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# Capital controls, macroprudential regulation, and the bank balance sheet channel[☆]

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ABSTRACT

We incorporate a banking sector with balance sheet frictions into a model of a small open economy and compare the effectiveness of capital controls and macroprudential regulation. We show that the welfare-improving effect of capital controls is larger than that of macroprudential regulation if the degree of financial friction between domestic banks and foreign investors is high, while the welfare-improving effect of macroprudential regulation is larger than that of capital controls if the degree of financial friction is low. We also show that the welfare ranking of the two policies depends on whether an economy suffers from liability dollarization.

## 1. Introduction

During the global financial crisis and its aftermath, emerging economies experienced changes of unprecedented magnitude in international capital flows. Policymakers in emerging economies struggle with how to manage capital flows.[3] More policymakers and economists, including the IMF, think that unorthodox measures such as capital controls and macroprudential regulations could

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[3] For literature related to the issues and policies associated with capital flows in emerging economies, see, for example, Montiel (2014).

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mitigate the vulnerability of emerging economies to external shocks.[4] In response to the instability, emerging economies such as Brazil, Indonesia, South Korea, Taiwan, and Thailand changed the intensity of capital controls.[5][6] Policymakers in emerging economies tightened both macroprudential regulations and capital controls in the face of capital inflows (Ghosh et al., 2017). Against this background, an increasing number of researchers focus on capital controls and macroprudential policies in emerging economies, and studies extend this research in a variety of new directions.[7] A natural question arises as to which of the two policies is to be adopted in light of the goals. Korinek and Sandri (2016) are the first to differentiate between macroprudential regulation and capital controls and tackle this question. By distinguishing between domestic and foreign lending, they investigate the comparative advantages of the two types of prudential instruments and provide policy lessons from their optimal use. They show that both types of policy measures make the economy more stable and reduce the severity of crises. They also show that in advanced countries where the risk of contractionary exchange rate depreciation is more limited, the role of capital controls subsides, whereas macroprudential regulation is essential to mitigate booms and busts in asset prices.

As in Korinek and Sandri (2016)'s study, we compare the effectiveness of capital controls and macroprudential regulation. However, in contrast to Korinek and Sandri (2016), we explicitly incorporate a banking sector into a small open economy model and then compare the effectiveness of these two policies from the different perspective of the bank balance sheet channel. Fig. 1 illustrates the difference between capital controls and macroprudential regulation. Fig. 1 is equivalent to Fig. 1 in Korinek and Sandri (2016), but includes banks as a key player. Capital controls apply to transactions between domestic banks and foreign creditors, whereas macroprudential regulations restrict borrowing by domestic agents (i.e., domestic firms).

We incorporate banks into our model because disruptions in financial intermediation were critical for the global financial crisis; after the crisis, more researchers focused on the balance sheets of financial intermediaries (e.g., Gertler and Kiyotaki, 2010 and Gertler and Karadi (2011)).[8] Another reason is that, as is also well known, the share of financial intermediaries such as banks in the financial sector is larger in emerging economies than it is in developed economies. In addition, banks' external borrowing is critical for credit supply in emerging economies (Baskaya et al., 2017; Blanchard et al., 2016).[9] Therefore, we develop a small open economy model augmented with banks à la Gertler and Kiyotaki (2010) and Gertler and Karadi (2011).[10]

Explicitly incorporating banks into a small open economy model enables us to specifically examine how the bank balance sheet channel affects the policy choice between capital controls and macroprudential regulation. In our model, to fund capital investments, banks use deposits obtained from local households and foreign borrowing from foreign investors in addition to their net worth. Therefore, we can explicitly distinguish financial frictions between banks and foreign creditors from those between banks and domestic creditors. In this study, we focus on the financial friction between banks and foreign investors and then examine how this financial friction affects the policy choice between capital controls and macroprudential regulations. We show that the welfare-improving effect of macroprudential regulation is larger than that of capital controls if the degree of financial frictions between domestic banks and foreign investors is low. However, the welfare-improving effect of capital controls is larger than that of macroprudential regulation if the degree of financial frictions between domestic banks and foreign investors is high. It is noteworthy that we can obtain these results only by incorporating a banking sector into a small open economy and considering the financial friction between banks and foreign investors.

Emerging economies have difficulty borrowing abroad in their own currencies and face a mismatch in the currency denomination of their liabilities and assets. Therefore, in our model, we assume that banks face the "liability dollarization" problem and that the banks' liabilities are denominated in a foreign currency, whereas the banks' assets are denominated in the domestic currency.[11] When the economy suffers from liability dollarization, exchange rate behavior through the banks' balance sheets may amplify the effect of financial frictions on a small open economy. We also consider a no-liability dollarization economy in which there is no direct negative valuation effect of exchange rate deterioration on banks' balance sheets. Comparing two economies, one with and one without liability dollarization, we find that the welfare-improving effect of macroprudential regulation is larger than that of capital controls in

[4] For details, see Ostry et al. (2010), IMF (2011), Habermeier et al. (2011), and Ostry et al. (2012).

[5] For details, see, for example, Jongwanich and Kohpaiboon (2012), Ahmed and Zlate (2014), Forbes et al. (2016), and Ghosh et al. (2017).

[6] Eichengreen and Rose (2014) and Fernández et al. (2015) find that capital controls tend to be highly durable and do not vary in a countercyclical manner. However, Ghosh et al. (2017) find that emerging economies respond to capital flows by imposing capital controls. Ghosh et al. (2017) argue that their result differs from those of Eichengreen and Rose (2014) and Fernández et al. (2015) due to the use of different capital account openness indices, sample periods, and countries, and because they analyze the behavior of capital controls against capital flows directly (not against macroeconomic indicators).

[7] Capital controls are not a new policy instrument. Even before the recent global financial crisis, capital controls were widely discussed, both theoretically and empirically. For earlier literature on capital controls, see Kitano (2011).

[8] Previous studies on financial frictions emphasize the credit constraints that non-financial borrowers face (e.g., Bernanke et al., 1999).

[9] Igan and Tan (2015) find that the "other flows" including bank flows are critical for credit growth in a sample of 33 countries including emerging and developed countries.

[10] Aoki et al. (2016), Ghilardi and Peiris (2016), Mimir and Sunel (2019), and Cuadra and Nuguer (2018) also develop open economy models with financial frictions à la Gertler and Kiyotaki (2010) and Gertler and Karadi (2011), although for different purposes. The former three are New Keynesian small open economy models, and the latter is a two-country model.

