Discussion Paper Series

RIEB

Kobe University

DP2023-12

Capital Controls or Macroprudential Regulation: Which is Better for Land Booms and Busts?

Yang ZHOU

Shigeto KITANO

April 28, 2023

Research Institute for Economics and Business Administration

Kobe University

2-1 Rokkodai, Nada, Kobe 657-8501 JAPAN

Capital controls or macroprudential regulation: Which is better for land booms and busts?*

Yang Zhou†   Shigeto Kitano‡

Abstract

Emerging markets have experienced land booms and busts along with international capital inflows and outflows repeatedly. This study quantitatively examines the effectiveness of (i) macroprudential policies targeting land markets and (ii) capital controls targeting capital inflows and outflows. We analyze which policy better manages the coincidence between land booms (busts) and capital inflows (outflows). We build a small open economy NK-DSGE model in which banks choose their asset portfolio between physical capital and land subject to financial constraints. The quantitative results show that the superiority of the two policies depends on the type of shock impacting a small open economy. In the case of domestic land market shocks, macroprudential policies enhance welfare, whereas capital controls reduce welfare. Conversely, in the case of foreign interest rate shocks, the superiority of the two policies is reversed: capital controls enhance welfare, while macroprudential policies deteriorate welfare.

Keywords: Capital control, Macroprudential policy, Financial frictions, Balance sheets channel, DSGE

JEL classification: E69, F32, F38, F41

*This work was supported by JSPS KAKENHI (20K01744, 20H05633).

†Institute of Developing Economies, JETRO, 3-2-2, Wakaba, Mihama-ku, Chiba, 261-8545 Japan. Email: Yang_Zhou@ide.go.jp

‡Corresponding author. RIEB, Kobe University, 2-1, Rokkodai, Nada, Kobe, 657-8501 Japan, E-mail: kitano@rieb.kobe-u.ac.jp.

1 Introduction

There is a long historical association between international capital inflows, real estate booms, and ensuing financial crises (Reinhart and Rogoff, 2009). After 2000, many countries suffered from real estate booms (busts) and capital inflows (outflows) during the same period. The coincidence between real estate booms (busts) and capital inflows (outflows) is a robust global phenomenon in advanced and emerging countries (Ferrero, 2015). Large capital inflows and real estate booms in the United States before the global financial crisis of 2008–9 have elicited considerable discussion (e.g., Bernanke, 2010). Against this background, the coincidence between real estate booms (busts) and international capital inflows (outflows) since the 2000s has been rigorously examined in many studies (e.g., Obstfeld and Rogoff, 2009; Aizenman and Jinjarak, 2009; Favilukis et al., 2013; Ferrero, 2015; Cesa-Bianchi et al., 2015).

Emerging countries have long been suffering from this issue. For example, the coincidence between real estate booms and capital inflows in emerging countries occurred before the Asian crisis of the 1990s (Obstfeld and Rogoff, 2009). Another well-known episode is the unprecedented capital inflows and asset price bubbles in emerging countries before and after the global financial crisis (Ahmed and Zlate, 2014). Real estate boom-bust cycles and capital inflow-outflow cycles are important issues for policymakers, especially in emerging countries. Policymakers have two main policy alternatives: macroprudential policies targeting real estate markets and capital controls targeting capital flows. A reasonable question arises: which of these two policies should be adopted when dealing with the problematic coincidence? This study investigates the comparative advantages of macroprudential policies targeting real estate markets and capital controls limiting capital flows to address the problematic coincidence between real estate booms (busts) and capital inflows (outflows) in emerging countries. To examine which policy is more suitable, we incorporate land assets into a small open economy New Keynesian Dynamic Stochastic General

Equilibrium (NK-DSGE) model with banks borrowing from abroad *à la* Aoki et al. (2016).[1] [2] In our model, banks provide capital and land funds to firms for production. We consider two exogenous shocks: external (international) and internal (domestic). In our model, both types of exogenous shock replicate the coincidence between real estate booms (busts) and capital inflows (outflows). The two exogenous shocks are amplified through banks' balance sheets owing to the financial accelerator mechanism.

We find that the superiority between the two policies depends on the types of exogenous shocks striking a small open economy. When a small open economy suffers from foreign interest rate shocks, capital controls are welfare-enhancing, mitigate capital inflow-outflow cycles, and stabilize the fluctuation of the other macroeconomic variables. Conversely, macroprudential policies deteriorate welfare. Although macroprudential policies mitigate real estate boom-bust cycles, they cannot stabilize other macroeconomic variables such as output and consumption.

However, when a small open economy suffers from domestic land market shocks, the superiority between the two policies is reversed: macroprudential policies are better than capital controls. Capital controls deteriorate welfare in this case; although capital controls mitigate capital inflow-outflow cycles, they cannot stabilize other macroeconomic variables such as output and consumption. Contrarily, macroprudential policies are welfare-enhancing; they mitigate real estate boom-bust cycles and stabilize the fluctuation of other macroeconomic variables.

The remainder of this paper is organized as follows. In Section 2, we present a

---

[1] The seminal works modeling financial frictions in real estate markets are Iacoviello (2005, 2015), Iacoviello and Neri (2010), and Liu et al. (2013). They show that a collateral constraint that restricts household borrowing to a fraction of real estate amplifies business cycle fluctuations. There is extensive literature based on this mechanism (e.g., Kannan et al., 2012; Rubio and Carrasco-Gallego, 2015; Alpanda and Zubairy, 2017; Chen et al., 2020; Ferrero et al., 2022; Forster and Sun, 2022).

[2] The seminal works modeling financial intermediaries are Gertler and Kiyotaki (2010), Gertler and Karadi (2011), and Gertler et al. (2012). A growing body of literature exists on small open economy models based on the financial accelerator mechanism, including Aoki et al. (2016) (e.g., Ghilardi and Peiris, 2016; Jin and Xiong, 2018; Agénor et al., 2018; Cuadra and Nuguer, 2018; Kitano and Takaku, 2018; Mimir and Sunel, 2019).

small open economy NK-DSGE model *à la* Aoki et al. (2016) augmented with real estates (lands). Section 3 describes our calibration. Section 4 presents numerical experiments that shed light on the role of capital controls and macroprudential policies. Finally, Section 5 concludes the paper.

Related Literature.—Korinek and Sandri (2016) are the first to differentiate between macroprudential policies and capital controls.[3] [4] By distinguishing between domestic and foreign lending, they show that both policy measures stabilize the economy and reduce the severity of crises. They find that it is desirable to employ both instruments in a calibration based on the East Asian crisis countries. Building on Korinek and Sandri (2016)'s framework, Matschke (2022) shows that the analysis is most suitable for countries with less-developed domestic financial markets. Nispi Landi (2017) shows that the desirability between capital controls and macroprudential policies is shock-dependent. Capital controls are preferred over macroprudential policies under foreign interest rate and financial shocks. Conversely, macroprudential policies are more desirable under technology shocks. Kitano and Takaku (2020) show that the superiority between the two policies depends on the degree of financial friction between domestic banks and foreign investors. Under low financial friction in foreign borrowing, macroprudential policies are more appropriate than capital controls. Conversely, capital controls are more appropriate than macroprudential policies under high financial friction in foreign borrowing.

It is noteworthy that any of the above studies differentiating between macroprudential policies and capital controls do not consider real estates. To the best of our knowledge, this study is the first to analyze the superiority between the two

[3]Capital controls were first discussed as a policy tool for internalizing the externalities associated with financial crises and preventing excessive borrowing (e.g., Jeanne and Korinek, 2010; Bianchi, 2011; Brunnermeier and Sannikov, 2015). More studies have examined capital controls as a regular policy tool from different perspectives (e.g., Liu and Spiegel, 2015; Chang et al., 2015; Jin, 2016; Jung, 2016; Davis and Presno, 2017; Kitano and Takaku, 2018; Agénor and Jia, 2020; Johnson, 2021).

[4]Macroprudential policy has been examined mainly in terms of its interaction with monetary policy (e.g., Angeloni and Faia, 2013; Angelini et al., 2014; Levine and Lima, 2015; De Paoli and Paustian, 2017; Gelain and Ilbas, 2017; Van der Ghote, 2018; Palek and Schwanebeck, 2019).

policies for the problematic coincidence by incorporating real estates into a small open economy model.

2 Model

The model framework is similar to Aoki et al. (2016). However, we incorporate land assets into a small open economy NK-DSGE model *à la* Aoki et al. (2016). The model has seven types of agents: households, final goods firms, intermediate goods firms, capital investment firms, land investment firms, the government, and banks. Intermediate goods firms require land, in addition to capital, as a production input. Firms obtain funds from banks for land and capital acquisitions. Banks provide loans to firms using their net worth, household deposits, and foreign borrowing. The government uses capital controls to regulate banks' foreign borrowing. The government also uses macroprudential policies to regulate bank financing of firms' land acquisitions.

2.1 Households

Following Gertler and Karadi (2013), we assume that within a representative household, a fraction, f, are bankers, and a fraction, $1-f$, are workers. Workers supply labor to intermediate goods firms and obtain wages for the representative household. Each banker manages a financial institution and transfers dividends to the household. The banker is assumed to exit the market with probability σ to limit the banker's ability to accumulate wealth. The expected survival time of a banker is $1/(1-\sigma)$, and $(1-\sigma)f$ of bankers exit and transfer their remaining net worth as dividends to the household. Exited bankers become workers, and the same number of workers become bankers. The household supplies new bankers with start-up funds.

We adopt the GHH preference for the representative household's expected lifetime utility as follows:

$$E_0 \left[\sum_{t=0}^{\infty} \beta^t \ln \left(C_t - \frac{\zeta_0}{1+\zeta} h_t^{1+\zeta} \right) \right], \tag{1}$$

where E_0 is the expectation operator conditional on date 0 information.[5] C_t and h_t denote consumption and labor supply, respectively. $\beta \in (0,1)$, ζ, and $\zeta_0 (> 0)$ denote the discount factor, the inverse of Frisch elasticity of labor supply, and the relative utility weight of labor, respectively.

The household's budget constraint is given by

$$\begin{aligned} & C_t + Q_t K_t^h + \chi\left(K_t^h\right) + Q_t^l L_t^h + \chi^l\left(L_t^h\right) + D_t \\ & \qquad = w_t h_t + \Pi_t + \left(Z_t + \lambda Q_t\right) K_{t-1}^h + \left(Z_t^l + \lambda^l Q_t^l\right) \xi_t^l L_{t-1}^h + R_t D_{t-1}, \end{aligned} \tag{2}$$

where w_t is the real wage, and K_t^h and L_t^h denote households' capital and land holdings, respectively. The payoffs in period t for holding capital and the land acquired in period $t-1$ are $(Z_t + \lambda Q_t)$ and $\left(Z_t^l + \lambda^l Q_t^l\right) \xi_t^l$, respectively. Z_t and Z_t^l are the rental rates for capital and land, respectively. Q_t and Q_t^l are capital and land prices, respectively. λ and λ^l denote one minus depreciation rates of capital and land, respectively. ξ_t^l represents the land market shock. We assume that there is the land market shock ξ_t^l to introduce an exogenous source of variation in the return on landholding in a simple way.[6] D_t is the household's bank deposit. The gross real return on deposits, R_t, is given by

$$R_t = \frac{1 + i_{t-1}}{\pi_t}, \tag{3}$$

[5]The GHH preference by Greenwood et al. (1988) is commonly used in open economy literature. It abstracts from the wealth effects on labor supply and captures procyclical employment (Aoki et al., 2016). This is suitable for matching open economies' second moments (Correia et al., 1995; Raffo, 2008; Luk and Zheng, 2020). For more details, see, for example, Mendoza (1991) and Neumeyer and Perri (2005).

[6]The land shock corresponds to the capital shock in Gertler et al. (2012) and Gertler and Karadi (2013), which serves as an exogenous trigger of asset price dynamics.

where i_t denotes the nominal interest rate on the deposit, and $\pi_t = P_t/P_{t-1}$ is the inflation rate. We assume that although households can directly obtain capital and land, there exist extra management costs for capital and landholdings (Aoki et al., 2016):

$$\chi\left(K_t^h\right) = \frac{\varkappa}{2}\left(K_t^h\right)^2, \quad \chi^l\left(L_t^h\right) = \frac{\varkappa^l}{2}\left(L_t^h\right)^2, \tag{4}$$

where the positive values of $\varkappa$ and $\varkappa^l (> 0)$ imply a disadvantage for workers in financing relative to bankers. Π_t in (2) denotes the total profits from firms and banks (net start-up funds for bankers). We show the details of Π_t in Appendix A3.

The representative household chooses labor supply h_t, deposit D_t, capital holding K_t^h, land holding L_t^h, and consumption C_t to maximize the expected lifetime utility (1) subject to the budget constraint (2). The household's first-order conditions are given by

$$w_t = \zeta_0 h_t^\zeta, \tag{5}$$

$$1 = E_t\left(\Lambda_{t,t+1} R_{t+1}\right), \tag{6}$$

$$1 = E_t\left(\Lambda_{t,t+1}\frac{Z_{t+1} + \lambda Q_{t+1}}{Q_t + \varkappa K_t^h}\right), \tag{7}$$

$$1 = E_t\left(\Lambda_{t,t+1}\frac{Z_{t+1}^l + \lambda^l Q_{t+1}^l}{Q_t^l + \varkappa^l L_t^h}\xi_{t+1}^l\right), \tag{8}$$

and

$$\Lambda_{t,t+1} \equiv \beta\frac{C_t - \frac{\zeta_0}{1+\zeta}h_t^{1+\zeta}}{C_{t+1} - \frac{\zeta_0}{1+\zeta}h_{t+1}^{1+\zeta}}, \tag{9}$$

where $\Lambda_{t,t+1}$ denotes the stochastic discount factor.

2.2 Non-financial firms

There are four types of nonfinancial firms: (i) final goods firms, (ii) intermediate goods firms, (iii) capital investment firms, and (iv) land investment firms.

