become more severe if both central banks aim at attaining the determinacy of the global equilibrium.

6 Transmission mechanism of financial market imperfections in an open economy

This section examines the international transmission mechanism of structural shocks in a two-country model with incomplete pass-through of the loan rate[11]. This section mainly focuses on the case where ψ_r^* changes when shocks occur in the foreign country. Hence, the parameter ψ_r is set to 0.25 for the simulation in this section.

[Figure 5 around here]

Figure 5 illustrates the impulse response to a foreign productivity shock. As observed in previous studies, the productivity shock leads to a decline in inflation and an increase in output in the foreign country. This leads to appreciation of the real exchange rate in terms of the home country. A decline in the real exchange rate implies an improvement

[11] See Ida (2015) for impulse response analyses with/without a cost channel in a two-country economy. He also considers the performance of alternative monetary policy rules in the two-country model.

of the home terms of trade, reducing the home real marginal cost. Consequently, home inflation decreases, resulting in a decline in home output. Both home and foreign asset prices co-move in response to this shock. This co-movement becomes increasingly tightened as ψ_r^* takes a larger value. Importantly, this international transmission of a foreign productivity shock is amplified by a larger value of ψ_r^*. Notice that, home inflation seems to be unchanged by a large value of ψ_r^*, thereby inducing a substantial drop in home output. This indicates that the presence of incomplete loan rate pass-through in one country steadily affects the macrovariables of other countries.

[Figure 6 around here]

Figure 6 depicts the impulse response to a foreign loan rate shock. This loan rate shock acts as a cost-push shock (Ravenna and Walsh, 2006). Thus, a foreign loan rate shock leads to an increase in inflation and decline in output in the foreign country. This trade-off is worsened by a larger value of ψ_r^*. Such a foreign loan rate shock leads to an increase in the foreign policy rate, which induces a depreciation of the exchange rate in terms of the home country. This real exchange rate depreciation increases both inflation and output in the home country. Interestingly, this implies that a foreign loan rate shock, which generates a trade-off between inflation and output stabilisation in the foreign country, results in a boom in the home country. In particular, a larger value of ψ_r^* more aggressively increases home inflation for a foreign loan rate shock. It follows from Figure 6 that this boom is amplified with more severe incomplete pass-through of the foreign loan rate ψ_r^*. Finally, a co-movement of both home and foreign asset prices can also be observed in the case of a foreign loan rate shock. A larger value of ψ_r^* amplifies this co-movement. A loan rate shock can be regarded as tightness of a credit market. Therefore, regardless of the simple introduction of financial market imperfections to examine the role of incomplete loan rate pass-through in an open economy, this result might partially explain the simultaneous decline in international stock prices after the Lehman collapse that originated in the United States.

[Table 2 around here]

Table 2 summarises standard deviations of key macrovariables for both countries under several parameterisations of incompleteness of foreign loan rate pass-through ψ_r^*. The result of Table 2 is consistent with that of the impulse response analysis. Compared with the case of complete foreign loan rate pass-through (i.e. $\psi_r^* = 0$), a larger value of ψ_r^* generates larger standard deviations of both inflation and the output gap in the foreign country. This leads to a large fluctuation in the real exchange rate, thereby creating a larger fluctuation on the home output gap. As Figures 1 shows, the standard deviation of home inflation seems to be unaffected by the degree of ψ_r^*.[12]

The results obtained from an impulse response analysis and standard deviations of macrovariables reveal that the presence of financial market imperfections in the foreign country is never negligible to the home country. 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 a home loss function as follows:

$$L_{H,t} = (1-\beta)E_0 \sum_{t=0}^{\infty} \beta^t (\pi_{H,t}^2 + \alpha y_t^2), \tag{45}$$

The parameter α represents the weight of the output gap relative to inflation stabilisation. The parameter α is set to 0.25 based on the existing literature in the new Keynesian model.[13]

This paper addresses the advantages of using this loss function. First, this loss function is simple and intuitively understandable. Second, several studies faced difficulty in deriving the central bank's loss function use this simple criterion (Bernanke and Gertler, 1999; Monacelli, 2005; Kannan, Rabanal and Scott, 2012). Third, Equation (45) resembles the loss function derived under the assumption of no policy coordination by Clarida,

[12]This standard deviation is calculated for a case that contains both foreign productivity and loan rate shocks. Therefore, it can be easily confirmed that home inflation is affected by a larger value of ψ_r^* by considering the case where a foreign loan rate shock only occurs in the simulation.

[13]A robustness check of this result was conducted under several parameterisation of α. The result remains unchanged for any value of α. The detailed calculation of this robustness check is available on request.

Gali and Gertler (2002).[14][15]

[Figure 7 around here]

Figure 7 illustrates the home welfare loss when γ and ψ_r^* change under a foreign productivity shock. If a closed economy is assumed, the welfare loss appears to be almost null. However, even in the case of $\gamma = 0$, a larger value of ψ_r^* increases the home welfare loss. This is because the foreign loan rate induced by a change in ψ_r^* affects the home policy rate through an interest rate parity condition. Therefore, a rise in ψ_r^* causes fluctuations in macrovariables in the home country. This tendency remains unchanged even for a smaller value of γ. However, when γ is above 0.2, the home welfare loss increases again as ψ_r^* takes a larger value. For instance, for a range $\gamma \in [0, 0.5)$,the maximum welfare loss is roughly 2% when $\psi_r^* = 2.0$.