[11] Eichengreen and Hausmann (1999) refer to this incompleteness in financial markets as "original sin." Eichengreen and Hausmann (2005) also argue that "[w]hile the quality of institutions and policies varies enormously among developing countries, the extent of original sin does not" (page 6) and that "the difficulty emerging markets experience in attempting to borrow abroad in their own currencies has something to do with the structure of the international system"(page 6).

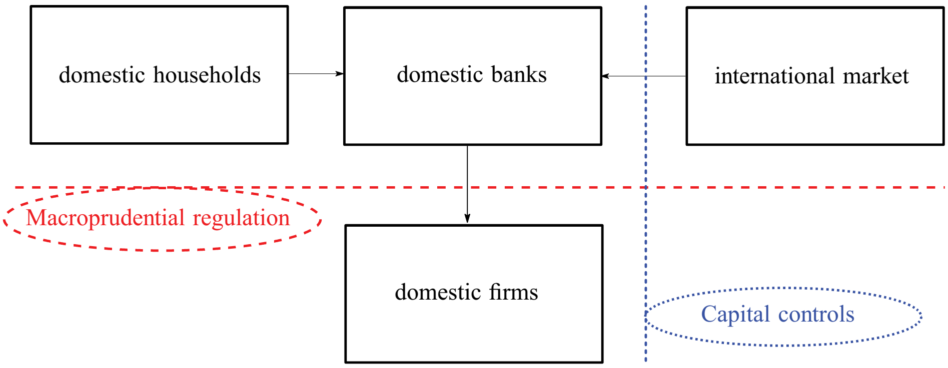



**Fig. 1.** Capital controls versus macroprudential regulation.

an economy without liability dollarization. It is again noteworthy that we can compare the liability dollarization economy and the no-liability dollarization economy only by incorporating a banking sector into a small open economy.

The remainder of the paper proceeds as follows. In Section 2, we present a small open economy model augmented with liability dollarization and financial frictions à la Gertler and Kiyotaki (2010) and Gertler and Karadi (2011). We also calibrate our model to match key characteristics of emerging economies. In Section 3, we examine the welfare-improving effects of capital controls and macroprudential regulation and compare them under different degrees of financial frictions. In addition, we compare the welfare-improving effects of these two policies in an economy with liability dollarization to those without liability dollarization. We present our conclusions in Section 4.

***Related Literature.***—Capital controls were first discussed as a policy tool to internalize externalities associated with financial crises and prevent excessive borrowing (e.g., Jeanne and Korinek, 2010; Bianchi, 2011; Brunnermeier and Sannikov, 2015).[12] While Ostry et al. (2010) argue that the use of capital controls is justified under limited circumstances, Jeanne et al. (2012) go further, arguing that "[p]roperly designed capital controls may even be effective as a regular instrument of economic policy"(p.110). In recent years, an increasing number of studies examine the potential effects of capital controls as a regular policy tool (e.g., De Paoli and Lipinska, 2013; Kitano and Takaku, 2017). A strand of the literature focuses on the effects of capital controls in the presence of nominal rigidities (e.g., Farhi and Werning, 2012; Schmitt-Grohé and Uribe, 2016). Another strand focuses on the effects of using capital controls combined with various types of monetary policies (Liu and Spiegel, 2015; Chang et al., 2015; Jin, 2016; Jung, 2016; Davis and Presno, 2017; Agénor and Jia, 2015; Kitano and Takaku, 2018a, and Kitano and Takaku, 2018b).[13]

In the aftermath of the financial crisis, the role of macroprudential regulation in promoting financial stability is also under discussion.[14] Many studies in the literature examine macroprudential regulations in monetary models. Kannan et al. (2012) examine macroprudential regulation and monetary policy in a New Keynesian model with housing markets. They show that macroprudential regulation that reacts to credit growth is welfare improving under financial shocks and housing demand shocks. Developing a New Keynesian model with bank runs, Angeloni and Faia (2013) show that a countercyclical capital requirement policy is welfare improving. Angelini et al. (2014) examine the interaction between macroprudential regulation and monetary policy in a New Keynesian model with a banking sector. They find that under supply shocks, countercyclical capital requirements yield negligible additional benefits without monetary policy. In contrast, under financial shocks, countercyclical capital requirements reduce volatility in output and the loans-to-output ratio, regardless of whether monetary and macroprudential authorities cooperate. Using a New Keynesian model with financial frictions à la Gertler et al. (2012), Levine and Lima (2015) show that macroprudential regulations on banks are welfare improving, and that there are welfare gains even when macroprudential and monetary authorities independently react to their own policy goals. De Paoli and Paustian (2017) study the coordination issues between monetary and macroprudential policies in a New Keynesian model with financial frictions à la Gertler and Karadi (2011). They show that when financial frictions equally affect the financing of different factors of production, macroprudential regulation eliminates inefficiencies, regardless of the source of the shock and whether monetary and macroprudential authorities cooperate. They also find that when policymakers cannot achieve the first-best scenario, leadership by a macroprudential authority leads to welfare outcomes as large as those achieved when authorities cooperate. Building a model with a banking sector and a frictional credit market, Fujimoto et al. (2017) examine optimal macroprudential and monetary policies. They find that an optimal macroprudential policy, which is mainly associated with financial stability, is closely linked with price stability, and then with an optimal monetary policy.

While all of the above studies investigate macroprudential regulations in a closed economy model, the following studies adopt an open economy model. Developing an open economy model with financial frictions à la Bernanke et al. (1999), Unsal (2013) shows that under financial shocks, macroprudential regulation that reacts to total liabilities is more effective than that which reacts solely to

[12] Harberger (1986) notes that externalities accompany foreign borrowing, and policymakers can internalize these through a corrective tax on foreign borrowing.

[13] For a more detailed explanation of the recent literature, see Kitano and Takaku (2017).

[14] For the related literature, see, for example, Galati and Moessner (2013) and Engel (2016).

foreign liabilities. In addition, the desirability of macroprudential regulations depends on the exchange rate regimes. Ghilardi and Peiris (2016) examine macroprudential regulation and monetary policy in an open economy model with financial frictions à la Gertler and Karadi (2011). They show that macroprudential regulation can complement monetary policy and that countercyclical macroprudential policies can enhance welfare.