2.2.1 Final goods firms

The final goods are produced under perfect competition using a range of differentiated intermediate goods $y_{it}, i \in [0, 1]$:

$$Y_t = \left(\int_0^1 y_{it}^{\frac{\eta-1}{\eta}} \, di \right)^{\frac{\eta}{\eta-1}}, \tag{10}$$

where $\eta (> 1)$ is the elasticity of substitution across differentiated goods. Subject to the production function (10), the representative final goods producer chooses y_{it} to maximize its profit:

$$P_t Y_t - \int_0^1 p_{it} y_{it} di,$$

where p_{it} is the nominal price of good i, and P_t is the aggregate price index:

$$P_t = \left(\int_0^1 p_{it}^{1-\eta} di \right)^{\frac{1}{1-\eta}}.$$

The first-order condition for intermediate good i yields[7]

$$y_{it} = \left(\frac{p_{it}}{P_t} \right)^{-\eta} Y_t. \tag{11}$$

2.2.2 Intermediate goods firms

There is a continuum of intermediate goods firms indexed by $i \in [0, 1]$ that produce differentiated intermediate goods and sell them to final goods firms. Monopolistically competitive firms produce differentiated intermediate goods using capital k_{it}, land l_{it}, imported goods m_{it}, and labor h_{it}:

$$y_{it} = A_t \left(\frac{k_{it}}{\alpha_K} \right)^{\alpha_K} \left(\frac{l_{it}}{\alpha_L} \right)^{\alpha_L} \left(\frac{m_{it}}{\alpha_M} \right)^{\alpha_M} \left(\frac{h_{it}}{1 - \alpha_K - \alpha_L - \alpha_M} \right)^{1-\alpha_K-\alpha_L-\alpha_M}, \tag{12}$$

[7] Substituting Eq.(11) into Eq.(10) provides the aggregate price index P_t.

where $\alpha_K, \alpha_L, \alpha_M > 0$, $\alpha_K + \alpha_L + \alpha_M \in (0, 1)$, and A_t denotes aggregate total factor productivity. Subject to the demand function of intermediate goods (11) and the intermediate goods production function (12), the intermediate goods firms choose k_{it}, l_{it}, m_{it}, and h_{it} to minimize the cost $Z_t k_{it} + Z_t^l l_{it} + \epsilon_t m_{it} + w_t h_{it}$. Here, ϵ_t denotes the price of the imported goods, which equals the real exchange rate. The minimized unit cost is given by

$$m_t^C = \frac{1}{A_t} Z_t^{\alpha_K} \left(Z_t^l\right)^{\alpha_L} \epsilon_t^{\alpha_M} w_t^{1-\alpha_K-\alpha_L-\alpha_M}. \tag{13}$$

We define aggregate capital K_t, land L_t, imported goods M_t, and labor h_t as

$$K_t = \int_0^1 k_{it} di, \quad L_t = \int_0^1 l_{it} di, \quad M_t = \int_0^1 m_{it} di, \quad h_t = \int_0^1 h_{it} di.$$

In symmetric equilibrium, the aggregated production function is given by

$$Y_t = A_t \left(\frac{K_{t-1}}{\alpha_K}\right)^{\alpha_K} \left(\frac{L_{t-1}}{\alpha_L}\right)^{\alpha_L} \left(\frac{M_t}{\alpha_M}\right)^{\alpha_M} \left(\frac{h_t}{1-\alpha_K-\alpha_L-\alpha_M}\right)^{1-\alpha_K-\alpha_L-\alpha_M}. \tag{14}$$

The first-order conditions for cost minimization are given by

$$\frac{Z_t^l L_{t-1}}{Z_t K_{t-1}} = \frac{\alpha_L}{\alpha_K}, \tag{15}$$

$$\frac{\epsilon_t M_t}{Z_t K_{t-1}} = \frac{\alpha_M}{\alpha_K}, \tag{16}$$

and

$$\frac{w_t h_t}{Z_t K_{t-1}} = \frac{1-\alpha_K-\alpha_L-\alpha_M}{\alpha_K}. \tag{17}$$

We assume that each intermediate goods firm produces a single variety and faces nominal rigidity in the form of quadratic price adjustment costs *à la* Rotemberg (1982) to introduce price stickiness. The intermediate goods firm pays capital and land expenditure before production by borrowing funds from banks and households.

The intermediate goods firm i chooses price p_{it} to maximize the discounted value of its profits,

$$E_0 \left\{ \sum_{t=0}^{\infty} \Lambda_{0,t} \left[\left(\frac{p_{it}}{P_t} - m_t^C \right) y_{it} - \frac{\kappa}{2} \left(\frac{p_{it}}{p_{it-1}} - 1 \right)^2 Y_t \right] \right\}, \tag{18}$$

subject to Eq.(11). κ is the adjustment cost parameter that determines the degree of nominal price rigidity. Imposing symmetry on firms (i.e., $p_{it} = P_t$ and $y_{it} = Y_t$), we obtain the first-order condition with respect to p_{it}:[8]

$$(\pi_t - 1)\,\pi_t = \frac{1}{\kappa}\left(1 - \eta + \eta m_t^C\right) + E_t \left[\Lambda_{t,t+1} \frac{Y_{t+1}}{Y_t} \pi_{t+1} \left(\pi_{t+1} - 1\right) \right]. \tag{19}$$

2.2.3 Capital and land investment firms

Capital and land investments, I_t and I_t^l, are accompanied by adjustment costs.

$$\Psi \left(\frac{I_t}{I} \right) \cdot I_t = \frac{\kappa_I}{2} \left(\frac{I_t}{I} - 1 \right)^2 I_t, \quad \Psi_l \left(\frac{I_t^l}{I^l} \right) \cdot I_t^l = \frac{\kappa_I^l}{2} \left(\frac{I_t^l}{I^l} - 1 \right)^2 I_t^l, \tag{20}$$

where I and I^l denote steady-state levels. $\Psi(\cdot)$ and $\Psi_l(\cdot)$ satisfy $\Psi(1) = \Psi_l(1) = \Psi'(1) = \Psi_l'(1) = 0$; $\Psi''(\cdot) > 0$, and $\Psi_l''(\cdot) > 0$. Maximizing the discounted profits,

$$E_0 \sum_{t=0}^{\infty} \Lambda_{0,t} \left[Q_t I_t - \left[1 + \frac{\kappa_I}{2} \left(\frac{I_t}{I} - 1 \right)^2 \right] I_t \right], \quad E_0 \sum_{t=0}^{\infty} \Lambda_{0,t} \left[Q_t^l I_t^l - \left[1 + \frac{\kappa_I^l}{2} \left(\frac{I_t^l}{I^l} - 1 \right)^2 \right] I_t^l \right],$$

with respect to I_t and I_t^l, we obtain the first-order conditions for capital and land:

$$Q_t = 1 + \frac{\kappa_I}{2} \left(\frac{I_t}{I} - 1 \right)^2 + \left(\frac{I_t}{I} \right) \kappa_I \left(\frac{I_t}{I} - 1 \right), \tag{21}$$

[8] Following Aoki et al. (2016), we set

$$\kappa = \frac{(\eta - 1)\,\omega}{(1 - \omega)(1 - \beta\omega)},$$

where ω denotes the probability of maintaining price. Setting κ in this manner, we obtain the same New Keynesian Phillip as in Calvo (1983).

and

$$Q_t^l = 1 + \frac{\kappa_I^l}{2}\left(\frac{I_t^l}{I^l} - 1\right)^2 + \left(\frac{I_t^l}{I^l}\right)\kappa_I^l\left(\frac{I_t^l}{I^l} - 1\right), \tag{22}$$

respectively.

2.3 Banks

Banks raise funds from households by issuing one-period riskless deposits d_t at the gross real interest rate R_{t+1}. They also raise funds from foreigners by issuing foreign debt d_t^* at the exogenous gross real foreign interest rate R_t^*. They lend funds on capital and land (k_t^b and l_t^b) to intermediate goods firms at prices Q_t and Q_t^l, respectively. As we explain in Section 2.4, the government imposes capital controls and macroprudential policies. We characterize capital controls and macroprudential policies as tax rates on banks' foreign debt and land holdings, respectively.

A bank's balance sheet is given by

$$Q_t k_t^b + \left(1 + \tau_t^l\right) Q_t^l l_t^b = \left(1 + \tau_t^n\right) n_t + d_t + \left(1 - \tau_t^*\right) \epsilon_t d_t^*, \tag{23}$$

where τ_t^*, τ_t^l, n_t, and τ_t^n denote tax rates on banks' foreign debt and land holdings, banks' net worth, and subsidy rates on banks' net worth, respectively. The bank's balance sheet (23) includes the real exchange rate ϵ_t, which implies that the bank faces a liability dollarization problem.[9]

The bank's net worth evolves as the difference between the gross return on assets and the cost of borrowing, as follows:

$$n_t = \left(Z_t + \lambda Q_t\right) k_{t-1}^b + \left(Z_t^l + \lambda^l Q_t^l\right) \xi_t^l l_{t-1}^b - R_t d_{t-1} - \epsilon_t R_{t-1}^* d_{t-1}^*. \tag{24}$$

As argued in section 2.1, Z_t and Z_t^l denote the rental prices of capital and land,

[9] See Eichengreen and Hausmann (1999) and Eichengreen and Hausmann (2005) for the liability dollarization problem (or "original sin").

respectively. $(Z_t + \lambda Q_t)$ and $\left(Z_t^l + \lambda^l Q_t^l\right)\xi_t^l$ are the gross returns on capital and land, respectively. ξ_t^l denotes the land market shock mentioned in Section 2.1.

As we argue in Section 2.1, the banker exits the market with probability σ in each period. The banker's objective is to maximize the expected present value of future wealth given by

$$V_t = \max\ E_t\left[\sum_{j=1}^{\infty} \Lambda_{t,t+j}\sigma^{j-1}(1-\sigma)\, n_{t+j}\right], \tag{25}$$

where n_{t+j} denotes the net worth of the bank that survives until period $t+j-1$ but exits the market in period $t+j$. As the bank belongs to a representative household, we use the household's stochastic discount factor $\Lambda_{t,t+j}$ to discount the stream of the bank's net worth.

We assume that financial frictions exist when banks obtain funds from both depositors and foreign creditors. When banks raise funds, they can divert a fraction of the funds and transfer it to the representative household or hold their assets until payoffs are realized and repay their liabilities to creditors. When creditors supply funds, they require the banks' expected present value of future wealth, V_t, to be not less than the amount that banks can divert. This introduces the incentive-compatibility constraint for banks as follows:

$$V_t \geq \Theta(x_t)\left[Q_t k_t^b + Q_t^l l_t^b\right], \tag{26}$$

where $\Theta(x_t)$ is the proportion of assets that banks can divert. Following Aoki et al. (2016), we assume as follows:

$$\Theta(x_t) = \theta\left(1 + \frac{\gamma}{2}x_t^2\right), \quad \text{where } x_t \equiv \frac{\epsilon_t d_t^*}{\left(Q_t k_t^b + Q_t^l l_t^b\right)}, \tag{27}$$

which implies that, as the ratio of a bank's foreign debt to assets increases, banks can divert a larger fraction of assets.

The bank's optimization problem is to choose its asset and liability positions to maximize its expected present value of future wealth:

$$V_t = \max \ E_t \left\{ \Lambda_{t,t+1} \left[(1-\sigma) n_{t+1} + \sigma V_{t+1} \right] \right\}, \tag{28}$$

subject to the balance sheet constraint (23), law of motion of net worth (24), and incentive compatibility constraint (26).

Following Aoki et al. (2016), we express Eq.(28) as

$$\psi_t \equiv \frac{V_t}{n_t} = \max E_t \left\{ \Lambda_{t,t+1} \left(1 - \sigma + \sigma \psi_{t+1}\right) \frac{n_{t+1}}{n_t} \right\}. \tag{29}$$

We also express Eq.(23) as

$$\underbrace{\frac{Q_t k_t^b}{n_t}}_{\phi_t} + \left(1+\tau_t^l\right) \underbrace{\frac{Q_t^l l_t^b}{n_t}}_{\phi_t^l} = \left(1+\tau_t^n\right) + \frac{d_t}{n_t} + \left(1-\tau_t^*\right) \underbrace{\frac{\epsilon_t d_t^*}{Q_t k_t^b + Q_t^l l_t^b}}_{x_t} \frac{Q_t k_t^b + Q_t^l l_t^b}{n_t}, \tag{30}$$

where $\phi_t \equiv Q_t k_t^b / n_t$, $\phi_t^l \equiv Q_t^l l_t^b / n_t$, and $x_t \equiv \epsilon_t d_t^* / (Q_t k_t^b + Q_t^l l_t^b)$. By using ϕ_t, ϕ_t^l, and ψ_t (and Eq.(27)), we rewrite the incentive-compatibility constraint (26) as

$$\psi_t \geq \Theta\left(x_t\right) \left[\phi_t + \phi_t^l\right] = \theta \left(1 + \frac{\gamma}{2} x_t^2\right) \left[\phi_t + \phi_t^l\right]. \tag{31}$$

By using ϕ_t, ϕ_t^l, x_t and Eq.(30), we rewrite the law motion of net worth (24) as[10]

$$\begin{aligned} \frac{n_{t+1}}{n_t} = & \left[\frac{\left(Z_{t+1} + \lambda Q_{t+1}\right)}{Q_t} - R_{t+1} \right] \phi_t + \left[\frac{\left(Z_{t+1}^l + \lambda^l Q_{t+1}^l\right) \xi_{t+1}^l}{Q_t^l} - \left(1+\tau_t^l\right) R_{t+1} \right] \phi_t^l \\ & + \left[\left(1-\tau_t^*\right) R_{t+1} - \frac{\epsilon_{t+1}}{\epsilon_t} R_t^* \right] x_t \left(\phi_t + \phi_t^l\right) + \left(1+\tau_t^n\right) R_{t+1}. \end{aligned} \tag{32}$$

Substituting Eq.(32) into (29), we can rewrite (29) as

$$\psi_t = \max_{\phi_t, \phi_t^l, x_t} \left\{ \mu_t \phi_t + \mu_t^l \phi_t^l + \mu_t^* \left(\phi_t + \phi_t^l\right) x_t + \nu_t \right\}, \tag{33}$$