[Figure 8 around here]

Figure 8 shows the home welfare loss under several combinations of γ and ψ_r^* when a loan rate shock occurs in the foreign country. Compared with the case depicted in Figure 1, the home welfare loss is larger in the case of a foreign loan rate shock than in a foreign productivity shock. The maximum welfare loss is achieved at the combination of $\gamma = 0.5$ and $\psi_r^* = 2.0$. It follows from Figure 8 that the home welfare loss is about 7% at values of this combination.

[Figure 9 around here]

[14]As explained by Walsh (2005), this criterion may lead to misguiding results. In the two-country model, Clarida, Gali and Gertler (2002) derive the central bank's loss function in the case of policy coordination as well as no policy coordination. In their analysis, the welfare criterion under no policy coordination is related to the home loss function in the present model. Such a criterion is derived under the presumption that the home country treats foreign variables as given. However, this paper does not 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 the present paper's purpose.

[15]More precisely, they derive the loss function under no policy coordination in the case of $a = 1$.

Incomplete pass-through of the home loan rate ψ_r is set to 0.25 as a benchmark value. Now, how the home welfare loss changes in accordance with combinations of both ψ_r and ψ_r^* will be analysed. Figure 9 demonstrates the home welfare loss when both ψ_r and ψ_r^* in the case of a foreign productivity shock. The home welfare loss seems negligible unless ψ_r is above unity. When $\psi_r = 2.0$, an increase in ψ_r^* appears to reduce the home welfare loss within $\psi_r^* \in (0, 1.5)$. However, the welfare loss increases again when ψ_r^* is above 1.6. In particular, when ψ_r^* takes 2.0, the maximum welfare loss is attained regardless of any values of ψ_r.

[Figure 10 around here]

Finally, Figure 10 plots the home welfare loss when both ψ_r and ψ_r^* change in the case of a foreign loan rate shock. As the value of ψ_r^* decreases, a larger value of ψ_r increases the home welfare loss. In particular, when loan rate pass-through is complete in the foreign country (i.e. $\psi_r^* = 0$), the maximum welfare loss is about 6% in the case of $\psi_r = 2.0$. Interestingly, in contrast to the case of Figure 9, a larger value of ψ_r^* reduces the home welfare loss if ψ_r takes a smaller value. In particular, the case of $\psi_r = \psi_r^* = 2.0$ leads to the smallest welfare loss for the home country across all combinations of ψ_r and ψ_r^*.

7 Concluding remarks

The objective of this study was to examine 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 such a two-country framework. In the case of no financial friction in the foreign country, the findings obtained for a standard open economy model are applicable to the present model. However, the presence of financial frictions in both countries significantly changes the implications for monetary policy derived in a standard two-country model. The findings of this paper are summarised as follows.

This paper showed how the severity of incomplete loan rate pass-through changes the global determinacy condition. More concretely, it shows that a change in openness affects the worldwide determinacy condition in the presence of financial market imperfections in both countries. The present paper also shows that whether domestic and foreign goods are substitute or complements in the Pareto-Edgeworth sense will affect global determinacy conditions. When both goods are Pareto-Edgeworth substitutes, the worldwide equilibrium attains determinacy even in the presence of severe financial market imperfections in both countries. However, the determinacy regions of the global equilibrium shrink drastically when both goods are Pareto-Edgeworth complements.

Next, we examined how the difference in inflation stabilisation across both countries affects the global equilibrium determinacy in the presence of incomplete loan rate pass-through. In the case of no incomplete loan rate pass-through in the foreign country, home and foreign central banks can achieve the unique worldwide REE if they respond more than one-for-one to inflation, i.e. the Taylor principle. This is consistent with previous studies. However, this result is overturned when incomplete pass-through of the loan rate is more severe in the foreign country. In particular, the worldwide equilibrium is always indeterminate unless the foreign central bank sets inflation stabilisation in the policy rule to a value of around 2.0. In contrast to the findings of Llosa and Tuesta (2009) and Surico (2008), this study found that the coefficient for the output gap in the Taylor rule is more restricted by an open economy effect when incompleteness of loan rate pass-through is more severe in the foreign country. In particular, both upper and lower bounds for the output gap stabilisation in the foreign policy rule are more restrictive when loan rate pass-through is more incomplete in the foreign country. Accordingly, the open economy increases the severity of the restriction on the output gap stabilisation if both central banks aim at attaining the determinacy of the world equilibrium.

The present study also showed how a change in foreign loan rate pass-through affects international transmission mechanism of foreign structural shocks. A foreign productivity shock leads to a decline in both inflation and output in the home country. Severe incomplete pass-through of the foreign loan rate induces a huge decline in home output,

whereas home inflation is not subject to a change in foreign loan rate pass-through. On the other hand, a foreign loan rate shock results in a boom in the home country. This boom is amplified by a severe foreign loan rate pass-through. This paper showed that a change in foreign loan rate pass-through significantly affects the welfare loss in terms of the home country. Specifically, compared with the case of a foreign productivity shock, the home welfare loss is deteriorated by the severity of foreign incomplete loan rate pass-through in the case of a foreign loan rate shock.

Finally, this paper has some limitations and future studies could address these as well as 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 by 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. It would therefore be interesting to assess how financial market imperfections affect an open macroeconomic model with an incomplete exchange rate pass-through. Optimal monetary policy in a two-country economy with financial market imperfections might also be worth investigating. It would be interesting to better understand how the 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.