## 2. Model

The model framework is basically similar to Kitano and Takaku (2017). We incorporate financial frictions à la Gertler and Kiyotaki (2010) into a real business cycle model of a small open economy. Households, non-financial firms (goods producers and capital producers), the government, and banks exist in an economy. To make loans to domestic non-financial firms, banks use their net worth, deposits obtained from local households, and foreign borrowing. The government uses capital controls to regulate banks' foreign borrowing. The government also uses macroprudential regulations to regulate banks' lending to non-financial firms.

### 2.1. Households

To maintain the tractability of the representative agent approach, we formulate the household sector following Gertler and Kiyotaki (2010) and Gertler and Karadi (2011). Two types of members exist within a representative household: a fraction $1-f$ of workers and a fraction $f$ of bankers. Both workers and bankers return their wages and dividends to the household. There is perfect consumption insurance within the household. A banker remains a banker in the next period with probability $\sigma$. $(1-\sigma)f$ bankers become workers in the next period; the same number of workers become bankers. The fraction of each type of member therefore remains constant over time. Exiting bankers transfer their retained earnings to the household, whereas the household provides new bankers with start-up funds.

The household's expected lifetime utility is given by

$$E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, L_t), \tag{1}$$

where $E_0$ represents the mathematical expectations operator conditional on information available at time 0, $C_t$ denotes a composite consumption index, $L_t$ denotes labor effort, and $\beta \in (0, 1)$ is the discount factor. Composite consumption is a CES function of domestic goods and imported goods, where $C_t \equiv \left[(1-\upsilon)^{\frac{1}{\iota}} C_{H,t}^{\frac{\iota-1}{\iota}} + \upsilon^{\frac{1}{\iota}} C_{F,t}^{\frac{\iota-1}{\iota}}\right]^{\frac{\iota}{\iota-1}}$. The parameter $\iota\,(>0)$ is the elasticity of substitution between domestic and imported goods (i.e., trade elasticity), and $\upsilon \in (0, 1)$ is the degree of trade openness. The implied consumer price index (CPI) is then $P_t \equiv [(1-\upsilon)P_{H,t}^{1-\iota} + \upsilon P_{F,t}^{1-\iota}]^{\frac{1}{1-\iota}}$, where $P_{H,t}$ is the domestic price and $P_{F,t}$ is the import price.

A household's budget constraint is given by

$$C_t + T_{h,t} + D_t = R_t D_{t-1} + w_t L_t + \Pi_t^{fb}, \tag{2}$$

where $D_t$ is bank deposits, $R_t$ is the gross return on bank deposits, $\Pi_t^{fb}$ denotes dividends from banks and non-financial firms, $w_t$ is the real wage, and $T_{h,t}$ is lump-sum taxes.

The household's first-order optimality conditions are

$$U_C(C_t, L_t) = \varrho_t, \tag{3}$$

$$U_L(C_t, L_t) + \varrho_t w_t = 0, \tag{4}$$

and

$$1 = E_t \Lambda_{t,t+1} R_{t+1}, \tag{5}$$

where $\varrho_t$ is the Lagrange multiplier on Eq. (2), and $\Lambda_{t,t+1} \equiv \beta \frac{\varrho_{t+1}}{\varrho_t}$. The household chooses domestic and imported goods to minimize expenditure conditional on total composite demand. The demand functions for domestic and foreign goods are then given by[15]

$$C_{H,t} = (1-\upsilon)\left(\frac{P_{H,t}}{P_t}\right)^{-\iota} C_t, \tag{6}$$

and

$$C_{F,t} = \upsilon\left(\frac{P_{F,t}}{P_t}\right)^{-\iota} C_t. \tag{7}$$

### 2.2. Banks

The balance sheet of a bank is given by

[15] From Eqs. (6), (7), and the CPI, we thus obtain $P_{H,t} C_{H,t} + P_{F,t} C_{F,t} = P_t C_t$.

$$Q_t s_t = n_t + e_t b_t + d_t, \tag{8}$$

where $Q_t$ and $s_t$ denote the price and quantity of a bank's financial claims on goods producers, respectively. $n_t$ is net worth, $b_t$ is foreign debt, $e_t$ is the real exchange rate, and $d_t$ is deposits from households. Banks face the liability dollarization problem. Eq. (8) shows that a depreciation in the domestic currency has a direct negative impact on the bank's balance sheet because it increases the foreign debt burden in domestic currency terms. In the liability dollarization economy, through the bank balance sheet channel, the exchange rate amplifies the effect of a foreign interest rate shock on the economy. We will also consider an economy where banks do not face the liability dollarization problem in Sections 3.6 and A.2.

The bank's net worth evolves as the difference between earnings on assets and payments on liabilities:

$$n_t = (1 - \mathcal{T}_t^k) R_{k,t} Q_{t-1} s_{t-1} - (1 + \mathcal{T}_t^b) R_{b,t} e_{t-1} b_{t-1} - R_t d_{t-1} + \zeta_t, \tag{9}$$

where $R_{kt}$ is the gross return on assets, $\zeta_t$ is the government's lump-sum transfer to a bank, and $R_{bt}$ and $R_t$ denote the gross interest rate on foreign debt (in terms of domestic currency) and that on deposits, respectively. $\mathcal{T}_t^k$ and $\mathcal{T}_t^b$ denote the tax rate on a bank's asset holdings and that on a bank's foreign currency debt holdings, respectively. Under macroprudential regulation and capital controls, banks' lending and foreign borrowing are taxed.

Taking into account the probability of exiting the banking industry, the bank maximizes its expected terminal wealth:

$$V_t = E_t \sum_{i=1}^{\infty} (1 - \sigma) \sigma^{i-1} \Lambda_{t,t+i} n_{t+i}, \tag{10}$$

where $1 - \sigma$ is the probability of exiting the banking industry in the next period.

To limit a bank's ability to expand its balance sheet, we introduce an agency problem à la Gertler and Kiyotaki (2010) and Gertler and Karadi (2011) and assume that it is possible for a banker to transfer some fraction of "divertable" assets to the household. If a bank diverts assets, it becomes bankrupt. This introduces an incentive constraint:

$$V_t \geq \Theta(d_t + n_t) + \Theta^* e_t b_t, \tag{11}$$

where $\Theta$ denotes the "divertable" fraction of assets financed by deposits ($d_t$) and net worth ($n_t$), and $\Theta^*$ denotes the "divertable" fraction of assets financed by foreign borrowing ($e_t b_t$). We assume that $\Theta^* > \Theta$, which implies that the assets financed by foreign borrowing are easier to divert than those financed by deposits and net worth. The left-hand side of Eq. (11) represents the banker's losses from bankruptcy, whereas the right-hand side of Eq. (11) is the banker's gain from bankruptcy. Therefore, the left-hand side must not be less than the right-hand side so that households and foreign investors are willing to lend to a bank. In other words, the incentive constraint (11) limits a bank's ability to expand its balance sheet.