[10]For the detail on the derivation of Eq.(32), see Appendix A4.

where

$$\mu_t = E_t \left\{ \Omega_{t+1} \left[\underbrace{\frac{(Z_{t+1} + \lambda Q_{t+1})}{Q_t}}_{\mathcal{R}^k_{t+1}} - R_{t+1} \right] \right\}, \tag{34}$$

$$\mu^l_t = E_t \left\{ \Omega_{t+1} \left[\underbrace{\frac{\left(Z^l_{t+1} + \lambda^l Q^l_{t+1}\right) \xi^l_{t+1}}{Q^l_t} - \tau^l_t R_{t+1}}_{\mathcal{R}^l_{t+1}} - R_{t+1} \right] \right\}, \tag{35}$$

$$\mu^*_t = E_t \left\{ \Omega_{t+1} \left[R_{t+1} - \underbrace{\left(\frac{\epsilon_{t+1}}{\epsilon_t} R^*_t + \tau^*_t R_{t+1} \right)}_{\mathcal{R}^{D*}_{t+1}} \right] \right\}, \tag{36}$$

$$\text{and} \quad \nu_t = E_t \left\{ \Omega_{t+1} \left(1 + \tau^n_t\right) R_{t+1} \right\}. \tag{37}$$

Here, we define $\Omega_{t+1} \equiv \Lambda_{t,t+1} \left(1 - \sigma + \sigma \psi_{t+1}\right)$ as banks' augmented stochastic discount factor. In Eqs.(34), (35), and (36), we define that $\mathcal{R}^k_{t+1} \equiv \frac{(Z_{t+1} + \lambda Q_{t+1})}{Q_t}$, $\mathcal{R}^l_{t+1} \equiv \frac{\left(Z^l_{t+1} + \lambda^l Q^l_{t+1}\right) \xi^l_{t+1}}{Q^l_t} - \tau^l_t R_{t+1}$, and $\mathcal{R}^{D*}_{t+1} \equiv \frac{\epsilon_{t+1}}{\epsilon_t} R^*_t + \tau^*_t R_{t+1}$, which denote the returns on capital and land holdings and the cost on foreign debt holding, respectively. μ_t is the net return on capital holdings, μ^l_t is the net return on land holdings, and μ^*_t is the cost advantage of foreign borrowing.

Banks choose ϕ_t, ϕ^l_t, and x_t to maximize Eq.(33), subject to the incentive compatibility constraint (31). The first-order conditions for ϕ_t, ϕ^l_t, and x_t are

$$\mu_t + \mu^*_t x_t = \frac{\upsilon_t}{1 + \upsilon_t} \Theta\left(x_t\right), \tag{38}$$

$$\mu^l_t + \mu^*_t x_t = \frac{\upsilon_t}{1 + \upsilon_t} \Theta\left(x_t\right), \tag{39}$$

$$\text{and} \quad \mu^*_t = \frac{\upsilon_t}{1 + \upsilon_t} \Theta'\left(x_t\right), \tag{40}$$

where υ_t denotes the Lagrangian multiplier on Eq.(31).[11] When the incentive com-

[11] The Lagrangian is $\mathcal{L} = \psi_t + \upsilon_t(\psi_t - \Theta\left(x_t\right)\left[\phi_t + \phi^l_t\right]) = (1 + \upsilon_t)(\mu_t \phi_t + \mu^l_t \phi^l_t + \mu^*_t \left(\phi_t + \phi^l_t\right) x_t + \nu_t) - \upsilon_t \Theta\left(x_t\right)\left[\phi_t + \phi^l_t\right])$.

patibility constraint is not binding (i.e.,$\upsilon_t = 0$), we have $\mu_t = \mu_t^h = \mu_t^* = 0$, which indicates that the interest rate spreads (μ_t, μ_t^h, and μ_t^*) are zero. When the incentive compatibility constraint is binding (i.e., $\upsilon_t > 0$), the interest rate spreads (μ_t, μ_t^h, and μ_t^*) become positive.

From Eqs.(38) and (39), we obtain

$$\mu_t = \mu_t^l, \tag{41}$$

which indicates that, in equilibrium, banks earn the same rate of return from capital and land holdings (i.e., $\mathcal{R}_t^k = \mathcal{R}_t^l$ in Eqs.(34) and (35)).

We define the bank's leverage ratio as $\Phi_t \equiv (Q_t k_t^b + Q_t^l l_t^b)/n_t$. With $\phi_t (\equiv Q_t k_t^b / n_t)$ and $\phi_t^l (\equiv Q_t^l l_t^b / n_t)$, the bank's leverage ratio can be expressed as

$$\Phi_t = \phi_t + \phi_t^l. \tag{42}$$

Combining Eq.(31) with (33) and (41), we can transform the expression $\Phi_t (= \phi_t + \phi_t^l)$ into

$$\Phi_t = \frac{\nu_t}{\theta \left(1 + \frac{\gamma}{2} x_t^2\right) - \mu_t - \mu_t^* x_t}, \tag{43}$$

which indicates that the bank's leverage ratio Φ_t is decreasing in the parameter of the banks' diversion θ, and increasing in the net return on capital and land holdings $\mu_t (= \mu_t^l)$ and the cost advantage of foreign debt μ_t^*.

Combining Eq.(39) with (40) (and using (31)), we obtain x_t as[12]

$$x_t = \frac{1}{\tilde{\mu_t^*}} \left[-1 + \sqrt{1 + \frac{2}{\gamma} \left(\tilde{\mu_t^*}\right)^2} \right], \tag{44}$$

[12] From (39) and (40) (and using (31)), we have that $\frac{\tilde{\mu_t^*}}{2} x_t^2 + x_t - \frac{\tilde{\mu_t^*}}{\gamma} = 0$. By solving this problem, we obtain Eq.(44).

where

$$\tilde{\mu_t^*} \equiv \mu_t^*/\mu_t^l. \tag{45}$$

As ϕ_t, ϕ_t^l, and x_t are independent of bank-specific factors, we have

$$\phi_t = \frac{Q_t K_t^b}{N_t}, \tag{46}$$

$$\phi_t^l = \frac{Q_t^l L_t^b}{N_t}, \tag{47}$$

$$\text{and} \quad x_t = \frac{\epsilon_t D_t^*}{Q_t K_t^b + Q_t^l L_t^b}, \tag{48}$$

where the capital letters indicate aggregate variables.

Following related studies, we assume that new bankers receive a fraction of $\xi/(1-\sigma)$ of exiting bankers' total final period assets.[13] As the aggregate net worth N_t is the sum of the net worth of existing and new bankers, we obtain the evolution of N_t from Eq.(24) as follows:

$$N_t = (\sigma + \xi)\left[(Z_t + \lambda Q_t) K_{t-1}^b + \left(Z_t^l + \lambda^l Q_t^l\right) \xi_t^l L_{t-1}^b\right] - \sigma\left(R_t D_{t-1} + \epsilon_t R_{t-1}^* D_{t-1}^*\right). \tag{49}$$

As we argue in Section 2.4, the government returns tax revenues from capital controls and macroprudential policies to banks as a subsidy for banks' net worth. Thus, the aggregate balance sheet is given by

$$Q_t K_t^b + Q_t^l L_t^b = N_t + D_t + \epsilon_t D_t^*. \tag{50}$$

2.4 Government

As argued in Section 2.3, the government imposes capital controls and macroprudential policies. We characterize capital controls and macroprudential policies as taxes on foreign debt and landholdings, respectively. τ_t^* and τ_t^l in the bank's bal-

[13]For example, see Gertler and Kiyotaki (2010) and Gertler and Karadi (2011).

ance sheets (23) are the tax rates on foreign debt and landholdings, respectively. We assume that τ_t^* and τ_t^l follow the following simple rules:

$$\tau_t^* = \omega^* \left(\ln D_t^* - \ln \bar{D}^* \right), \tag{51}$$

and

$$\tau_t^l = \omega^l \left(\ln Q_t^l - \ln \bar{Q}^l \right), \tag{52}$$

where $\bar{D}^*$ and $\bar{Q}^l$ denote the steady-state values of D_t^* and Q_t^l, respectively. Eqs.(51) and (52) imply that the government adjusts the tax rates on foreign debt τ_t^* responding to the aggregate foreign debt of the entire banking sector D_t^* and adjusts the tax rates on land holdings τ_t^l responding to the land price Q_t^l. Following Gertler et al. (2012) and Aoki et al. (2016), we assume that collected taxes are returned to banks as subsidies for their net worth N_t:

$$\tau_t^n N_t = \tau_t^* \epsilon_t D_t^* + \tau_t^l Q_t^l L_t^b. \tag{53}$$

We posit the following simple monetary policy rule:

$$i_t - \bar{i} = (1 - \rho_i)\,\omega_\pi (\pi_t - 1) + \rho_i (i_{t-1} - \bar{i}), \tag{54}$$

where $\bar{i}$ denotes the steady-state level of i_t.

2.5 Equilibrium

Demand for final goods comprises consumption (C_t), capital and land investment (I_t and I_t^l), the accompanied adjustment costs ($\Psi(\cdot)\, I_t$ and $\Psi_l(\cdot)\, I_t^l$), the household's extra management costs on capital and land investment ($\chi(\cdot)$ and $\chi^l(\cdot)$), the adjustment cost of changing prices in Eq.(18), and foreign demand E_{Xt}, as follows:

$$Y_t = C_t + \left[1 + \Psi\left(\frac{I_t}{I}\right)\right] I_t + \left[1 + \Psi_l\left(\frac{I_t^l}{I^l}\right)\right] I_t^l + \chi\left(K_t^h\right) + \chi^l\left(L_t^h\right) + \frac{\kappa}{2}\left(\pi_t - 1\right)^2 Y_t + E_{Xt}. \tag{55}$$

Following Aoki et al. (2016), we assume that foreign demand decreases with relative price and increases with foreign income:

$$E_{Xt} = \left(\frac{P_t}{e_t P_t^*}\right)^{-\varphi} Y_t^* = \epsilon_t^{\varphi} Y_t^*, \tag{56}$$

where ϵ_t is the real exchange rate, and Y_t^* is the exogenous foreign income.

Foreign debt D_t^* is evolved according to

$$D_t^* = R_{t-1}^* D_{t-1}^* + M_t - \frac{1}{\epsilon_t} E_{Xt}, \tag{57}$$

and the current account CA_t is given by

$$CA_t = D_t^* - D_{t-1}^*. \tag{58}$$

The laws of motion for aggregate capital K_t and land L_t are given by

$$K_t = I_t + \lambda K_{t-1}, \tag{59}$$

$$\text{and} \quad L_t = \xi_t^l \left(I_t^l + \lambda^l L_{t-1}\right), \tag{60}$$

where

$$K_t \equiv K_t^b + K_t^h, \tag{61}$$

$$\text{and} \quad L_t \equiv L_t^b + L_t^h. \tag{62}$$

Here, ξ_t^l denotes the land market shock mentioned in Sections 2.1 and 2.3.

We consider two exogenous stochastic processes. The foreign (gross) interest rate

R_t^* and land market shock ξ_t^l are given by

$$\ln R_t^* - \ln R^* = \rho_{R^*}\left(\ln R_{t-1}^* - \ln R^*\right) + \epsilon_{R_t^*}, \qquad \epsilon_{R_t^*} \sim N\left(0, \sigma_{R^*}^2\right), \tag{63}$$

$$\ln \xi_t^l = \rho_\xi \ln \xi_{t-1}^l + \epsilon_{\xi t}, \qquad \epsilon_{\xi t} \sim N\left(0, \sigma_\xi^2\right), \tag{64}$$

where the innovation of these shocks is assumed to be $i.i.d$ and uncorrelated.

The recursive competitive equilibrium is given by 11 price variables $\{ R_t, i_t, \pi_t, w_t, Z_t, Z_t^l, Q_t, Q_t^l, \epsilon_t, m_t^C, \Lambda_{t,t+1} \}_{t=0}^{\infty}$, 17 quantity variables $\{ C_t, h_t, D_t, I_t, I_t^l, Y_t, M_t, E_{Xt}, K_t, K_t^h, K_t^b, L_t, L_t^h, L_t^b, N_t, D_t^*, CA_t \}_{t=0}^{\infty}$, 10 bank related variables $\{ x_t, \psi_t, \phi_t, \phi_t^l, \Phi_t, \nu_t, \mu_t, \mu_t^l, \mu_t^*, \tilde{\mu_t^*} \}_{t=0}^{\infty}$, 2 exogenous shocks $\{ R_t^*, \xi_t^l \}_{t=0}^{\infty}$, which satisfy 39 equations (3), (5)-(9), (13)-(17), (19), (21), (22), (33)-(37), (41)-(50), (54)-(64). Appendices A1 and A2 summarize the equilibrium conditions and the steady state, respectively.

3 Calibration

Table 1 lists the baseline parameter values in our model. The model is calibrated at quarterly frequency. We basically follow Aoki et al. (2016) and choose the conventional parameter values used in related literature. For some parameters, we choose their values to match the conventional steady-state levels used in related literature.

We set the parameters related to households as follows. The discount factor β is set to 0.985 ($R = 1/\beta = 1.015$), implying a steady-state domestic deposit rate of 1.5% (6% annually). The inverse of Frisch elasticity of labor supply ζ and the relative utility weight of labor ζ_0 are set at 0.2 and 5.89, respectively. The cost parameter for households' direct financing of capital $\varkappa$ is set at 9.85×10^{-4}. We set the same value for the cost parameter of households' direct land financing $\varkappa^l$.

Following Iacoviello and Neri (2010), we set the land share in production α_L and one minus depreciation rate on land λ^l at 0.1 and 0.99, respectively. Following Aoki et al. (2016), we set the other parameters related to producers. The capital share in production α_K, imported share in production α_M, and one minus the depreciation rate of capital λ are set at 0.3, 0.15, and 0.98, respectively. The elasticity of substitution among differentiated goods η, the probability of keeping prices ω, and the price elasticity of export demand φ are set to 9, 0.66, and 1, respectively. The adjustment cost parameter for capital investment, κ_I, is set to 1. We set the same value for the adjustment cost parameter for land investment, κ_I^l.