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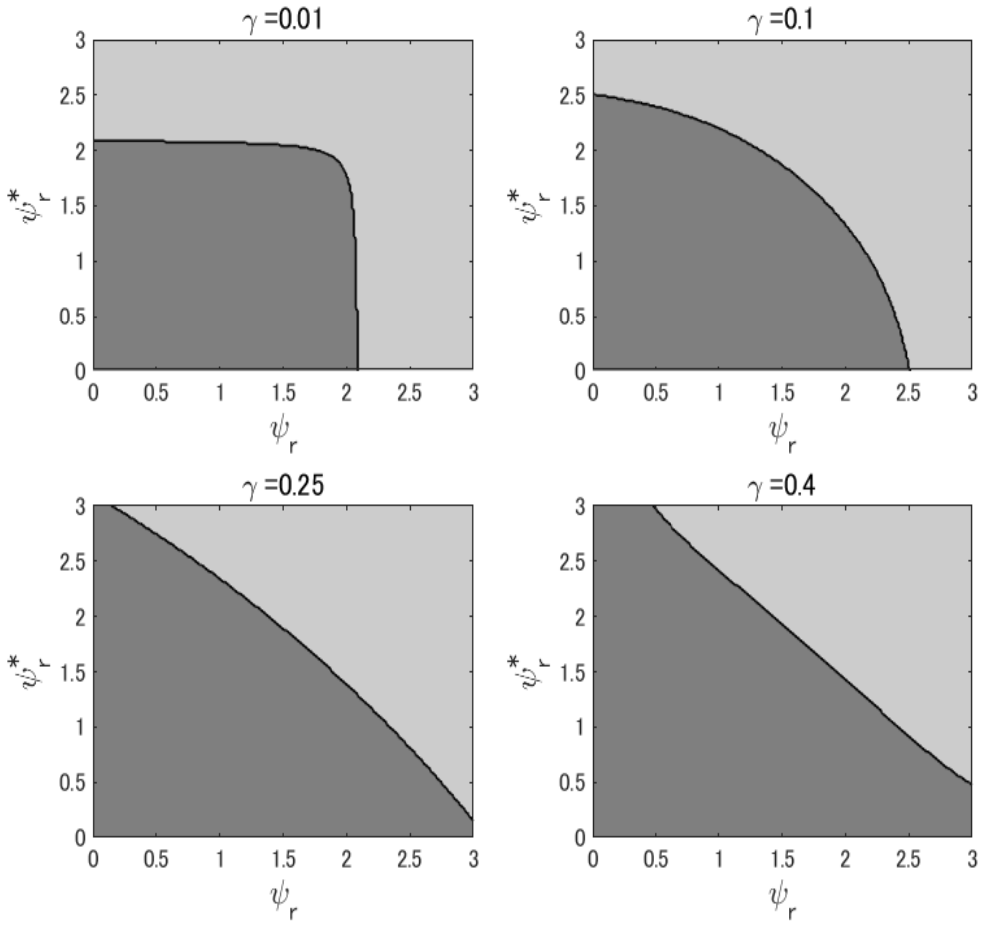
Table 1: Calibrated parameter values

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 labour supply	1.0
γ	Degree of openness	0.2
θ	Elasticity of substitution between individual goods	5.0
a	Elasticity of substitution between home and foreign goods	1.5
ϕ_π	Inflation stabilisation in the Taylor rule	1.5
ϕ_y	Stabilisation of the output gap in the Taylor rule	0.5
σ_z	Standard deviation of a productivity shock	0.01
σ_ν	Standard deviation of a loan rate shock	0.01
σ_u	Standard deviation of a monetary policy shock	0.01
ρ_z	Auto-regression coefficient for a productivity shock	0.8
ρ_ν	Auto-regression coefficient for a loan rate shock	0.8
ρ_u	Auto-regression coefficient for a monetary policy shock	0.5

Table 2: Standard deviations of key macrovariables under several parameterisations of ψ_r^*

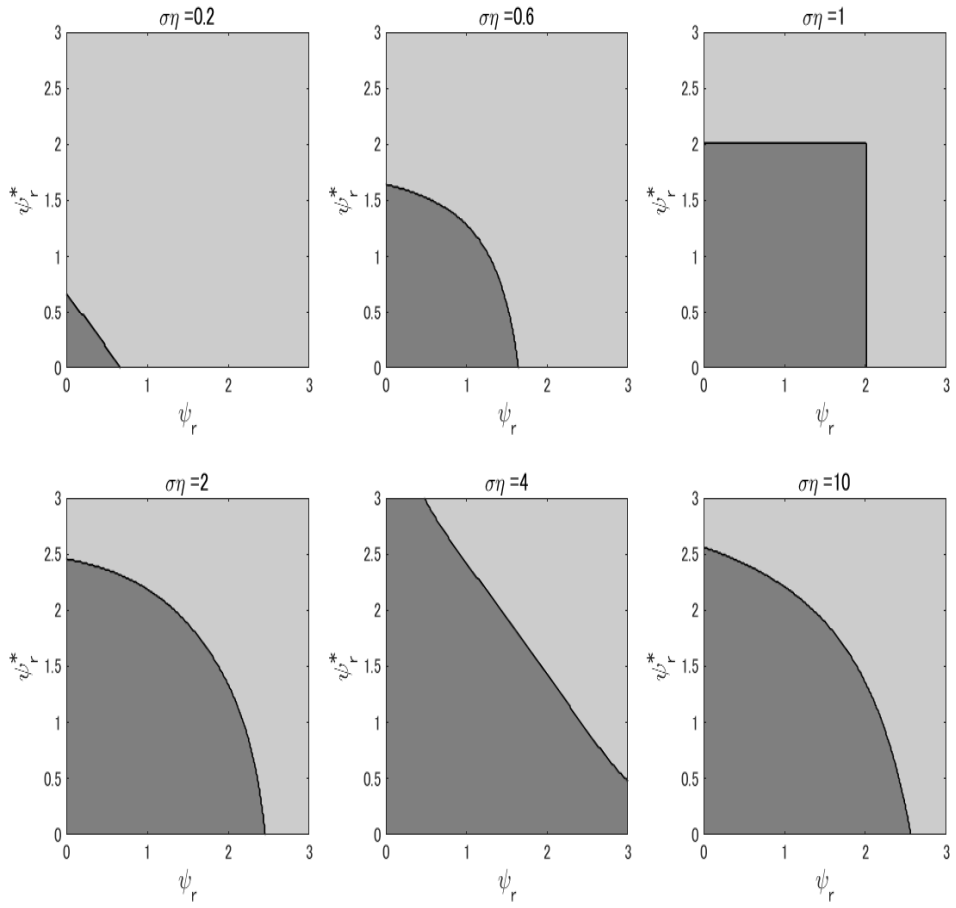
Variables	$\psi_r^* = 0$	$\psi_r^* = 1.0$	$\psi_r^* = 2.0$
Home inflation	0.125	0.130	0.140
Foreign inflation	0.493	0.646	1.000
Home output gap	0.209	0.243	0.325
Foreign output gap	0.906	1.090	1.553
Real exchange rate	1.080	1.264	1.625