We introduce parameter $\chi(> 0)$, which indexes the degree of financial frictions between banks and foreign investors:

$$\Theta^* = (1 + \chi)\Theta. \tag{12}$$

A higher value of $\chi$ implies that the asset financed by foreign borrowing is easier to divert than that financed by domestic deposits. Therefore, a higher value of $\chi$ indicates a higher degree of financial friction in foreign borrowing.[16] Substituting Eqs. (8) and (12) into the right-hand side of Eq. (11), we rewrite the right-hand side of Eq. (11) as[17]

$$\begin{aligned}\Theta(d_t + n_t) + \Theta^* e_t b_t &= \Theta(d_t + n_t) + \Theta(1 + \chi) e_t b_t \\ &= \Theta(Q_t s_t + \chi e_t b_t).\end{aligned} \tag{13}$$

As Appendix A.1 shows, we can express $V_t$ as follows:

$$V_t(s_t, b_t, n_t) = \mu_t Q_t s_t + \mu_{b,t} e_t b_t + \mathcal{V}_t n_t, \tag{14}$$

with

$$\mu_t = E_t \Lambda_{t,t+1} \Omega_{t+1} [(1 - \mathcal{T}_{t+1}^k) R_{k,t+1} - R_{t+1}], \tag{15}$$

$$\mu_{b,t} = E_t \Lambda_{t,t+1} \Omega_{t+1} [R_{t+1} - (1 + \mathcal{T}_{t+1}^b) R_{b,t+1}], \tag{16}$$

and

$$\mathcal{V}_t = E_t \Lambda_{t,t+1} \Omega_{t+1} R_{t+1}, \tag{17}$$

where

$$\Omega_t \equiv (1 - \sigma) + \sigma(\phi_t \mu_t + \mathcal{V}_t), \tag{18}$$

and

[16] Mimir and Sunel (2019) examine how this kind of asymmetric financial frictions are related with the violation of the uncovered interest parity condition.

[17] Because the "divertable" amount of funds financed by foreign borrowing must not be greater than the total amount of the funds financed by foreign borrowing, $e_t b_t \geq \Theta(1 + \chi) e_t b_t$ must hold, and the upper limit for $\chi$ must exist (i.e., $\frac{1}{\Theta} - 1 \geq \chi$).

$$\phi_t \equiv \frac{\mathcal{V}_t}{\Theta - \mu_t}. \tag{19}$$

We can obtain analytical insights from the banks' optimization problem as follows. First, we consider the left-hand-side of Eqs. (15) and (16). As Appendix A.1 shows, we have $\mu_t \equiv \frac{\mathcal{V}_{s,t}}{Q_t} - \mathcal{V}_t$, and $\mu_{b,t} \equiv \mathcal{V}_t - \frac{\mathcal{V}_{b,t}}{e_t}$. In frictionless economies, the marginal value of assets $\frac{\mathcal{V}_{s,t}}{Q_t}$ is equal to the marginal cost of domestic borrowing $\mathcal{V}_t$. If this is the case, we have $\mu_t = 0$. However, if banks are constrained,

$$\mu_t \equiv \frac{\mathcal{V}_{s,t}}{Q_t} - \mathcal{V}_t > 0, \tag{20}$$

which implies that banks' lending is limited such that the marginal value of assets remains higher than the marginal cost of domestic borrowing. Similarly, in frictionless economies, the marginal cost of domestic borrowing $\mathcal{V}_t$ is equal to the marginal cost of foreign borrowing $\frac{\mathcal{V}_{b,t}}{e_t}$ (i.e., $\mu_{b,t} = 0$). However, if banks are constrained,

$$\mu_{b,t} \equiv \mathcal{V}_t - \frac{\mathcal{V}_{b,t}}{e_t} > 0, \tag{21}$$

which indicates that the marginal price of domestic borrowing exceeds the marginal price of foreign borrowing. This implies that the foreign market is less efficient than the domestic market (i.e., $\chi > 0$, indicating that assets financed by foreign borrowing are easier to divert than those financed by domestic borrowing).

We next consider the right-hand-side of Eqs. (15) and (16). In frictionless economies, the credit spread ($R_k - R$) is zero. However, in a model with financial frictions, the equilibrium allocation is not efficient due to the credit distortion and the credit spread is not zero (Nispi Landi, 2017; De Paoli and Paustian, 2017). From the other banks' first-order conditions (A.4) and (A.5) in Appendix A.1, we obtain

$$\mu_t = \Theta \frac{1}{1 + (1/\lambda_t)}, \tag{22}$$

and

$$\mu_{b,t} = \chi\Theta \frac{1}{1 + (1/\lambda_t)}, \tag{23}$$

where $\lambda_t$ is the Lagrange multiplier for the incentive constraint. A policy maker can influence $\mu_t$ and $\mu_{b,t}$ by changing $\mathcal{T}^b$ and $\mathcal{T}^k$ in Eqs. (15) and (16). It follows from Eqs. (22) and (23) that when $\mu_t$ (or $\mu_{b,t}$) is reduced, the Lagrange multiplier of bank's incentive constraint $\lambda_t$ decreases, which implies that capital controls and macroprudential regulation can loosen financial conditions.[18]