We target the steady-state levels of the aggregate banks' leverage ratio Φ, spread (i.e., return rate on capital (or land) minus deposit rate) $R^l - R$, and banks' foreign debt-to-assets ratio x at 6, 0.02, and 0.25, respectively. To match the steady-state level targets, we choose the divertable fraction of assets θ, home bias in funding γ, and fraction of transfers to entering banks ξ at 0.6, 5, and 4×10^{-4}, respectively. We set the banks' survival probability σ to 0.93, which is slightly lower than 0.94 in Aoki et al. (2016).

We choose the persistence and standard deviation of foreign interest shocks (ρ_{R^*} and σ_{R^*}) as 0.95 and 0.00075, respectively. The steady-state foreign interest rate $\bar{R}^*$ is set at 1.005% (1.02% annually). The coefficient and persistence for the monetary policy rule (ω_π and ρ_i) are set at 1.5 and 0.85, respectively. For the land shock, we set the values of ρ_ξ and σ_ξ to 0.66 and 0.05, respectively. These are the same values for the capital quality shock in Gertler and Kiyotaki (2010).

Variable	Description	Value
	Parameters related to households	
β	discount factor	0.985
ζ	inverse of Frisch elasticity of labor supply	0.2
ζ_0	relative utility weight of labor	5.89
$\varkappa$	cost parameter of direct finance: capital	9.85×10^{-4}
$\varkappa^l$	cost parameter of direct finance: land	9.85×10^{-4}
	Parameters related to firms	
α_K	capital share	0.3
α_L	land share	0.1
α_M	imported goods share	0.15
λ	one minus depreciation rate: capital	0.98
λ^l	one minus depreciation rate: land	0.99
η	elasticity of substitution	9
ω	probability of retaining prices	0.66
κ_I	adjustment cost on capital investment	1
κ_I^l	adjustment cost on land investment	1
φ	price elasticity of export demand	1
	Parameters related to banks	
σ	survival probability	0.93
θ	divertable fraction of assets	0.6
γ	home bias in funding	5.0
ξ	transfer to entering banks	4×10^{-4}
	Other parameters	
ω_π	coefficient for monetary policy rule	1.5
ρ_i	persistence: monetary policy rule	0.85
ρ_{R^*}	persistence: foreign interest rate shock	0.95
σ_{R^*}	standard deviation: foreign interest rate shock	0.00075
ρ_ξ	persistence: land shock	0.66
σ_ξ	standard deviation: land shock	0.05
R^*	steady state foreign interest rate (in annual)	1.02

Table 1: Parameters

4 Numerical Experiments

Next, we present numerical experiments to shed light on the roles of capital controls and macroprudential policies. We consider two exogenous shocks: foreign interest rate and land market shocks.

4.1 Impulse responses to foreign interest rate shocks

First, we show how capital controls and macroprudential policies affect the impulse responses of the main variables to foreign interest rate shocks.

4.1.1 Capital controls to foreign interest rate shocks

In this section, we analyze the impulse responses of the main variables, with and without capital controls, to foreign interest rate shocks. We consider a 0.075% unanticipated decrease in foreign interest rates R_t^* (with a persistence coefficient of 0.95) as an initiating disturbance. In Figure 1, the solid (red) lines show impulse responses without capital controls. The dashed (blue) lines show impulse responses with capital controls. In the latter case, we select the optimal value of $\omega^*(=6)$ in Eq.(51), which we will explain in detail in Section 4.3.

From Eq.(36), we can infer that without capital controls, a fall in foreign interest rates R_t^* would reduce the cost of raising funds through foreign borrowing and cause capital inflows. This implies that the current account (to GDP ratio) $\frac{CA_t}{Y_t}$ is in deficit, foreign debt D_t^* increases, and the real exchange rate ϵ_t appreciates, as shown by the solid (red) lines in Figure 1. From Eq.(49), it is evident that the cost reduction in raising funds due to the fall in foreign interest rates R_t^* raises the banks' net worth N_t. The increase in net worth N_t reduces the banks' borrowing constraints and raises capital and land investments (I_t and I_t^l). Capital and land prices (Q_t and Q_t^l) also increase with increases in I_t and I_t^l. With this loosening, the credit spread $\mathcal{R}_{t+1}^k - R_{t+1}$ (which equals $\mathcal{R}_{t+1}^l - R_{t+1}$ in the equilibrium) decreases. A fall in the credit spread reduces borrowers' costs and increases capital and land investments (I_t and I_t^l). Capital and land prices (Q_t and Q_t^l) increase further with increases in I_t and I_t^l. In other words, the financial accelerator mechanism amplifies the volatility of the main variables due to a foreign interest rate shock through the banks' balance sheets. As the appreciation of the real exchange rate ϵ_t reduces foreign demand, the output Y_t falls first. However, the output gradually increases owing to a decrease in

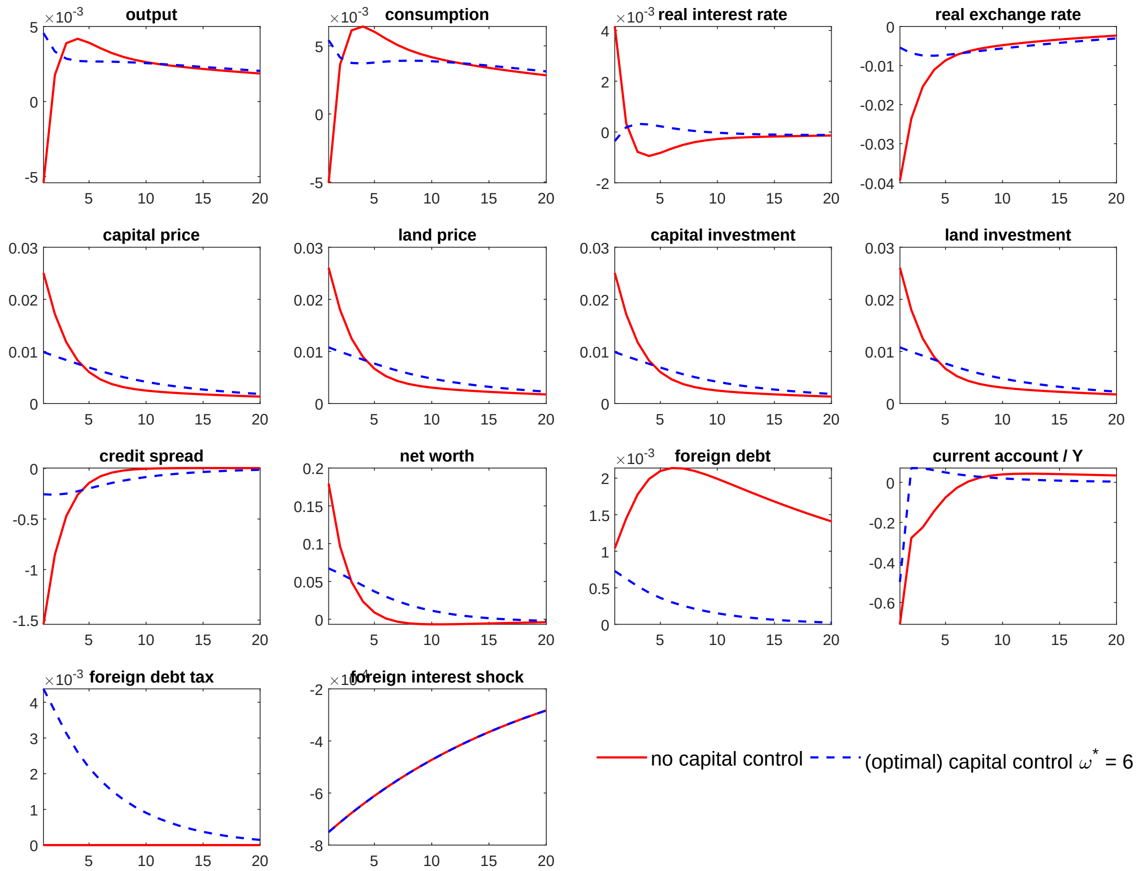


Figure 1: Impulse responses to foreign interest rate shocks with and without capital controls

foreign interest rates R_t^* through the financial accelerator mechanism. Consumption (C_t) follows the output path (Y_t), and the real interest rate ($\ln R_t$) moves in the opposite direction to consumption (C_t).

However, if we use capital controls, with the tax rate reacting to the banks' percentage deviation of foreign debt from its steady-state level in Eq.(51), the results are different. Capital controls with an optimal value of $\omega^*(= 6)$ (dashed blue lines) achieve smaller fluctuations in the main variables. Capital controls also mitigate the appreciation of the real exchange rate (ϵ_t), the rise in foreign debt (D_t^*), and the current account deficit ($\frac{CA_t}{Y_t}$). Capital controls dampen the amplification effect in the banking sector through the financial accelerator mechanism. Capital controls mitigate the increases in banks' net worth (N_t), capital and land investments (I_t and I_t^l), and capital and land prices (Q_t and Q_t^l). The decrease in the credit spread is also mitigated, restraining the amplification effect through the financial accelerator mechanism. By dampening the amplification effect through the financial accelerator mechanism, capital controls stabilize output (Y_t), consumption (C_t), and the real interest rate ($\ln R_t$).

4.1.2 Macroprudential policies to foreign interest rate shocks

Next, we analyze the impulse responses of the main variables with and without macroprudential policies on banks' land funding in response to foreign interest rate shocks. We consider the same initiating disturbance as in the capital controls case, which is a 0.075% unanticipated fall in foreign interest rates, R_t^* with a persistence coefficient of 0.95. In Figure 2, the impulse responses without macroprudential policies are shown by the solid (red) lines, which are the same as those in Figure 1. The dashed (blue) lines show impulse responses with macroprudential policies. In the latter case, we set an arbitrary value of $\omega^l(= 0.6)$ in Eq.(52). We do so because, as we show in Section 4.3, macroprudential policies responding to foreign interest rate shocks do not improve welfare, and there is no optimal value of ω^l.

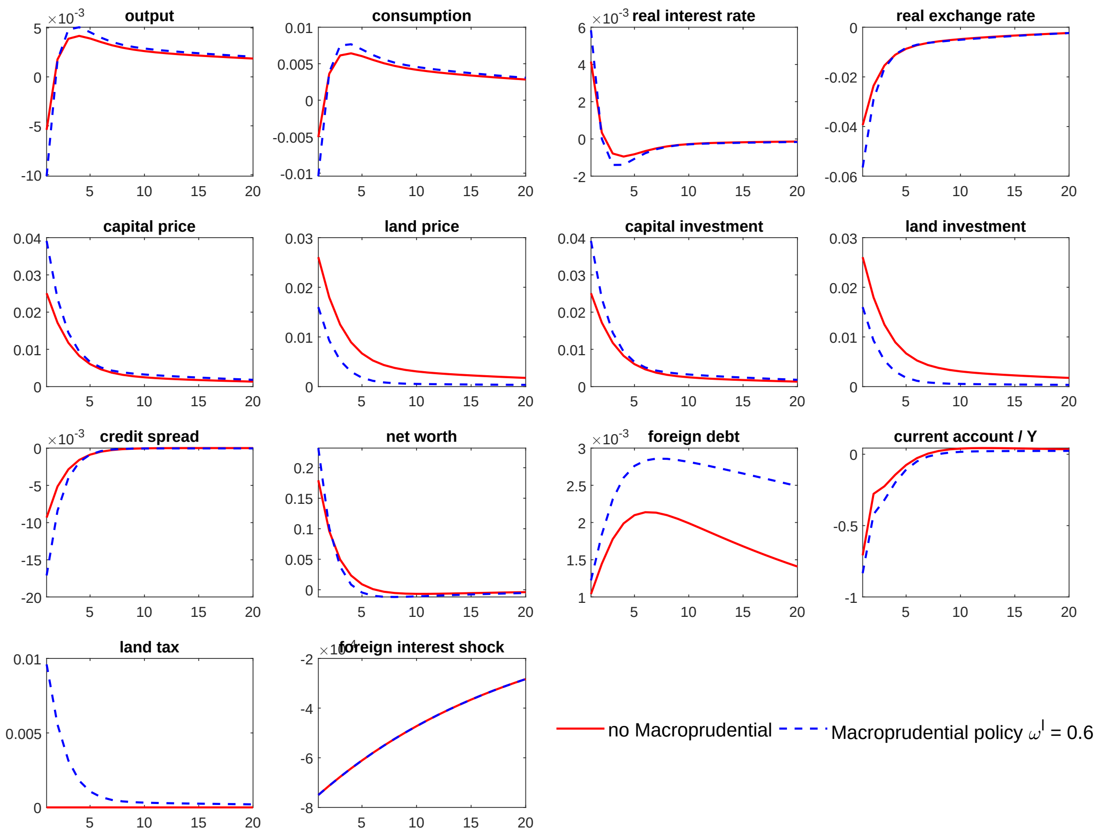


Figure 2: Impulse responses to foreign interest rate shocks with and without macroprudential policies

When the macroprudential policy on the banks' land funding is in place, as the policy intends, it restrains land investment (I_t^l) and land price (Q_t^l) from rising compared with the no-policy case. However, simultaneously, the macroprudential policy on banks' land funding boosts capital investment (I_t) and capital prices (Q_t). The rise in capital investment and price leads to a greater decline in the credit spread ($\mathcal{R}_{t+1}^k - R_{t+1}$) than in the no-policy case. Therefore, contrary to the policy's intention, the macroprudential policy on banks' land funding amplifies the effect through the financial accelerator mechanism. This causes further capital inflows, implying a larger deficit in the current account (to GDP ratio) $\frac{CA_t}{Y_t}$, a larger increase in foreign debt D_t^*, and a higher degree of the real exchange rate ϵ_t appreciation. Enforcing the amplification effect through the financial accelerator mechanism, the macroprudential policy on the banks' land funding destabilizes output (Y_t), consumption (C_t), and the real interest rate ($\ln R_t$).