Figure 1: Worldwide equilibrium determinacy when ψ_r and ψ_r^* change



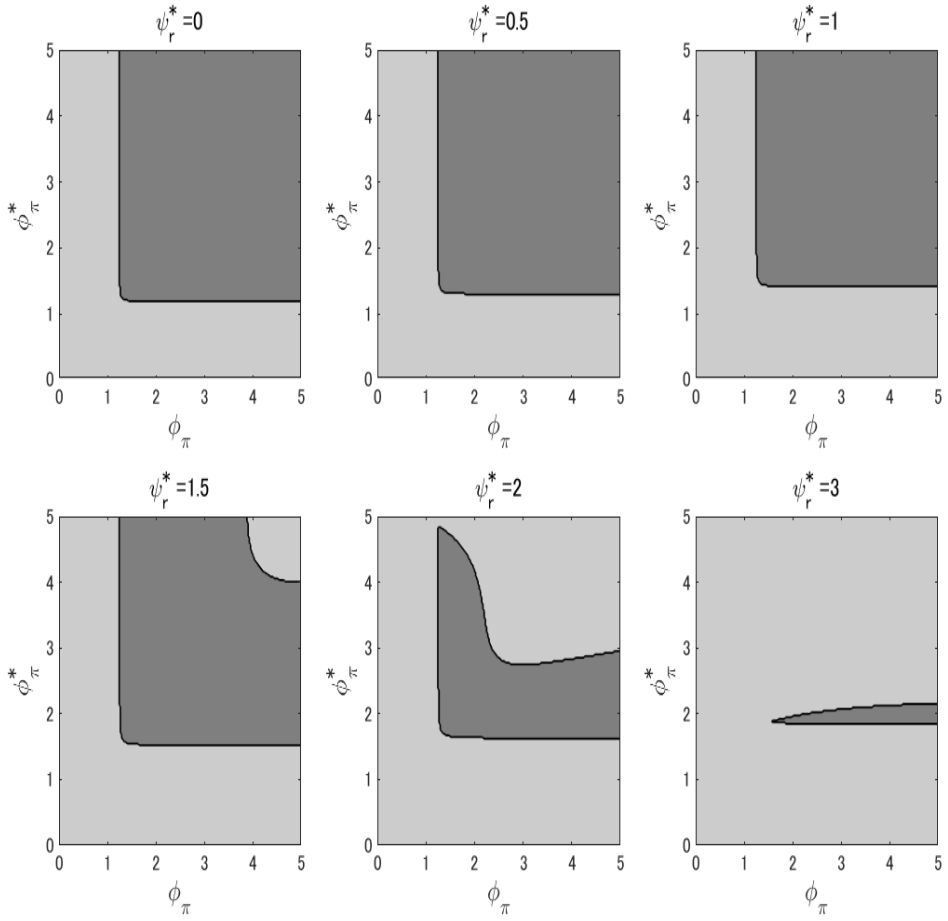
Note: Dark and light shading indicates determinate and indeterminate regions, respectively.