It follows from the first-order conditions obtained from maximizing the value function subject to the incentive constraint (11) (and (13)) that

$$\mu_{b,t} = \chi\mu_t, \tag{24}$$

and

$$Q_t s_t = \phi_t n_t - \frac{\phi_t}{\phi_{b,t}} e_t b_t, \tag{25}$$

where

$$\phi_{b,t} \equiv \frac{\mathcal{V}_t}{\chi\Theta - \mu_{b,t}}. \tag{26}$$

Since $\phi_t$ and $\phi_{b,t}$ are independent of bank-specific factors, we can aggregate across banks. Therefore, from Eq. (25), we obtain

$$N_t = \frac{1}{\phi_t} Q_t S_t + \frac{1}{\phi_{b,t}} e_t B_t, \tag{27}$$

where the capital letters indicate the aggregate variables. From Eqs. (19), (24), (26), (27), and the aggregate balance sheet ($Q_t S_t = N_t + e_t B_t + D_t$), we obtain the aggregate deposit:

$$D_t = -(1+\chi) e_t B_t + (\phi_t - 1) N_t. \tag{28}$$

As we will argue in Section 2.4, the government returns the tax revenues from capital controls and macroprudential policies to banks as a lump-sum transfer (i.e., $\zeta_t = \mathcal{T}^k_t R_{k,t} Q_{t-1} s_{t-1} + \mathcal{T}^b_t R_{b,t} e_{t-1} b_{t-1}$). Since the fraction $\sigma$ of banks continue to operate in the next period, we obtain the existing banks' net worth $N_{et}$ from Eq. (9) as follows:

$$N_{e,t} = \sigma (R_{k,t} Q_{t-1} S_{t-1} - R_{b,t} e_{t-1} B_{t-1} - R_t D_{t-1}). \tag{29}$$

[18] Eqs. (15) and (16) imply that if the incentive compatibility constraint in the banking sector does not bind, $\mathcal{T}^k_{t+1}$ and $\mathcal{T}^b_{t+1}$ would be zero.

Following previous related studies, we assume that new bankers receive the fraction $\xi/(1-\sigma)$ of the total final period assets of exiting bankers.[19] The new bank's net worth is then

$$N_{n,t} = \xi R_{k,t} Q_{t-1} S_{t-1}. \tag{30}$$

Since the total net worth $N_t$ is the sum of the net worth of existing banks $N_{e,t}$ and that of new banks (i.e., $N_t = N_{e,t} + N_{n,t}$), we obtain the evolution of $N_t$:

$$N_t = (\sigma + \xi) R_{k,t} Q_{t-1} S_{t-1} - \sigma R_{b,t} e_{t-1} B_{t-1} - \sigma R_t D_{t-1}. \tag{31}$$

## 2.3. Non-financial firms

### 2.3.1. Goods producers

Competitive goods producers use capital and labor to produce domestic goods:

$$Y_t = Z_t K_t^{\alpha} L_t^{1-\alpha}, \tag{32}$$

where $Y_t$ is domestic output, $Z_t$ is total factor productivity, and $K_t$ is capital. Goods producers purchase capital by obtaining funds from banks:

$$Q_t K_{t+1} = Q_t S_t. \tag{33}$$

Since we focus on financial frictions on banks, we assume no friction in the process of obtaining funds from banks. It follows from the firm's first-order conditions that

$$(1-\alpha)\frac{P_{H,t}}{P_t}\frac{Y_t}{L_t} = w_t. \tag{34}$$

Since goods producers are perfectly competitive, the expected gross return on capital is

$$R_{k,t+1} = \frac{\frac{P_{H,t+1}}{P_{t+1}}\alpha\frac{Y_{t+1}}{K_{t+1}} + Q_{t+1}(1-\delta)}{Q_t}, \tag{35}$$

where $\delta$ is the depreciation rate of capital.

### 2.3.2. Capital producers

As in $C_t$, investment $I_t$ is composed of domestic and imported goods, where $I_t \equiv \left[(1-\upsilon)^{\frac{1}{\iota}} I_{H,t}^{\frac{\iota-1}{\iota}} + \upsilon^{\frac{1}{\iota}} I_{F,t}^{\frac{\iota-1}{\iota}}\right]^{\frac{\iota}{\iota-1}}$.[20] Competitive capital producers make new capital subject to adjustment costs on investment. The capital producer's objective is

$$\max_{I_t} E_t \sum_{i=0}^{\infty} \Lambda_{t,t+i}\left\{Q_{t+i} I_{t+i} - \left[1 + f\left(\frac{I_{t+i}}{I_{t+i-1}}\right)\right] I_{t+i}\right\}, \tag{36}$$

where $f\left(\frac{I_{t+i}}{I_{t+i-1}}\right) I_{t+i}$ reflects convex adjustment costs, with $f(1) = f'(1) = 0$ and $f''(I_{t+i}/I_{t+i-1}) > 0$. From the first-order condition for $I_t$, we obtain

$$Q_t = 1 + f\left(\frac{I_t}{I_{t-1}}\right) + \frac{I_t}{I_{t-1}} f'\left(\frac{I_t}{I_{t-1}}\right) - E_t \Lambda_{t,t+1}\left(\frac{I_{t+1}}{I_t}\right)^2 f'\left(\frac{I_{t+1}}{I_t}\right). \tag{37}$$

The capital stock evolves according to

$$K_{t+1} = (1-\delta) K_t + I_t. \tag{38}$$

## 2.4. Government

The government's budget constraint is

$$G_t + \mathcal{Z}_t = \mathcal{T}_t^k R_{k,t} Q_{t-1} S_{t-1} + \mathcal{T}_t^b R_{b,t} e_{t-1} B_{t-1} + T_{h,t}, \tag{39}$$

where $G_t (=G)$ is constant government spending and $\mathcal{Z}_t$ denotes the aggregate variable for $\zeta_t$. As we argue in Section 2.2, we assume that the government returns the tax revenue on capital controls and macroprudential regulation to banks as a lump-sum transfer (i.e., $\mathcal{Z}_t = \mathcal{T}_t^k R_{k,t} Q_{t-1} S_{t-1} + \mathcal{T}_t^b R_{b,t} e_{t-1} B_{t-1}$), which implies that the lump-sum tax $T_{h,t} (=G)$ is also constant. That is, the government's role

[19] For a similar assumption, see Gertler and Kiyotaki (2010) and Gertler and Karadi (2011).

[20] As in $C_t$, from the optimal expenditure allocation between domestic and imported goods, we obtain the demand functions of domestic goods, $I_{H,t} = (1-\upsilon)\left(\frac{P_{H,t}}{P_t}\right)^{-\iota} I_t$, and foreign goods, $I_{F,t} = \upsilon\left(\frac{P_{F,t}}{P_t}\right)^{-\iota} I_t$. From $I_{H,t}$, $I_{F,t}$, and the CPI, we obtain $P_{H,t} I_{H,t} + P_{F,t} I_{F,t} = P_t I_t$.

reduces to simple taxation of banks' lending and foreign borrowing and returning the collected revenues to banks.[21]

Capital controls and macroprudential regulation are characterized by simple rules:

$$\mathcal{T}_t^b = \tau_b\left[\log\left(\frac{e_{t-1}B_{t-1}}{eB}\right)\right], \tag{40}$$

and

$$\mathcal{T}_t^k = \tau_k\left[\log\left(\frac{Q_{t-1}S_{t-1}}{QS}\right)\right], \tag{41}$$

where $eB$ and $QS$ denote the steady-state value of $e_tB_t$ and that of $Q_tS_t$, respectively. The capital control rule implies that when the aggregate value of a bank's foreign borrowing increases (decreases), the government raises (reduces) the tax rate on the bank's foreign borrowing. The macroprudential rule implies that when the aggregate value of a bank's asset holdings increases (decreases), the government raises (reduces) the tax rate on the bank's asset holdings.