In summary, the macroprudential policy on banks' land funding mitigates the boom in land investment and prices. However, it boosts the rise in capital investment and price. It amplifies the effect of foreign interest rate shocks on aggregate variables through the financial accelerator mechanism. In other words, the macroprudential policy on the banks' land funding has the distortion effect of directing capital inflows from land investment to capital investment and, therefore, results in exacerbating the amplification effect through the financial accelerator mechanism.

4.2 Impulse responses to land market shocks

The last section considers the impulse responses to external foreign interest rate shocks with and without capital controls and macroprudential policies. This section analyzes the impulse responses to internal land market shocks. As we argue in sections 2.1 and 2.3, land market shocks capture exogenous variations in the value of land holding in a simple manner. The land shock is equivalent to the capital shock, which is an exogenous trigger for asset price dynamics in Gertler and Kiyotaki (2010) and Gertler et al. (2012).

4.2.1 Capital Controls to land market shocks

In this section, we show the impulse responses of the main variables, with and without capital controls, to land market shocks. We consider a 5% unanticipated increase in land value with a persistence coefficient of 0.66 as a land market shock ξ_t^l. In Figure 3, the solid (red) lines indicate impulse responses without capital controls.[14] The dashed (blue) lines indicate impulse responses to capital controls. In the latter case, we set an arbitrary value of $\omega_\tau^*(= 1.17)$ in Eq.(51). We do so because, as shown in section 4.3, capital controls responding to land market shocks prove not to be welfare-improving. Therefore, there is no optimal value of ω_τ^* in this case.

From Eq.(49), we know that the exogenous increase in the land value raises the banks' net worth N_t. The rise in net worth N_t reduces the banks' borrowing constraints and raises capital and land investments (I_t and I_t^l). Capital and land prices (Q_t and Q_t^l) increase with increases in I_t and I_t^l. With this loosening, the credit spread $\mathcal{R}_{t+1}^k - R_{t+1}$ (which equals $\mathcal{R}_{t+1}^l - R_{t+1}$ in the equilibrium) decreases. As a fall in the credit spread reduces the cost for borrowers, capital and land investments (I_t and I_t^l) increase further through the financial accelerator mechanism, which raises output (Y_t) and consumption (C_t). An expansion in the banks' balance sheets also raises foreign borrowing and capital inflows, which implies the current account ($\frac{CA_t}{Y_t}$) deficit, foreign debt (D_t^*) expansion, and real exchange rate (ϵ_t) appreciation.

When capital controls are in place, as the policy intends, they mitigate the current account ($\frac{CA_t}{Y_t}$) deficit, foreign debt (D_t^*) expansion, and real exchange rate (ϵ_t) appreciation. Mitigating the change in credit spread $\mathcal{R}_{t+1}^k - R_{t+1}$ (or $\mathcal{R}_{t+1}^l - R_{t+1}$), capital controls also dampen volatile changes in capital and land investments (I_t and I_t^l) and capital and land prices (Q_t and Q_t^l). Nevertheless, by changing the

[14] In Figures 3 and 4, we follow Gertler and Kiyotaki (2010) and Gertler et al. (2012) and simulate the impulse responses for 40 quarters, which are longer than in Figures 1 and 2.

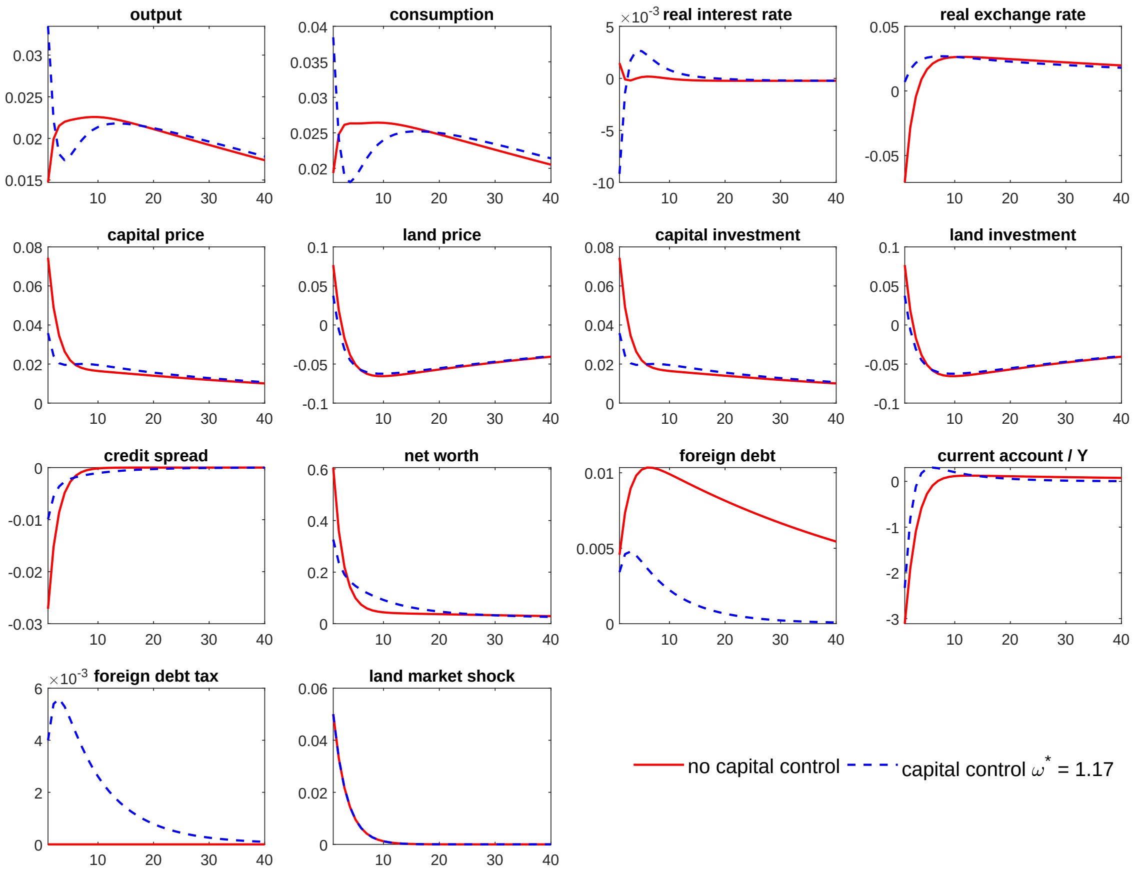


Figure 3: Impulse responses to land shocks with and without capital controls

foreign debt tax, τ_t^* in Eq.(36), capital controls distort the real interest rate ($\ln R_t$) and result in destabilizing output (Y_t) and consumption (C_t) compared with the no policy case.

4.2.2 Macroprudential policies to land market shocks

Next, we analyze the impulse responses of the main variables with and without macroprudential policies in response to land market shocks. In Figure 4, the impulse responses without macroprudential policies are indicated by the solid (red) lines. The dashed (blue) lines indicate the impulse responses to macroprudential policies. In the latter case, we select the optimal value of $\omega^l (= 0.04)$ in Eq.(52), which we will explain in detail in Section 4.3.

When the macroprudential policy is in place, as the policy intends, it mitigates the credit spread $\mathcal{R}_{t+1}^k - R_{t+1}$ (or $\mathcal{R}_{t+1}^l - R_{t+1}$) and dampens volatile changes in capital and land prices (Q_t and Q_t^l) as well as capital and land investments (I_t and I_t^l). The macroprudential policy also dampens the current account ($\frac{CA_t}{Y_t}$) deficit, foreign debt (D_t^*) expansion, and real exchange rate (ϵ_t) appreciation. Simultaneously, the macroprudential policy to change τ_t^l in Eq.(35) has the distortion effect on the real interest rate ($\ln R_t$). However, the magnitude of the policy distortion in this case is smaller than that in the previous capital control case. Overall, the macroprudential policy mitigates the fluctuations of capital and land investments and their prices. It also stabilizes the other main variables, such as output and consumption, in response to land market shocks.

4.3 Welfare analysis

Thus far, we have analyzed the impact of unexpected shocks on the economy using a first-order approximation. However, the first-order approximation is unsuitable for comparing welfare levels under different policies.[15] This section uses a second-

[15] Kim and Kim (2003) show that second-order solutions are necessary because conventional linearization may generate spurious welfare reversals when long-run distortions exist in the model.

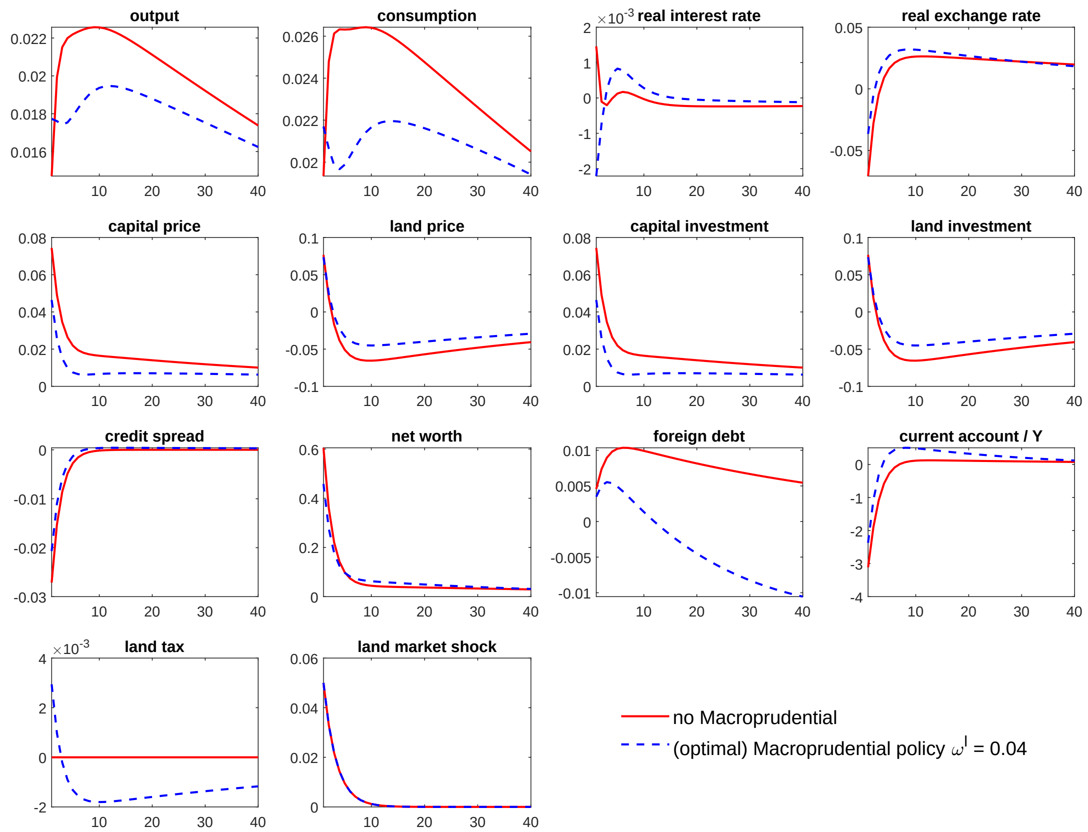


Figure 4: Impulse responses to land shocks with and without macroprudential policies

order approximation to examine the welfare implications of capital controls and macroprudential policies. For policy evaluation, we compute welfare levels for a range of policy rules and compare them with the no-policy case.

The welfare criterion is defined using a recursive household lifetime utility function:

$$W_t = u\left(C_t, h_t\right) + \beta E_t W_{t+1},$$

where W_t denotes the welfare level, and $u\left(C_t, h_t\right)$ is the utility function in Eq.(1). We compare the different policies using Schmitt-Grohé and Uribe (2007)'s definition of the consumption equivalent. Specifically, we define the proportion ι_w of the household's steady-state consumption level as

$$E_0 \sum_{t=0}^{\infty} \beta^t \ln\left(\left(1+\iota_w\right)\bar{C} - \frac{\xi_0}{1+\xi}\left(\bar{h}\right)^{1+\xi}\right) = E_0 \sum_{t=0}^{\infty} \beta^t \left(C_t - \frac{\xi_0}{1+\xi}\left(h_t\right)^{1+\xi}\right), \quad (65)$$

where $\bar{C}$ and $\bar{h}$ denote consumption and labor levels in their non-stochastic steady states, respectively.[16] We examine the welfare implications of capital controls and macroprudential policies by comparing the values of ι_w in the range of ω^* in (51) and ω^l in (52) to those in the no-policy regime ($\omega^* = \omega_l = 0$).

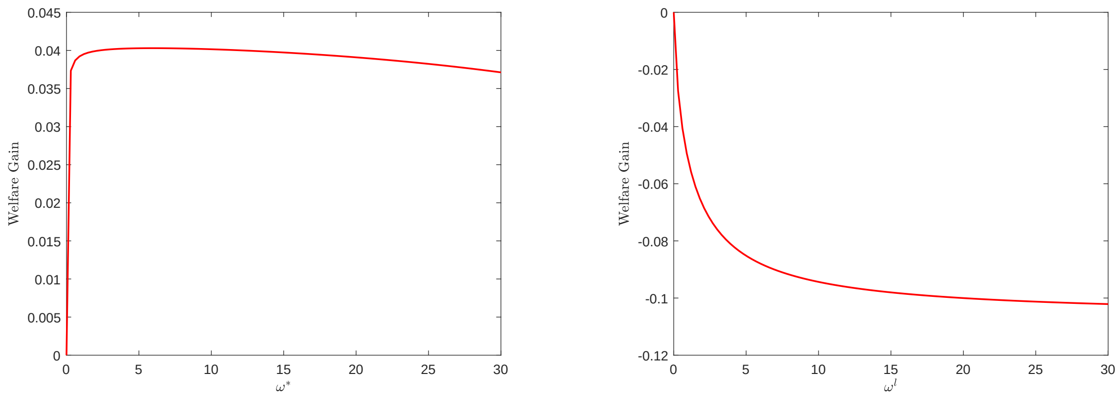
From the welfare gain perspective, we compare the two policies in response to the foreign interest rate shock in section 4.3.1 and the land market shock in section 4.3.2. We show a stark contrast between the two cases. In the former case, capital controls improve welfare, whereas macroprudential policies are welfare worsening. In the latter case, the opposite is true; capital controls worsen welfare, whereas macroprudential policies improve welfare.