Figure 2: Worldwide equilibrium determinacy when ψ_r and ψ_r^* change



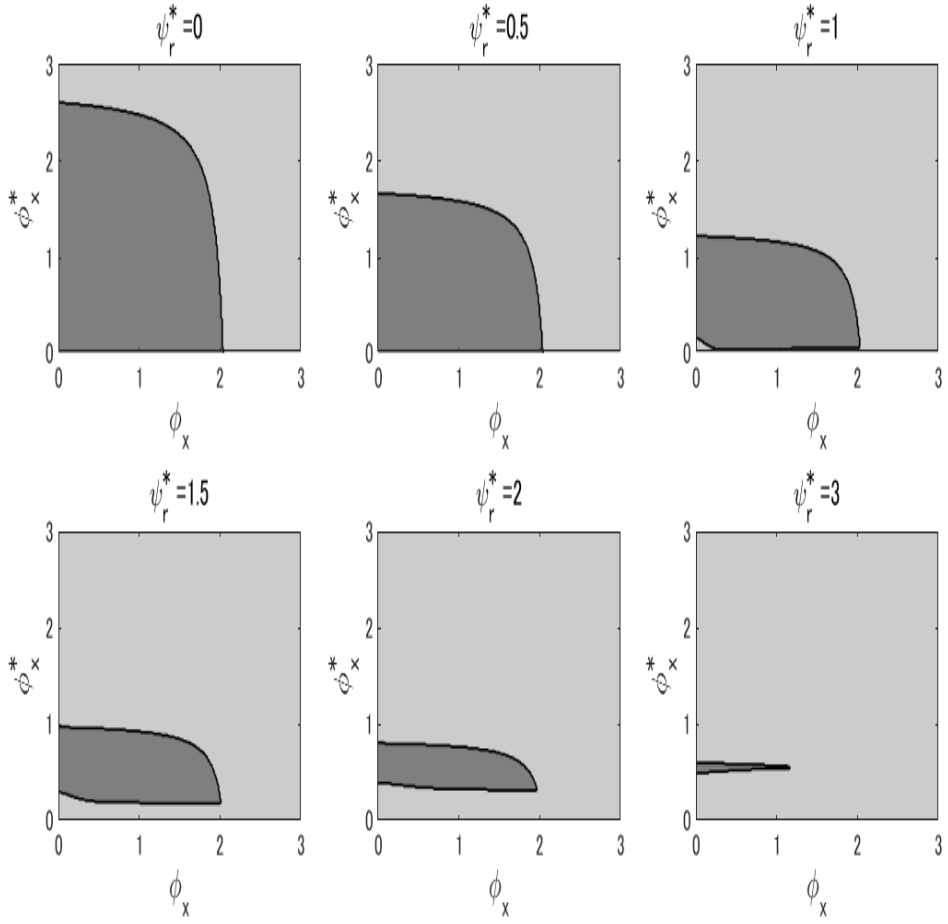
Note: Dark and light shading indicates determinate and indeterminate regions, respectively.

Figure 3: Worldwide equilibrium determinacy when ϕ_π and ϕ_π^* change



Note: Dark and light shading indicates determinate and indeterminate regions, respectively.

Figure 4: Worldwide equilibrium determinacy when ϕ_x and ϕ_x^* change



Note: Dark and light shading indicates determinate and indeterminate regions, respectively.