### 2.5. Equilibrium

The terms of trade is by definition,

$$q_t \equiv \frac{P_{F,t}}{P_{H,t}} = \frac{P_t^*}{P_{H,t}}, \tag{42}$$

where $P_t^*$ is the price index in the foreign country.[22] From the definition of the real exchange rate and that of the CPI, we can express the real exchange rate $e_t$ as a function of the terms of trade $q_t$:[23]

$$e_t \equiv \frac{P_t^*}{P_t} = \frac{q_t}{g(q_t)}, \tag{43}$$

where

$$g(q_t) \equiv \frac{P_t}{P_{H,t}} = [(1-\upsilon) + \upsilon q_t^{1-\iota}]^{\frac{1}{1-\iota}}. \tag{44}$$

Demand for domestic goods consists of consumption, investment, its adjustment cost, government expenditure, and exports. The domestic goods market clearing thus requires that

$$Y_t = (1-\upsilon)g(q_t)^{\iota}(C_t + I_t + \Gamma_t + G_t) + q_t EX_t, \tag{45}$$

where $EX_t$ is the exogenous demand for exports, and $\Gamma_t \equiv f\left(\frac{I_t}{I_{t-1}}\right)I_t$ denotes the adjustment costs on investment.

The trade balance (in terms of the CPI) is

$$TB_t \equiv \frac{Y_t}{g(q_t)} - C_t - I_t - G_t - \Gamma_t. \tag{46}$$

From Eq. (46), the foreign debt position $B_t$ evolves according to

$$B_t = R_{b,t}^* B_{t-1} - \frac{TB_t}{e_t}, \tag{47}$$

where

$$R_{b,t+1}^* = R_{t+1}^* + \psi\left[\exp\left\{\frac{q_tB_t}{Y_t} - \frac{qB}{Y}\right\} - 1\right]. \tag{48}$$

The bank's (gross) foreign borrowing rate (foreign currency terms) $R_{b,t}^*$ consists of two components: the exogenous world (gross) interest rate $R_t^*$ and a country premium, which is increasing in the ratio of foreign debt to output. As in many related studies, we induce the stationarity of foreign debt by assuming that the country premium is an increasing function of foreign debt.[24] The world (gross) interest rate $R_t^*$ is an exogenous stochastic process:

[21] As in $C_t$ and $I_t$, we have $G_t \equiv \left[(1-\upsilon)^{\frac{1}{\iota}}G_{H,t}^{\frac{\iota-1}{\iota}} + \upsilon^{\frac{1}{\iota}}G_{F,t}^{\frac{\iota-1}{\iota}}\right]^{\frac{\iota}{\iota-1}}$, where $G_{H,t} = (1-\upsilon)\left(\frac{P_{H,t}}{P_t}\right)^{-\iota}G_t$ and $G_{F,t} = \upsilon\left(\frac{P_{F,t}}{P_t}\right)^{-\iota}G_t$. From the demand functions and the CPI, we have $P_{H,t}G_{H,t} + P_{F,t}G_{F,t} = P_tG_t$.

[22] Without loss of generality, we assume that $P_{F,t} = P_t^*$, since the home country is small enough not to affect the price in the foreign country.

[23] Assuming a small open economy (i.e., the home country is small enough not to affect the price in the foreign country) implies asymmetric home bias in preference, so purchasing power parity does not hold (i.e., $e_t \neq 1$).

[24] The small open economy model with incomplete asset markets features equilibrium dynamics that possess a random walk component. Schmitt-Grohé and Uribe (2003) present alternative approaches to induce stationarity.

$$\log R^*_{t+1} = (1-\rho_{R^*})\log R^* + \rho_{R^*}\log R^*_t + \varepsilon^{R^*}_{t+1}, \quad \varepsilon^{R^*}_{t+1} \sim i.\ i.\ d.\ \ N\left(0, \sigma^2_{R^*}\right). \tag{49}$$

Since $R^*_{b,t}$ is in foreign currency terms and $R_{b,t}$ in Eq. (31) is in domestic currency terms, we have the relationship between $R_{b,t}$ and $R^*_{b,t}$:

$$R_{b,t+1} = R^*_{b,t+1}\frac{e_{t+1}}{e_t}. \tag{50}$$

From the evolution of foreign debt (47), we obtain the current account $CA_t$:

$$CA_t = -B_t + B_{t-1}. \tag{51}$$

The equilibrium of this economy is a set of stationary stochastic processes $\{C_t, C_{H,t}, C_{F,t}, L_t, \varrho_t, \mu_t, \mu_{b,t}, \mathcal{V}_t, \Omega_t, \phi_t, \phi_{b,t}, S_t, D_t, N_{e,t}, N_{n,t}, N_t, Y_t, K_{t+1}, Q_t, I_t, w_t, R_t, R_{k,t+1}, R^*_{b,t}, R_{b,t}, e_t, g(q_t), q_t, TB_t, B_t, CA_t, \mathcal{T}^b_t, \mathcal{T}^k_t, T_{h,t}\}^{\infty}_{t=0}$ satisfying Eqs. (3)-(7), (15)-(24), (26)-(35), (37)-(41), (43)-(48), (50), and (51) (combined with the related equations for other variables), given $Z_t = Z$, $G_t = G$, $EX_t = EX$, exogenous stochastic processes $R^*_t$, and initial values for $D_{-1}$, $B_{-1}$, $K_0$, $N_{-1}$, and $S_{-1}$.