We conducted second-order computations using Dynare. See Adjemian et al. (2011) for further details. We also used the method developed by Kim et al. (2008) to eliminate explosive paths by pruning the terms of the high-order effects.

[16] The steady-state levels of consumption and labor are identical in the policy and no-policy regimes because the steady state levels of tax rates on banks' foreign debt and land holdings (τ_t^* and τ_t^l) are zero.

4.3.1 Welfare comparison between capital controls and macroprudential policies to foreign interest rate shocks

Figures 5a and 5b show the welfare gains from capital controls and macroprudential policies, respectively, in response to foreign interest rate shocks.



(a) Capital controls (b) Macroprudential policies

Figure 5: Welfare gains of capital controls and macroprudential policies in response to foreign interest rate shocks

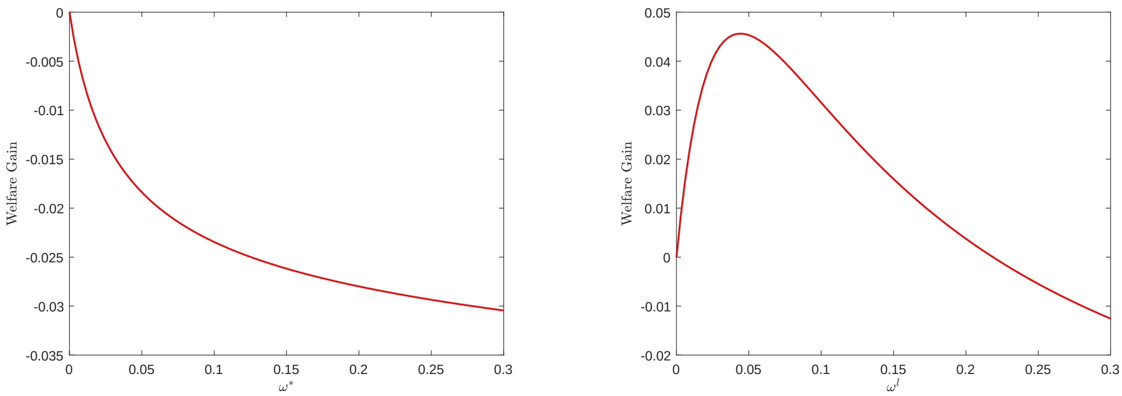
Figure 5a presents the corresponding welfare gains of different degrees of capital controls (i.e., adopting different values of ω^* instead of the no-policy case ($\omega^* = 0$)). The horizontal axis represents ω^*. The vertical axis represents the welfare gain, which is the difference between the value of ι_w associated with each value of ω^* and that in the no-policy case. We find that there exists a range of ω^* that improves welfare levels compared with the no-policy case. The optimal value of ω^* is 6.0, which maximizes the welfare gain from capital controls. The maximum welfare gain is 0.04.

Figure 5b presents the corresponding welfare gains of different degrees of macroprudential policies (i.e., adopting different values of ω^l instead of the no-policy case ($\omega^l = 0$)). Figure 5b shows that, as macroprudential policies are more responsive (i.e., a higher value of ω^l), the welfare deteriorates more, which implies that macroprudential policy responding to foreign interest rate shocks causes a distortion.

Our welfare analysis is consistent with the impulse-response analysis in section 4.3.1. The impulse responses of the main variables to foreign interest rate shocks in Section 4.3.1 suggest that capital controls are superior to macroprudential policies in stabilizing economies affected by foreign interest rate shocks. Our results confirm that capital controls are appropriate for responding to foreign interest rate shocks; however, macroprudential policies are not.

4.3.2 Welfare comparison between capital controls and macroprudential policies to land market shocks

Thus far, we have analyzed the welfare implications of capital controls and macroprudential policies in response to foreign interest rate shocks. Next, we examine the welfare-improving effects of these two policies in response to land market shocks. Figures 6a and 6b show the welfare gains from capital controls and macroprudential policies, respectively, in response to land market shocks.



(a) Capital controls

(b) Macroprudential policies

Figure 6: Welfare gains of capital controls and macroprudential policies in response to land market shocks

Figure 6a presents the corresponding welfare gains of different degrees of capital controls in response to land market shocks (i.e., adopting different values of ω^* instead of the no-policy case ($\omega^* = 0$)). Figure 6a shows that as capital controls are more responsive (i.e., a higher value of ω^*), the welfare deteriorates more, implying that capital controls responding to land market shocks cause a distortion.

Figure 6b presents the corresponding welfare gains of different degrees of macroprudential policies (i.e., adopting different values of ω^l instead of the no-policy case ($\omega^l = 0$)). We find that there exists a range of ω^l that improves welfare levels compared with the no-policy case. The optimal value of ω^l that maximizes the welfare gain from capital controls is 0.04. The maximum welfare gain is 0.045.

5 Conclusion

Faced with the problem of coincidence between real estate booms (busts) and capital inflows (outflows), policymakers can implement macroprudential policies targeting domestic real estate markets and capital controls targeting international capital flows. Building a small open economy NK-DSGE model, in which banks choose their asset portfolio between physical capital and land, we quantitatively examined the effectiveness of the two policies and analyzed which policy is more appropriate for managing the coincidence between land booms (busts) and capital inflows (outflows). As foreign and domestic exogenous shocks are amplified through the financial accelerator mechanism due to the banks' balance sheets, both capital controls on capital flows and macroprudential policies on the banks' land funding seem to be potentially welfare-enhancing. However, the quantitative results show that the superiority of the two policies depends on the type of shock impacting a small open economy. In the case of foreign interest rate shocks, capital controls improve welfare, whereas macroprudential policies reduce welfare. Conversely, the superiority of the two policies is reversed in the case of domestic land market shocks. In this case, macroprudential policies improve welfare, whereas capital controls reduce welfare. In other words, our results imply that employing policies directly related to shocks (i.e., foreign policies to foreign shocks and domestic policies to domestic shocks) are likely to be appropriate, but employing policies indirectly related to shocks are not.

The policy implications of this study are as follows. Identifying the source of the shock generating the coincidence between real estate booms (busts) and capital inflows (outflows) is important. If the exogenous shock is domestic, macroprudential policies are likely to be more effective than capital controls. Conversely, if it is foreign, capital controls are likely to be more effective than macroprudential policies. The empirical literature starting from Calvo et al. (1993) has a long tradition of examining which of the domestic (or 'pull') factors or the external (or 'push') factors are more important in determining capital flows in emerging countries. Many empirical studies (e.g., Dooley et al., 1996; Frankel and Okongwu, 1996; Fernandez-Arias, 1996) suggest that the external (or "push") factors are more important than the domestic (or "pull") factors. If this is the case, our results imply that capital controls would be more suitable for managing the coincidence of real estate booms (busts) and capital inflows (outflows) compared with macroprudential policies.

References

Adjemian, Stéphane, Houtan Bastani, Michel Juillard et al. (2011) "Dynare: Reference Manual, Version 4," Dynare Working Papers 1, CEPREMAP.

Agénor, Pierre-Richard and Pengfei Jia (2020) "Capital controls and welfare with cross-border bank capital flows," *Journal of Macroeconomics*, Vol. 65, p. 103220.

Agénor, Pierre-Richard, Koray Alper, and Luiz Pereira da Silva (2018) "External shocks, financial volatility and reserve requirements in an open economy," *Journal of International Money and Finance*, Vol. 83, pp. 23–43.

Ahmed, Shaghil and Andrei Zlate (2014) "Capital flows to emerging market economies: A brave new world?" *Journal of International Money and Finance*, Vol. 48, Part B, pp. 221 – 248.

Aizenman, Joshua and Yothin Jinjarak (2009) "Current account patterns and national real estate markets," *Journal of Urban Economics*, Vol. 66, No. 2, pp. 75–89, September.

Alpanda, Sami and Sarah Zubairy (2017) "Addressing household indebtedness: Monetary, fiscal or macroprudential policy?" *European Economic Review*, Vol. 92, pp. 47–73.

Angelini, Paolo, Stefano Neri, and Fabio Panetta (2014) "The Interaction between Capital Requirements and Monetary Policy," *Journal of Money, Credit and Banking*, Vol. 46, No. 6, pp. 1073–1112.

Angeloni, Ignazio and Ester Faia (2013) "Capital regulation and monetary policy with fragile banks," *Journal of Monetary Economics*, Vol. 60, No. 3, pp. 311–324.

Aoki, Kosuke, Gianluca Benigno, and Nobuhiro Kiyotaki (2016) "Monetary and Financial Policies in Emerging Markets," Princeton University.

Bernanke, Ben S. (2010) "Monetary Policy and the Housing Bubble," Speech at the Annual Meeting of the American Economic Association, Atlanta, Georgia.

Bianchi, Javier (2011) "Overborrowing and Systemic Externalities in the Business Cycle," *American Economic Review*, Vol. 101, No. 7, pp. 3400–3426.

Brunnermeier, Markus K. and Yuliy Sannikov (2015) "International Credit Flows and Pecuniary Externalities," *American Economic Journal: Macroeconomics*, Vol. 7, No. 1, pp. 297–338.

Calvo, Guillermo A (1983) "Staggered prices in a utility-maximizing framework," *Journal of Monetary Economics*, Vol. 12, No. 3, pp. 383–398.

Calvo, Guillermo A., Leonardo Leiderman, and Carmen M. Reinhart (1993) "Capital Inflows and Real Exchange Rate Appreciation in Latin America: The Role of External Factors," *IMF Staff Papers*, Vol. 40, No. 1, pp. 108–151, March.

Cesa-Bianchi, Ambrogio, Luis Felipe Cespedes, and Alessandro Rebucci (2015) "Global Liquidity, House Prices, and the Macroeconomy: Evidence from Advanced and Emerging Economies," *Journal of Money, Credit and Banking*, Vol. 47, No. S1, pp. 301–335, March.

Chang, Chun, Zheng Liu, and Mark M. Spiegel (2015) "Capital Controls and Optimal Chinese Monetary Policy," *Journal of Monetary Economics*, Vol. 74, pp. 1–15.

Chen, Jiaqian, Daria Finocchiaro, Jesper Lindé, Karl Walentin, and Christopher J Erceg (2020) "The Costs of Macroprudential Deleveraging in a Liquidity Trap," *IMF Working Papers*, Vol. 2020, No. 089.

Correia, Isabel, Joao C Neves, and Sergio Rebelo (1995) "Business cycles in a small open economy," *European Economic Review*, Vol. 39, No. 6, pp. 1089–1113.

Cuadra, Gabriel and Victoria Nuguer (2018) "Risky banks and macro-prudential policy for emerging economies," *Review of Economic Dynamics*, Vol. 30, pp. 125 – 144.

Davis, J. Scott and Ignacio Presno (2017) "Capital Controls and Monetary Policy Autonomy in a Small Open Economy," *Journal of Monetary Economics*, Vol. 85, No. C, pp. 114–130.

De Paoli, Bianca and Matthias Paustian (2017) "Coordinating Monetary and Macroprudential Policies," *Journal of Money, Credit and Banking*, Vol. 49, No. 2-3, pp. 319–349.

Dooley, Michael, Eduardo Fernandez-Arias, and Kenneth Kletzer (1996) "Is the Debt Crisis History? Recent Private Capital Inflows to Developing Countries," *World Bank Economic Review*, Vol. 10, No. 1, pp. 27–50, January.

Eichengreen, Barry and Ricardo Hausmann (1999) "Exchange Rates and Financial Fragility," Working Paper 7418, National Bureau of Economic Research.

——— eds. (2005) *Other People's Money*: University of Chicago Press.

Favilukis, Jack, David Kohn, Sydney C. Ludvigson, and Stijn Van Nieuwerburgh (2013) "International Capital Flows and House Prices: Theory and Evidence," in Glaeser, Edward L. and Todd Sinai eds. *Housing and the Financial Crisis*, Chap. 6, pp. 235–299: University of Chicago Press.

Fernandez-Arias, Eduardo (1996) "The New Wave of Private Capital Inflows: Push or Pull?" *Journal of Development Economics*, Vol. 48, No. 2, pp. 389–418, March.

Ferrero, Andrea (2015) "House price booms, current account deficits, and low interest rates," *Journal of Money, Credit and Banking*, Vol. 47, No. S1, pp. 261–293.

Ferrero, Andrea, Richard Harrison, and Benjamin Nelson (2022) "House price dynamics, optimal LTV limits and the liquidity trap,"Technical report, Bank of England.

Forster, Robert and Xiaojin Sun (2022) "Taming the housing crisis: An LTV macroprudential policy," *Economic Modelling*, Vol. 108, p. 105761.

Frankel, Jeffrey A and Chudozie Okongwu (1996) "Liberalized Portfolio Capital Inflows in Emerging Markets: Sterilization, Expectations, and the Incompleteness of Interest Rate Convergence," *International Journal of Finance & Economics*, Vol. 1, No. 1, pp. 1–23, January.

Gelain, Paolo and Pelin Ilbas (2017) "Monetary and macroprudential policies in an estimated model with financial intermediation," *Journal of Economic Dynamics and Control*, Vol. 78, pp. 164–189.

Gertler, Mark and Peter Karadi (2011) "A model of unconventional monetary policy," *Journal of Monetary Economics*, Vol. 58, No. 1, pp. 17–34.

——— (2013) "QE 1 vs. 2 vs. 3. . . : A Framework for Analyzing Large-Scale Asset Purchases as a Monetary Policy Tool," *International Journal of Central Banking*, Vol. 9, No. 1, pp. 5–53, January.

Gertler, Mark and Nobuhiro Kiyotaki (2010) "Chapter 11 - Financial Intermediation and Credit Policy in Business Cycle Analysis," in Friedman, Benjamin M. and Michael Woodford eds. *Handbook of Monetary Economics Volume 3*, pp. 547–599: Elsevier.

Gertler, Mark, Nobuhiro Kiyotaki, and Albert Queralto (2012) "Financial crises, bank risk exposure and government financial policy," *Journal of Monetary Economics*, Vol. 59, pp. S17–S34.