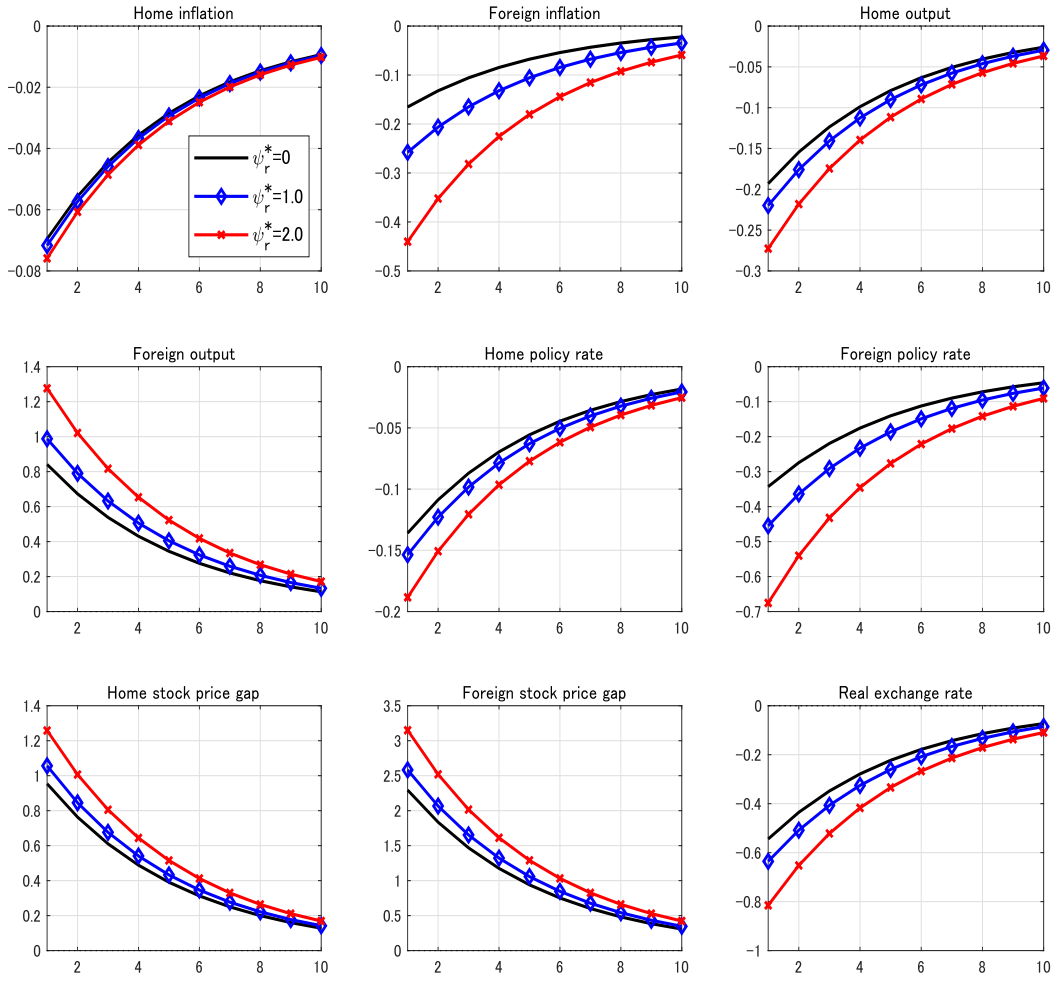


Figure 5: Impulse response to a foreign productivity shock

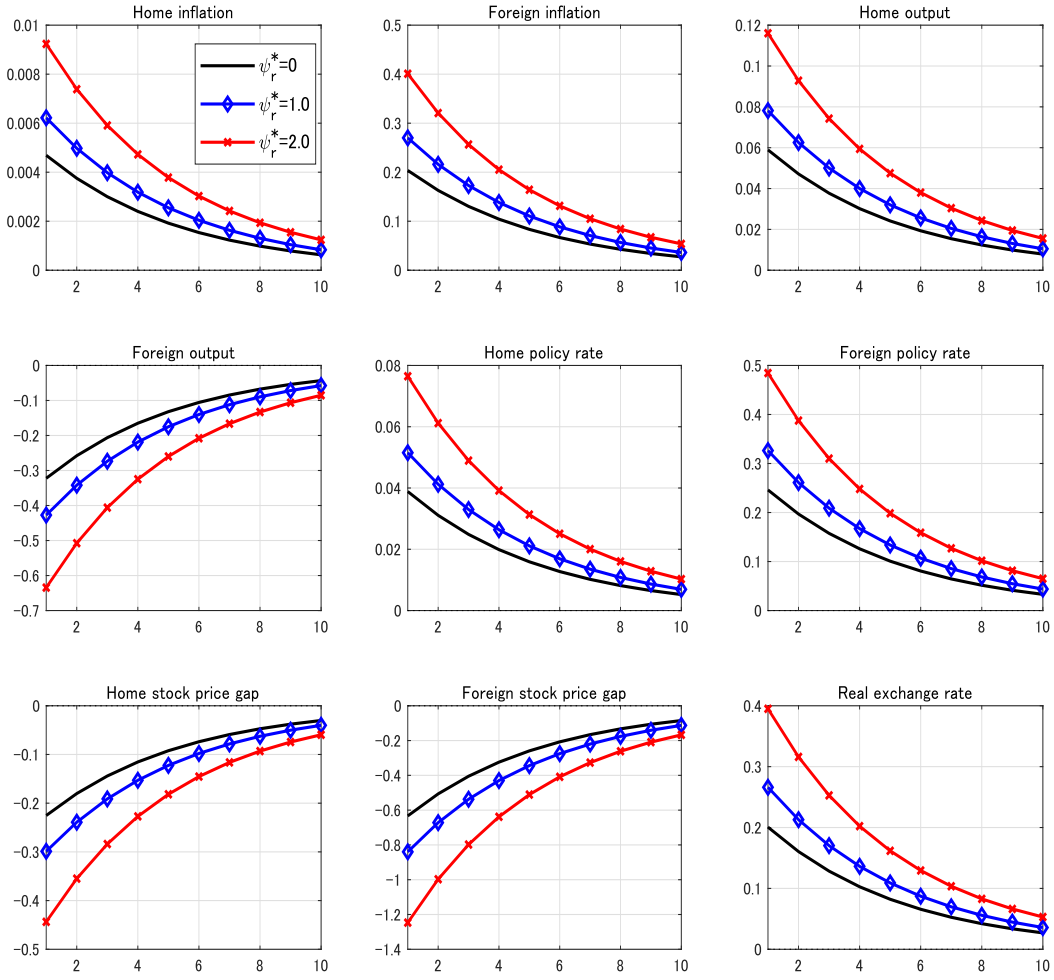


Figure 6: Impulse response to a foreign loan rate shock