### 2.6. Functional forms and calibration

For the functional form of the utility function, we adopt the GHH preference used in many open economy models:[25]

$$U(C_t, L_t) = \frac{(C_t - \frac{\varpi}{\varphi}L_t^{\varphi})^{1-\gamma} - 1}{1-\gamma}, \tag{52}$$

where $\gamma\ (>0)$ is the inverse of the intertemporal elasticity of substitution, $\varphi\ (>1)$ is the curvature parameter on labor, and $\varpi\ (>0)$ is the labor coefficient. For the functional form of the investment adjustment cost, we adopt a quadratic function:

$$f\left(\frac{I_t}{I_{t-1}}\right) = \frac{\eta}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2. \tag{53}$$

Table 2 summarizes the parameter values we use in our analysis. We choose the parameters related to households as follows. We set the inverse of intertemporal elasticity of substitution $\gamma$ and the discount factor $\beta$ to 2 and 0.98, respectively (as in e.g., Aguiar and Gopinath (2007)). We set the labor coefficient $\varpi$ to generate the steady-state labor hours ($L$) of 0.2 (as in, e.g., Schmitt-Grohé and Uribe (2003)). The curvature parameter on labor $\varphi$ is set to 1.455 (as in, e.g., Mendoza (1991)). For the parameters related to non-financial firms and government, we set the effective capital share $\alpha$, the parameter for adjustment cost on investment $\eta$, and the depreciation rate of capital $\delta$ to 0.33, 1.5, and 0.025, respectively. We set the steady-state value of the GDP ratio of government spending, $\frac{G}{Y}$, to 0.2.

For the parameters related to the open economy, we set the steady-state ratio of foreign debt to GDP, $\frac{B}{Y}$, to 0.31 by obtaining the average of 5 emerging economies from 2009 to 2017.[26] We set the elasticity of substitution between domestic and imported goods $\iota$ to 1.5 (as in, e.g., Ravenna and Natalucci (2008)). We set the degree of openness $\upsilon$ to 0.28 (as in e.g., Cook (2004)). We set the parameter for the country-specific interest rate premium $\psi$ to 0.005, which fits between 0.001 in Aguiar and Gopinath (2007) and 0.0075 in Unsal (2013). We set the persistence of the foreign interest rate shock, $\rho_{R^*}$, to 0.99.[27] We accordingly set the standard deviation of the foreign interest rate shock, $\sigma_{R^*}$, to 0.06% to render the model's volatility close to the data in the Table 3.

From Eqs. (15), (16), and (24) in the steady state, we calibrate the parameter $\chi$ that indicates a degree of financial friction in foreign borrowing as follows:

$$\chi = \frac{\overline{R} - \overline{R^*}}{\overline{R_k} - \overline{R}} = \frac{\overline{EMBI}}{\overline{R_k} - \overline{R}}, \tag{54}$$

where $\overline{EMBI}$ is the average of "JPM EMBI Global Diversified - Stripped Spread". We set $\overline{EMBI}$ to 0.0327 by obtaining the average of EMBI for 8 emerging countries in Table 1.[28]Following Elekdağ and Tchakarov (2007), we chose Argentina, Brazil, Indonesia, Korea, Malaysia, the Philippines, Thailand, and Turkey in Table 1 as our subject emerging market economies.

We set $\overline{R_k}$ to 1.1246 by calculating the emerging economies' average of the real (annual) lending rate.[29] We obtain $\overline{R}$ (=1.0484) in (54) by adding the average of "JPM EMBI Global Diversified - Stripped Spread" to the average of the real US interest rate.[30] By substituting $\overline{EMBI}$, $\overline{R_k}$, and $\overline{R}$ into Eq. (54), we obtain the benchmark value of $\chi$, 0.43. We then calibrate $\chi$ for each country in Table 1 by substituting the average value of EMBI for each country (instead of $\overline{EMBI}$). In our model, $\chi$ is the parameter that indicates the

[25] For details about the GHH preference, see, for example, Mendoza (1991) and Neumeyer and Perri (2005).

[26] We choose Brazil, Indonesia, Philippines, Thailand, and Turkey due to data availability. Data source: International Debt Statistics, 2019, the World Bank.

[27] We calibrate the foreign interest rate shock using US Treasury Bill Rate and GDP deflator (1990Q1-2017Q2) in International Financial Statistics (IFS).

[28] We exclude outliers over $\mu + 2\sigma$ for Brazil. As for Argentina, we exclude outliers in the default and debt restructuring period, which almost corresponds to samples over $\mu + 2\sigma$. This is because we do calibration using steady state values, and outliers should be excluded to calculate the steady state values.

[29] We obtain the real lending rate using lending rate and GDP deflator in IFS. We use the available data from 1991Q1 to 2018Q2 of Argentina, Brazil, Indonesia, Korea, Malaysia, Philippines, and Thailand. The data for Turkey is not available.

[30] We obtain the average of the real (annual) US interest rate (=1.0157) (1990Q1-2017Q2) using Treasury Bill rate and GDP deflator in IFS.

**Table 1**
Calibration: EMBI and $\chi$.

| | EMBI(%) | $\chi$ |
|---|---|---|
| Argentina | 7.05 | 0.93 |
| Brazil | 4.59 | 0.60 |
| Indonesia | 2.68 | 0.35 |
| Korea | 1.72 | 0.23 |
| Malaysia | 1.79 | 0.24 |
| Philippines | 2.91 | 0.38 |
| Thailand | 1.54 | 0.20 |
| Turkey | 3.91 | 0.51 |
| Average | 3.27 | 0.43 |

Note) Source: JPM EMBI Global Diversified - Stripped Spread. EMBI for each country denotes the average in the sample period as follows: Argentina, 1994Q1–2019Q2; Brazil, 1994Q3–2019Q2; Indonesia, 2004Q3–2019Q2; Korea, 1994Q1–2004Q4; Malaysia, 1997Q1–2019Q2; The Philippines, 1998Q1–2019Q2; Thailand, 1997Q3–2006Q2; Turkey, 1996Q3–2019Q2. As for Brazil, data samples over $\mu + 2\sigma$ are excluded. As for Argentina, we exclude outliers in the default and debt restructuring period, which almost corresponds to samples over $\mu + 2\sigma$.