Ghilardi, Matteo F and Shanaka J Peiris (2016) "Capital flows, financial intermediation and macroprudential policies," *Open Economies Review*, Vol. 27, No. 4, pp. 721–746.

Greenwood, Jeremy, Zvi Hercowitz, and Gregory W Huffman (1988) "Investment, capacity utilization, and the real business cycle," *The American Economic Review*, pp. 402–417.

Iacoviello, Matteo (2005) "House prices, borrowing constraints, and monetary policy in the business cycle," *American Economic Review*, Vol. 95, No. 3, pp. 739–764.

——— (2015) "Financial business cycles," *Review of Economic Dynamics*, Vol. 18, No. 1, pp. 140–163.

Iacoviello, Matteo and Stefano Neri (2010) "Housing market spillovers: evidence from an estimated DSGE model," *American Economic Journal: Macroeconomics*, Vol. 2, No. 2, pp. 125–64.

Jeanne, Olivier and Anton Korinek (2010) "Excessive Volatility in Capital Flows: A Pigouvian Taxation Approach," *American Economic Review*, Vol. 100, No. 2, pp. 403–07.

Jin, Hao (2016) "Foreign Exchange Interventions, Capital Controls and Monetary Policy: The Case of China," CAEPR Working Paper, No.2015-019.

Jin, Hao and Chen Xiong (2018) "Financial openness, bank capital flows, and the effectiveness of macroprudential policies," *Macroeconomic Dynamics*, pp. 1–32.

Johnson, Christopher P. (2021) "International shadow banking and prudential capital controls," *Journal of International Money and Finance*, Vol. 119, p. 102470.

Jung, Yongseung (2016) "Limited Asset Market Participation and Capital Controls in a Small Open Economy," Kyung Hee University, mimeo.

Kannan, Prakash, Pau Rabanal, and Alasdair M. Scott (2012) "Monetary and Macroprudential Policy Rules in a Model with House Price Booms," *The B.E. Journal of Macroeconomics*, Vol. 12, No. Issue 1, Article 16, pp. 1–42.

Kim, Jinill and Sunghyun Henry Kim (2003) "Spurious Welfare Reversals in International Business Cycle Models," *Journal of International Economics*, Vol. 60, No. 2, pp. 471–500.

Kim, Jinill, Sunghyun Kim, Ernst Schaumburg, and Christopher A Sims (2008) "Calculating and using second-order accurate solutions of discrete time dynamic equilibrium models," *Journal of Economic Dynamics and Control*, Vol. 32, No. 11, pp. 3397–3414.

Kitano, Shigeto and Kenya Takaku (2018) "Capital Controls, Monetary Policy, and Balance Sheets in a Small Open Economy," *Economic Inquiry*, Vol. 56, No. 2, pp. 859–874.

——— (2020) "Capital controls, macroprudential regulation, and the bank balance sheet channel," *Journal of Macroeconomics*, Vol. 63, p. 103161.

Korinek, Anton and Damiano Sandri (2016) "Capital controls or macroprudential regulation?" *Journal of International Economics*, Vol. 99, Supplement 1, pp. S27 – S42.

Levine, Paul and Diana Lima (2015) "Policy mandates for macro-prudential and monetary policies in a new Keynesian framework," Working Paper Series 1784, European Central Bank.

Liu, Zheng and Mark M. Spiegel (2015) "Optimal Monetary Policy and Capital Account Restrictions in a Small Open Economy," *IMF Economic Review*, Vol. 63, No. 2, pp. 298–324.

Liu, Zheng, Pengfei Wang, and Tao Zha (2013) "Land-price dynamics and macroeconomic fluctuations," *Econometrica*, Vol. 81, No. 3, pp. 1147–1184.

Luk, Paul and Tianxiao Zheng (2020) "Foreign Direct Investment and Debt Financing in Emerging Economies," *Journal of Money, Credit and Banking*, Vol. 52, No. 4, pp. 863–905.

Matschke, Johannes (2022) "Macroprudential Policy Interlinkages," Federal Reserve Bank of Kansas City.

Mendoza, Enrique G. (1991) "Real Business Cycles in a Small Open Economy," *The American Economic Review*, Vol. 81, No. 4, pp. 797–818.

Mimir, Yasin and Enes Sunel (2019) "External Shocks, Banks, and Optimal Monetary Policy: A Recipe for Emerging Market Central Banks," *International Journal of Central Banking*, Vol. 15, No. 2, pp. 235–299, June.

Neumeyer, Pablo A. and Fabrizio Perri (2005) "Business Cycles in Emerging

Economies: The Role of Interest Rates," *Journal of Monetary Economics*, Vol. 52, No. 2, pp. 345–380, March.

Nispi Landi, Valerio (2017) "Capital controls, macroprudential measures and monetary policy interactions in an emerging economy," Temi di Discussione 1154, Bank of Italy.

Obstfeld, Maurice and Kenneth Rogoff (2009) "Global Imbalances and the Financial Crisis: Products of Common Causes," in *Asia and the Global Financial Crisis*, Federal Reserve Bank of San Francisco, Asia Economic Policy Conference, Santa Barbara, CA, October 18-20, 2009: Federal Reserve Bank of San Francisco.

Palek, Jakob and Benjamin Schwanebeck (2019) "Optimal monetary and macroprudential policy in a currency union," *Journal of International Money and Finance*, Vol. 93, pp. 167–186.

Raffo, Andrea (2008) "Net exports, consumption volatility and international business cycle models," *Journal of International Economics*, Vol. 75, No. 1, pp. 14–29.

Reinhart, Carmen M. and Kenneth S. Rogoff (2009) *This Time Is Different: Eight Centuries of Financial Folly*: Princeton University Press.

Rotemberg, Julio J (1982) "Sticky prices in the United States," *Journal of Political Economy*, Vol. 90, No. 6, pp. 1187–1211.

Rubio, Margarita and José A Carrasco-Gallego (2015) "Macroprudential and monetary policy rules: a welfare analysis," *The Manchester School*, Vol. 83, No. 2, pp. 127–152.

Schmitt-Grohé, Stephanie and Martin Uribe (2007) "Optimal simple and implementable monetary and fiscal rules," *Journal of Monetary Economics*, Vol. 54, No. 6, pp. 1702–1725.

Van der Ghote, Alejandro (2018) "Coordinating monetary and financial regulatory policies," ECB Working Paper.

Appendices

A1 Equilibrium conditions

$$R_t = \frac{1+i_{t-1}}{\pi_t}, \tag{A1}$$

$$\Lambda_{t,t+1} = \beta \frac{C_t - \frac{\zeta_0}{1+\zeta} h_t^{1+\zeta}}{C_{t+1} - \frac{\zeta_0}{1+\zeta} h_{t+1}^{1+\zeta}}, \tag{A2}$$

$$w_t = \zeta_0 h_t^{\zeta}, \tag{A3}$$

$$1 = E_t \left(\Lambda_{t,t+1} R_{t+1} \right), \tag{A4}$$

$$1 = E_t \left(\Lambda_{t,t+1} \frac{Z_{t+1} + \lambda Q_{t+1}}{Q_t + \varkappa K_t^h} \right), \tag{A5}$$

$$1 = E_t \left(\Lambda_{t,t+1} \frac{Z_{t+1}^l + \lambda^l Q_{t+1}^l}{Q_t^l + \varkappa^l L_t^h} \right) \xi_{t+1}^l, \tag{A6}$$

$$Y_t = A_t \left(\frac{K_{t-1}}{\alpha_K} \right)^{\alpha_K} \left(\frac{L_{t-1}}{\alpha_L} \right)^{\alpha_L} \left(\frac{M_t}{\alpha_M} \right)^{\alpha_M} \left(\frac{h_t}{1-\alpha_K-\alpha_L-\alpha_M} \right)^{1-\alpha_K-\alpha_L-\alpha_M}, \tag{A7}$$

$$m_t^C = \frac{1}{A_t} Z_t^{\alpha_K} \left(Z_t^l \right)^{\alpha_L} \epsilon_t^{\alpha_M} w_t^{1-\alpha_K-\alpha_L-\alpha_M}. \tag{A8}$$

$$\frac{Z_t^l L_{t-1}}{Z_t K_{t-1}} = \frac{\alpha_L}{\alpha_K}, \tag{A9}$$

$$\frac{\epsilon_t M_t}{Z_t K_{t-1}} = \frac{\alpha_M}{\alpha_K}, \tag{A10}$$

$$\frac{w_t h_t}{Z_t K_{t-1}} = \frac{1-\alpha_K-\alpha_L-\alpha_M}{\alpha_K}. \tag{A11}$$

$$(\pi_t - 1)\,\pi_t = \frac{1}{\kappa}\left(1-\eta+\eta m_t^C\right) + E_t\left[\Lambda_{t,t+1}\frac{Y_{t+1}}{Y_t}\pi_{t+1}\left(\pi_{t+1}-1\right)\right]. \tag{A12}$$

$$Q_t = 1 + \frac{\kappa_I}{2}\left(\frac{I_t}{I}-1\right)^2 + \left(\frac{I_t}{I}\right)\kappa_I\left(\frac{I_t}{I}-1\right), \tag{A13}$$

$$Q_t^l = 1 + \frac{\kappa_I^l}{2}\left(\frac{I_t^l}{I^l}-1\right)^2 + \left(\frac{I_t^l}{I^l}\right)\kappa_I^l\left(\frac{I_t^l}{I^l}-1\right). \tag{A14}$$

$$\psi_t = \max_{\phi_t,\phi_t^l,x_t}\left\{\mu_t\phi_t + \mu_t^l\phi_t^l + \mu_t^*\left(\phi_t+\phi_t^l\right)x_t + \nu_t\right\} \tag{A15}$$

$$\mu_t = E_t\left\{\Lambda_{t,t+1}\left(1-\sigma+\sigma\psi_{t+1}\right)\left[\frac{\left(Z_{t+1}+\lambda Q_{t+1}\right)}{Q_t} - R_{t+1}\right]\right\}, \tag{A16}$$

$$\mu_t^l = E_t\left\{\Lambda_{t,t+1}\left(1-\sigma+\sigma\psi_{t+1}\right)\left[\underbrace{\frac{\left(Z_{t+1}^l+\lambda^l Q_{t+1}^l\right)\xi_{t+1}^l}{Q_t^l} - \tau_t^l R_{t+1}}_{\mathcal{R}_{t+1}^l} - R_{t+1}\right]\right\}, \tag{A17}$$

$$\mu_t^* = E_t \left\{ \Lambda_{t,t+1} \left(1 - \sigma + \sigma \psi_{t+1}\right) \left[R_{t+1} - \underbrace{\left(\frac{\epsilon_{t+1}}{\epsilon_t} R_t^* + \tau_t^* R_{t+1} \right)}_{\mathcal{R}_{t+1}^{D^*}} \right] \right\}, \tag{A18}$$

$$\nu_t = E_t \left\{ \Lambda_{t,t+1} \left(1 - \sigma + \sigma \psi_{t+1}\right) \left(1 + \tau_t^n\right) R_{t+1} \right\}, \tag{A19}$$

$$\mu_t = \mu_t^l, \tag{A20}$$

$$\Phi_t = \phi_t + \phi_t^l. \tag{A21}$$

$$\Phi_t = \frac{\nu_t}{\theta \left(1 + \frac{\gamma}{2} x_t^2\right) - \mu_t - \mu_t^* x_t}, \tag{A22}$$

$$x_t = \frac{1}{\tilde{\mu_t^*}} \left[-1 + \sqrt{1 + \frac{2}{\gamma} \left(\tilde{\mu_t^*}\right)^2} \right], \tag{A23}$$

$$\tilde{\mu_t^*} = \mu_t^* / \mu_t^l. \tag{A24}$$

$$\phi_t = \frac{Q_t K_t^b}{N_t}, \tag{A25}$$

$$\phi_t^l = \frac{Q_t^l L_t^b}{N_t}, \tag{A26}$$

$$x_t = \frac{\epsilon_t D_t^*}{Q_t K_t^b + Q_t^l L_t^b}, \tag{A27}$$

$$N_t = (\sigma + \xi) \left[(Z_t + \lambda Q_t) K_{t-1}^b + \left(Z_t^l + \lambda^l Q_t^l \right) \xi_t^l L_{t-1}^b \right] - \sigma \left(R_t D_{t-1} + \epsilon_t R_{t-1}^* D_{t-1}^* \right). \tag{A28}$$

$$Q_t K_t^b + Q_t^l L_t^b = N_t + D_t + \epsilon_t D_t^*. \tag{A29}$$

$$i_t - \bar{i} = (1 - \rho_i) \omega_\pi (\pi_t - 1) + \rho_i (i_{t-1} - \bar{i}). \tag{A30}$$

$$Y_t = C_t + \left[1 + \Psi \left(\frac{I_t}{I} \right) \right] I_t + \left[1 + \Psi \left(\frac{I_t^l}{I^l} \right) \right] I_t^l + \chi \left(K_t^h \right) + \chi^l \left(L_t^h \right) + \frac{\kappa}{2} (\pi_t - 1)^2 Y_t + E_{Xt}. \tag{A31}$$

$$E_{Xt} = \left(\frac{P_t}{e_t P_t^*} \right)^{-\varphi} Y_t^* = \epsilon_t^\varphi Y_t^*, \tag{A32}$$

$$D_t^* = R_{t-1}^* D_{t-1}^* + M_t - \frac{1}{\epsilon_t} E_{Xt}. \tag{A33}$$

$$K_t = I_t + \lambda K_{t-1}, \tag{A34}$$

$$L_t = \xi_t^l \left(I_t^l + \lambda^l L_{t-1} \right), \tag{A35}$$

$$K_t \equiv K_t^b + K_t^h, \tag{A36}$$

$$L_t \equiv L_t^b + L_t^h. \tag{A37}$$

$$\ln R_t^* - \ln \bar{R}^* = \rho_{R^*} \left(\ln R_{t-1}^* - \ln \bar{R}^* \right) + \epsilon_{R_t^*}, \qquad \epsilon_{R_t^*} \sim N\left(0, \sigma_{R^*}^2\right), \tag{A38}$$

$$\ln \xi_t^l = \rho_\xi \ln \xi_{t-1}^l + \epsilon_{\xi t}, \qquad \epsilon_{\xi t} \sim N\left(0, \sigma_\xi^2\right), \tag{A39}$$

A2 Steady state

In the steady state, we set the following:

$$R^* = 1.005,$$

$$A = 1,$$

$$\tau^* = 0,$$

$$\tau^l = 0,$$

$$\tau^n = 0,$$

$$\pi = 1,$$

$$\epsilon = 1.$$

In the steady state, we obtain

$$
\begin{aligned}
Q &= 1, \quad \text{from (A13)} \\
Q_l &= 1, \quad \text{from (A14)} \\
R &= \frac{1}{\beta}, \quad \text{from (A2) and (A4)} \\
\Lambda &= \beta, \quad \text{from (A4)} \\
i &= \frac{1}{\beta} - 1, \quad \text{from (A1)} \\
m^C &= 1 - \frac{1}{\eta}. \quad \text{from eq. (A12)}
\end{aligned} \tag{A40}
$$

We define s, s^l, and s^* as follows:

$$s \equiv \beta (Z + \lambda) - 1, \quad \text{from (A16)} \tag{A41}$$

$$s^l \equiv \beta \left(Z^l + \lambda^l\right) - 1, \quad \text{from (A17)} \tag{A42}$$

$$s^* \equiv 1 - \beta R^*. \quad \text{from (A44)}$$

Note that while s^* is determined exogenously, s and s^l remain endogenous.