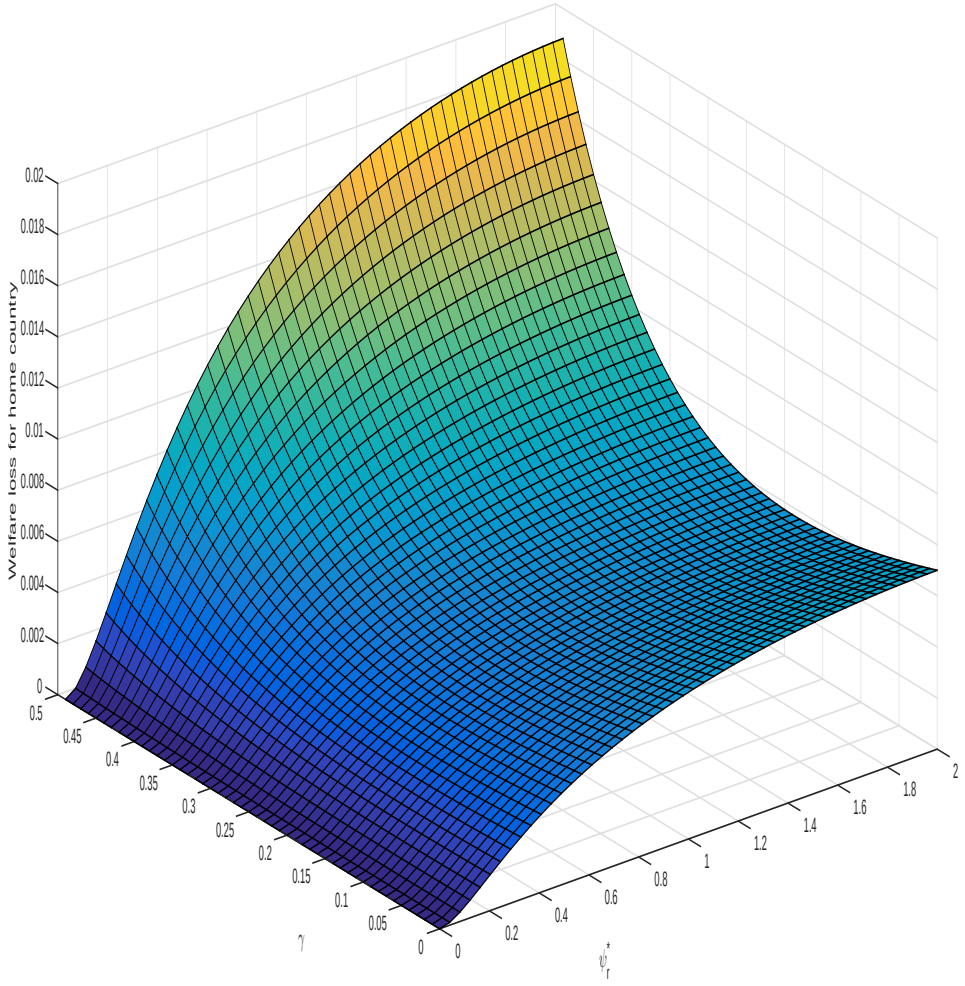


Figure 7: Welfare loss for home country under a foreign productivity shock

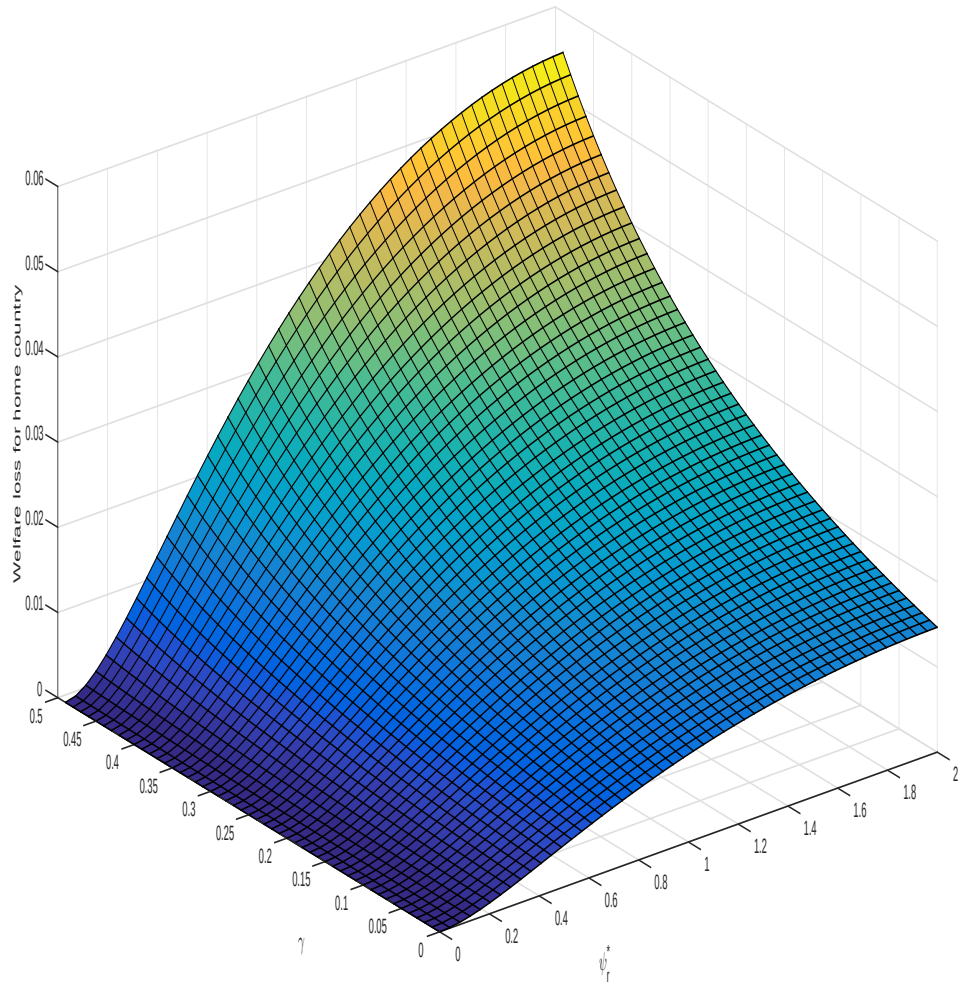


Figure 8: Welfare loss for home country under a foreign loan rate shock