From (A20), we obtain that

$$s = s^l. \tag{A43}$$

From (A16), (A17), (A24), and (A43), we obtain

$$\tilde{\mu^*} = \frac{\mu^*}{\mu^l} \left(= \frac{s^*}{s^l} \right) = \frac{s^*}{s}. \tag{A44}$$

Subsequently, we can express x as

$$x = \frac{s}{s^*} \left[-1 + \sqrt{1 + \frac{2}{\gamma} \left(\frac{s^*}{s} \right)^2} \right]. \quad \text{from eq. (A23)} \tag{A45}$$

Using Eqs.(A25), (A26), and (A27) and the definitions of s, s^l, s^*, we can rewrite Eq.(A28) in the steady state, as follows:

$$\beta = \sigma\beta \left[\frac{(Z+\lambda Q)\, K^b}{N} + \frac{(Z^l+\lambda^l Q^l)\, L^b}{N} - \frac{RD+\epsilon R^* D^*}{N} \right] + \xi\beta \left[\frac{(Z+\lambda Q)\, K^b}{N} + \frac{(Z^l+\lambda^l Q^l)\, L^b}{N} \right]$$
$$= \sigma\beta \left[(Z+\lambda-R)\,\phi + \left(Z^l+\lambda^l-R\right)\phi^l + (R-R^*)\left(\phi+\phi^l\right)x + R \right]$$
$$+ \xi\beta \left[(Z+\lambda Q)\,\phi + \left(Z^l+\lambda^l Q^l\right)\phi^l \right]$$
$$= \sigma \left[(s+s^* x)\,\phi + \left(s^l+s^* x\right)\phi^l + 1 \right] + \xi \left[(1+s)\phi + (1+s^l)\phi^l \right],$$
$$= \sigma + \left[\sigma\,(s+s^* x) + \xi\,(1+s)\right]\left(\phi+\phi^l\right). \quad \text{using } s = s^l$$

From this, we can express Φ as

$$\Phi \equiv \phi + \phi^l = \frac{\beta-\sigma}{\sigma\,(s+s^* x) + \xi\,(1+s)}. \tag{A46}$$

Substituting (A16), (A17), and (A44) into (A15) and using the definitions of s, s^l, s^*, we obtain the following:

$$\psi = \mu\phi + \mu^l\phi^l + \mu^*\left(\phi+\phi^l\right)x + \nu,$$
$$= (1-\sigma+\sigma\psi)\left[(s+s^* x)\,\phi + \left(s^l+s^* x\right)\phi^l + 1\right].$$

Thus, using $s = s^l$, we can express ψ as

$$\psi = \frac{(1-\sigma)\left[(s+s^* x)\left(\phi+\phi^l\right)+1\right]}{1-\sigma-\sigma\,(s+s^* x)\,(\phi+\phi^l)}. \tag{A47}$$

From incentive constraint (31), we obtain

$$\psi = \Theta\,(x_t)\,\Phi. \tag{A48}$$

Combining Eqs.(A47) with (A48), we obtain

$$\frac{(1-\sigma)\left[(s+s^{*}x)\,\Phi+1\right]}{1-\sigma-\sigma\,(s+s^{*}x)\,\Phi}=\Theta\left(x_{t}\right)\Phi. \tag{A49}$$

Substituting (A46) into (A49) yields:

$$\begin{aligned} H\left(s,s^{*}\right)\equiv{}&(1-\sigma)\left[\beta\left(s+s^{*}x\right)+\xi\left(1+s\right)\right]\left[\sigma\left(s+s^{*}x\right)+\xi\left(1+s\right)\right]\\ &-\Theta\left(x\right)\left(\beta-\sigma\right)\left[\left(1-\beta\right)\sigma\left(s+s^{*}x\right)+\xi\left(1+s\right)\left(1-\sigma\right)\right]=0. \end{aligned} \tag{A50}$$

From (A45), we obtain that

$$s^{*}x=\sqrt{s^{2}+\frac{2}{\gamma}\left(s^{*}\right)^{2}}-s,$$

which shows that '$s^{*}x$' in (A50) is the function of endogenous "s" and exogenous "s^{*}." Thus, we can obtain the steady state value of "s" by solving (A50).

Once we obtain the steady-state value of s, we obtain s^{l} in (A43), x in (A45), and Φ in (A46) as well. Using the steady state value of "s," we obtain the other endogenous variables as follows:

$$\begin{aligned} Z&=\frac{1+s}{\beta}-\lambda,\quad \text{from (A41)}\\ Z^{l}&=\frac{1+s^{l}}{\beta}-\lambda^{l},\quad \text{from (A42)}\\ K^{h}&=\frac{s}{\varkappa},\quad \text{from (A5)}\\ L^{h}&\left(=\frac{s^{l}}{\varkappa^{l}}\right)=\frac{s}{\varkappa^{l}}.\quad \text{from (A6)} \end{aligned}$$

Using Eqs.(A7), (A8), and (A40), we have

$$\frac{K}{Y}\left(=\frac{m^{C}\alpha_{K}}{Z}\right)=\left(1-\frac{1}{\eta}\right)\frac{\alpha_{K}}{Z}, \tag{A51}$$

$$\frac{L}{Y}=\left(1-\frac{1}{\eta}\right)\frac{\alpha_{L}}{Z^{l}}. \tag{A52}$$

Using Eqs.(A3), (A7), (A8), (A9), (A10), (A11), (A51), and (A52), we obtain

$$Y = \frac{1}{\left[(1-\alpha_K-\alpha_L-\alpha_M)^{\zeta}\zeta_0\right]^{\frac{1}{\zeta}}}\left\{\left(1-\frac{1}{\eta}\right)^{(\alpha_K+\alpha_L+\alpha_M)\zeta+1}\left(\frac{A}{(Z^l)^{\alpha_L}\epsilon^{\alpha_M}Z^{\alpha_K}}\right)^{1+\zeta}\right\}^{\frac{1}{\zeta(1-\alpha_K-\alpha_L-\alpha_M)}}.$$

With Y, we obtain

$$K = Y\left(1-\frac{1}{\eta}\right)\frac{\alpha_K}{Z}, \quad \text{from (A51)}$$
$$L = Y\left(1-\frac{1}{\eta}\right)\frac{\alpha_L}{Z^l}. \quad \text{from (A52)}$$

Using K and L, we obtain

$$M = \frac{\alpha_M}{\alpha_K}\frac{ZK}{\epsilon}, \quad \text{from (A10)}$$
$$h = \left(\frac{1-\alpha_K-\alpha_H-\alpha_M}{\alpha_K}\frac{ZK}{\zeta_0}\right)^{\frac{1}{1+\zeta}}, \quad \text{from (A3) and (A11)}$$
$$w = \zeta_0 L^{\zeta}, \quad \text{from (A3)}$$
$$K^b = K - K^h = K - \frac{s}{\varkappa}, \quad \text{from (A36)}$$
$$L^b = L - L^h = L - \frac{s^l}{\varkappa^l}, \quad \text{from (A37)}$$
$$I = (1-\lambda)K, \quad \text{from (A34)}$$
$$I^l = \left(1-\lambda^l\right)L. \quad \text{from (A35)}$$

From (A33) (using $x \equiv \frac{\epsilon D^*}{QK^b+Q^lL^b}$), we obtain $\frac{E_X}{Y}$:

$$\frac{E_X}{Y} = \alpha_M\left(1-\frac{1}{\eta}\right) + (R^*-1)\frac{x\left(QK_t^b+Q^hH^b\right)}{Y},$$

which yields $E_X \left(=\frac{E_X}{Y}Y\right)$.

From (A31), we obtain C:

$$C = Y - I - I^l - E_X - \frac{\varkappa}{2}(K^h)^2 - \frac{\varkappa^l}{2}(L^h)^2.$$

From (A21), (A25), and (A26), we obtain that

$$\phi = \frac{\Phi Q K^b}{QK^b + Q^l L^b},$$
$$\phi^l = \frac{\Phi Q^l L^b}{QK^b + Q^l L^b},$$
$$N = \frac{QK^b}{\phi}.$$

From the definition of x (A27), we obtain

$$D^* = \frac{x\left(QK^b + Q^l L^b\right)}{\epsilon}.$$

From the balance sheets (A29), we obtain

$$D = QK^b + Q^l L^b - N - \epsilon D^*.$$

From (A48), we obtain

$$\psi = \theta\left(1 + \frac{\gamma}{2}x^2\right)\Phi.$$

Using ψ, we obtain

$$\mu = \Omega\left[\frac{(Z + \lambda Q)}{Q} - R\right],$$
$$\mu^l = \Omega\left[\frac{\left(Z^l + \lambda^l Q^l\right)\xi^l}{Q^l} - R\right],$$
$$\mu^* = \Omega\left[R - R^*\right],$$
$$\nu = \Omega R,$$
$$\text{where} \quad \Omega \equiv \Lambda\left(1 - \sigma + \sigma\psi\right).$$

A3 The household's profits from firms and banks

In Eq.(2), Π_t denotes the total profits of firms and banks (net start-up funds for bankers). Π_t is given by:

$$\Pi_t = \underbrace{\int_0^1 \left[\left(\frac{p_{it}}{P_t} - m_t^C\right) y_{it} - \frac{\kappa}{2}\left(\frac{p_{it}}{p_{it-1}} - 1\right)^2 Y_t\right] di}_{\text{profit from intermediate goods firms}}$$
$$+ \underbrace{\left[Q_t - 1 - \Psi\left(\frac{I_t}{I}\right)\right] I_t + \left[Q_t^l - 1 - \Psi_l\left(\frac{I_t^l}{I^l}\right)\right] I_t^l}_{\text{profit from capital and land investment firms}}$$
$$+ \underbrace{(1-\sigma)\left[(Z_t + \lambda Q_t) K_{t-1}^b + \left(Z_t^l + \lambda^l Q_t^l\right) \xi_t^l L_{t-1}^b - R_t D_{t-1} - \epsilon_t R_{t-1}^* D_{t-1}^*\right]}_{\text{dividend from bankers}}$$
$$- \underbrace{\xi\left[(Z_t + \lambda Q_t) K_{t-1} + \left(Z_t^l + \lambda^l Q_t^l\right) \xi_t^l L_{t-1}\right]}_{\text{start-up fund for bankers}}.$$

The household's profit from the final goods firms is zero due to perfect competition.

A4 Derivation of Eq.(32)

It follows from Eq.(24):

$$\frac{n_{t+1}}{n_t} = \frac{(Z_{t+1} + \lambda Q_{t+1})}{Q_t}\frac{Q_t k_t^b}{n_t} + \frac{\left(Z_{t+1}^l + \lambda^l Q_{t+1}^l\right)\xi_{t+1}^l}{Q_t^l}\frac{Q^l l_t^b}{n_t} - R_{t+1}\frac{d_t}{n_t} - R_t^* \frac{\epsilon_{t+1}}{\epsilon_t}\frac{\epsilon_t d_t^*}{n_t}.$$

Using $\phi_t \equiv Q_t k_t^b / n_t$, $\phi_t^l \equiv Q_t^l l_t^b / n_t$, $x_t \equiv \frac{\epsilon_t d_t^*}{\left(Q_t k_t^b + Q_t^l l_t^b\right)}$, and Eq.(30), we have

$$\frac{n_{t+1}}{n_t} = \frac{(Z_{t+1} + \lambda Q_{t+1})}{Q_t}\phi_t + \frac{\left(Z_{t+1}^l + \lambda^l Q_{t+1}^l\right)\xi_{t+1}^l}{Q_t^l}\phi_t^l - R_t^* \frac{\epsilon_{t+1}}{\epsilon_t} x_t \left(\phi_t + \phi_t^l\right)$$
$$- R_{t+1}\left[\phi_t + \left(1 + \tau_t^l\right)\phi_t^l - (1 + \tau_t^n) - x_t (1 - \tau_t^*)\left(\phi_t + \phi_t^l\right)\right].$$

Transforming this equation, we obtain Eq.(32).

$$\frac{n_{t+1}}{n_t} = \left[\frac{(Z_{t+1} + \lambda Q_{t+1})}{Q_t} - R_{t+1}\right]\phi_t + \left[\frac{\left(Z_{t+1}^l + \lambda^l Q_{t+1}^l\right)\xi_{t+1}^h}{Q_t^l} - \left(1 + \tau_t^l\right)R_{t+1}\right]\phi_t^l$$
$$+ \left[(1 - \tau_t^*)\, R_{t+1} - \frac{\epsilon_{t+1}}{\epsilon_t} R_t^*\right] x_t \left(\phi_t + \phi_t^l\right) + (1 + \tau_t^n)\, R_{t+1}.$$