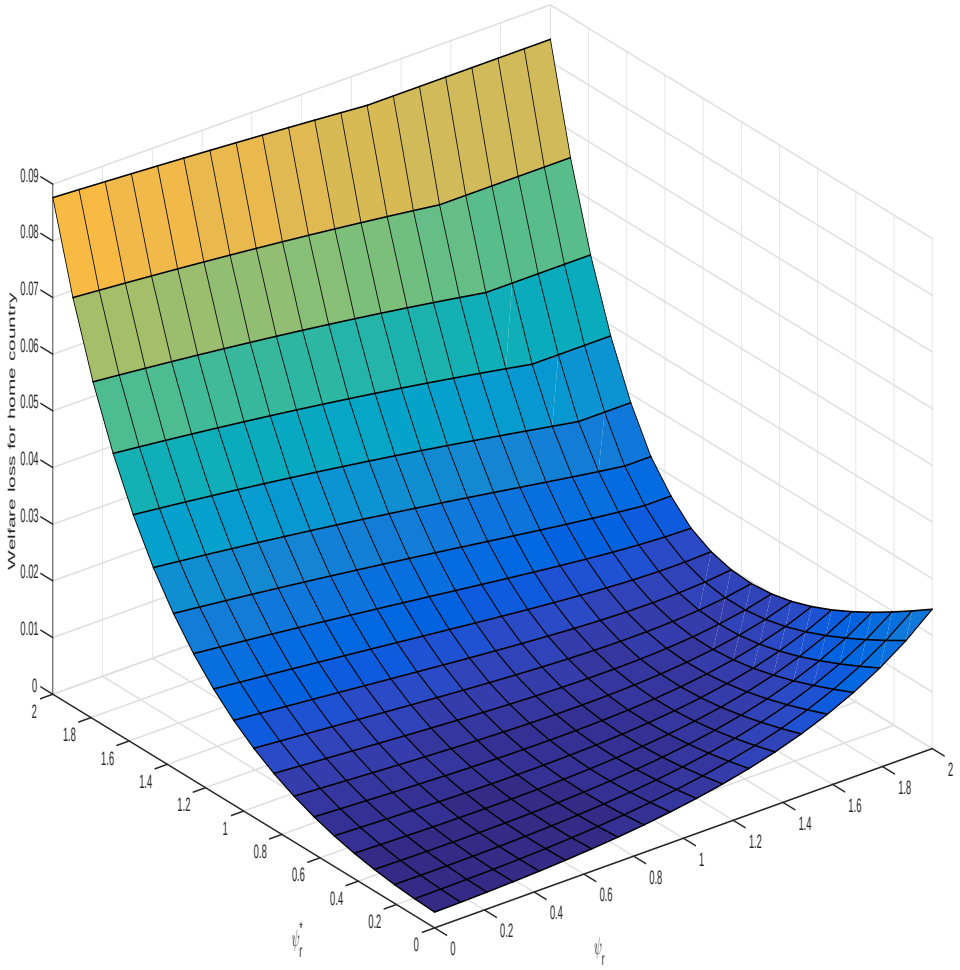


Figure 9: Welfare loss for home country under a foreign productivity shock

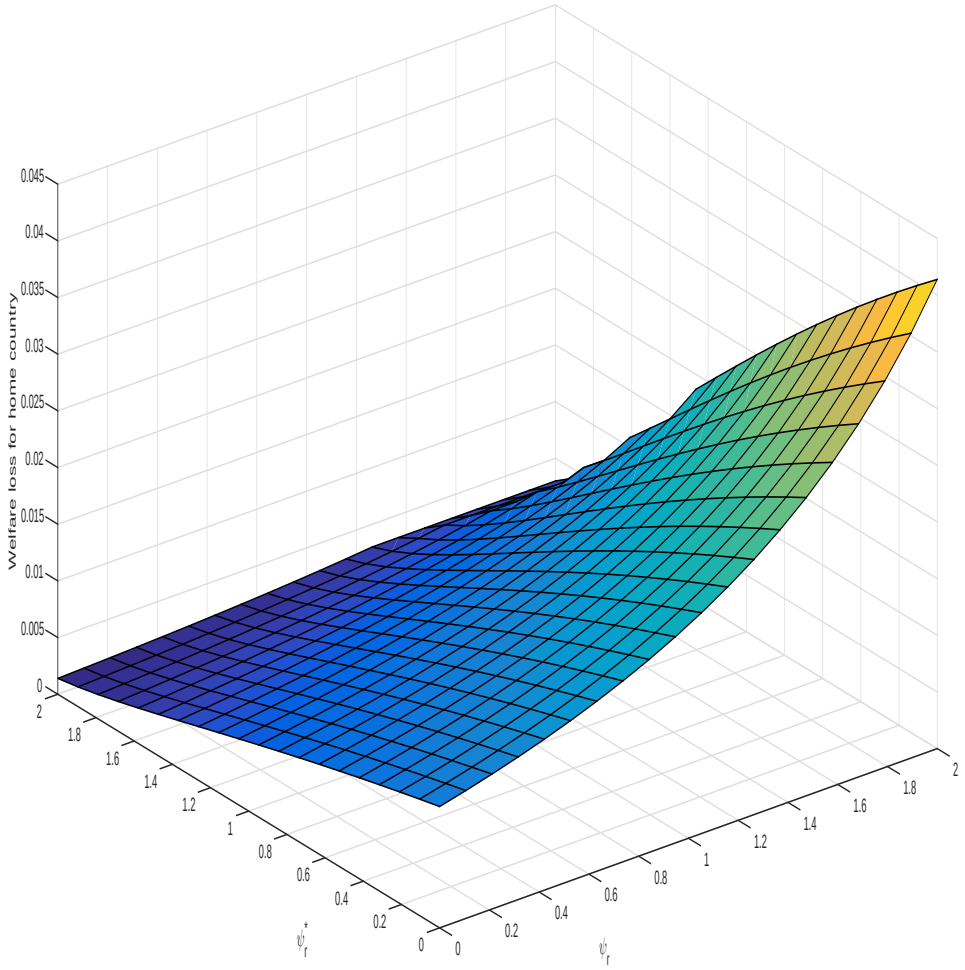


Figure 10: Welfare loss for home country under a foreign loan rate shock