**Table 2**
Parameterization.

| | Description | Value |
|---|---|---|
| | *Parameters related to households* | |
| $\gamma$ | Inverse of intertemporal elasticity of substitution | 2 |
| $\beta$ | Discount factor | 0.98 |
| $\varpi$ | Labor coefficient | 4.060 |
| $\varphi$ | Curvature parameter on labor | 1.455 |
| | *Parameters related to open economies* | |
| $\iota$ | Elasticity of substitution between domestic and imported goods | 1.5 |
| $\upsilon$ | Degree of openness | 0.28 |
| $\frac{B}{Y}$ | Steady-state ratio of foreign debt to GDP | 0.31 |
| $\psi$ | Parameter for country-specific interest rate premium | 0.005 |
| $\rho_{R^*}$ | Persistence: foreign interest rate shock | 0.99 |
| $\sigma_{R^*}$ | Standard deviation: foreign interest rate shock (%) | 0.06 |
| | *Parameters related to banks* | |
| $\chi$ | Degree of financial frictions | 0.43 |
| $\Theta$ | Fraction of divertable assets | 0.406 |
| $\xi$ | Transfer to entering bankers | $4.16 \times 10^{-4}$ |
| $\sigma$ | Survival rate of banks | 0.96 |
| | *Other parameters* | |
| $\alpha$ | Effective capital share | 0.33 |
| $\eta$ | Parameter for adjustment cost on investment | 1.5 |
| $\delta$ | Depreciation rate of capital | 0.025 |
| $\frac{G}{Y}$ | Steady-state ratio of government expenditure to GDP | 0.2 |

degree of financial frictions in foreign borrowing as shown in Eq. (12). Therefore, it would be appropriate to calibrate $\chi$ for each country so that each country's EMBI determines each country's $\chi$.

We set a steady-state interest rate spread to 165 basis points per year from data, which is higher than 136 in Mimir and Sunel (2019) and 150 in Akinci and Queralto (2018).[31] We set a steady-state leverage ratio to 4.5, which is a rough average of leverages between corporate sector and banking sector. The ratio of assets to equity in corporate sector is around 2, while leverage ratios in the banking sector are greater than 5 in emerging countries (IMF, 2015,2017,2018).[32] We set $\sigma$ to 0.96, which is between 0.94 in Aoki et al. (2016) and 0.972 in Gertler and Kiyotaki (2010). We choose the fraction of divertable assets, $\Theta$, and the transfer to

[31] We obtain this number by calculating the difference between the average real lending rate and deposit rate. However, we exclude outliers in real lending rate. Otherwise, the spread is over 760 basis points, which is extraordinarily high compared to those in the literature.
[32] We follow the argument of Akinci and Queralto (2018), which uses a rough average of leverage across different sectors.

**Table 3**
Business cycles in emerging economies: Data vs. model.

| *Standard deviations (in %)* | Output | Consumption | Investment | TB/Y ratio |
|---|---|---|---|---|
| Argentina | 4.56 | 5.77 | 11.19 | 2.31 |
| Brazil | 1.89 | 2.08 | 4.58 | 0.85 |
| Indonesia | 2.48 | 2.76 | 6.40 | 1.96 |
| Korea | 2.00 | 3.26 | 4.58 | 2.33 |
| Malaysia | 2.42 | 3.74 | 10.98 | 3.90 |
| Philippines | 1.33 | 1.09 | 5.36 | 2.37 |
| Thailand | 2.92 | 3.27 | 10.72 | 3.81 |
| Turkey | 5.03 | 4.56 | 10.41 | 2.24 |
| Average | 2.83 | 3.32 | 8.03 | 2.47 |
| Model | 2.87 | 3.70 | 11.94 | 1.67 |
| *Standard deviations relative to output* | | | | |
| Argentina | 1.0 | 1.27 | 2.45 | 0.51 |
| Brazil | 1.0 | 1.10 | 2.42 | 0.45 |
| Indonesia | 1.0 | 1.12 | 2.58 | 0.79 |
| Korea | 1.0 | 1.63 | 2.29 | 1.16 |
| Malaysia | 1.0 | 1.54 | 4.53 | 1.61 |
| Philippines | 1.0 | 0.82 | 4.02 | 1.78 |
| Thailand | 1.0 | 1.12 | 3.67 | 1.30 |
| Turkey | 1.0 | 0.91 | 2.07 | 0.45 |
| Average | 1.0 | 1.19 | 3.00 | 1.01 |
| Model | 1.0 | 1.29 | 4.16 | 0.58 |
| *Correlations with output* | | | | |
| Argentina | 1.0 | 0.95 | 0.88 | −0.63 |
| Brazil | 1.0 | 0.72 | 0.71 | −0.17 |
| Indonesia | 1.0 | 0.18 | 0.71 | −0.41 |
| Korea | 1.0 | 0.89 | 0.84 | −0.80 |
| Malaysia | 1.0 | 0.63 | 0.73 | −0.56 |
| Philippines | 1.0 | 0.44 | 0.39 | −0.10 |
| Thailand | 1.0 | 0.84 | 0.83 | −0.52 |
| Turkey | 1.0 | 0.91 | 0.79 | −0.15 |
| Average | 1.0 | 0.69 | 0.74 | −0.42 |
| Model | 1.0 | 0.78 | 0.58 | −0.28 |

Note) Argentina, 1993Q1–2017Q1; Brazil, 1995Q1–2017Q3; Indonesia, 1997Q1–2018Q3; Korea, 1990Q1–2018Q3; Malaysia, 1991Q1–2017Q1; The Philippines, 1990Q1–2018Q2; Thailand, 1993Q1–2018Q2; Turkey, 1990Q1–2018Q3. Source: IFS.

entering banks, $\xi$, to match the two targets of a steady-state leverage ratio of 4.5 and a steady-state interest rate spread of 165 basis points per year.

In Table 3, we report key business cycle statistics of the eight emerging countries included in Table 1.[33] Similarly as in Unsal (2013), we compare the simulated moments with the data, including the average of countries' values.[34] Although we include only the world interest rate shock, the model competently replicates key variable dynamics. Although it predicts a higher volatility of $I$ and lower volatility of $TB/Y$ ratio than the data average, all the simulated moments in the "*standard deviations relative to output*" and "*correlations with output*" range between the sample countries' minimum and maximum values, and most simulated moments are close to the data moments averages. It is noteworthy that it replicates the key feature of emerging economies' business cycle that the standard deviation of consumption relative to output is above one, which implies insufficient consumption smoothing in emerging economies (Schmitt-Grohé and Uribe, 2017).

## 3. Results

In this section, we present several numerical experiments that shed light on the roles of capital controls and macroprudential regulation. We first show how the capital control rule and macroprudential regulation rule affect the impulse responses of the main variables. As discussed at the G20 summit in 2016, policymakers are concerned that prospective increases in the US policy rate may cause massive capital outflows from emerging economies.[35] Therefore, in our analysis below, an increase in foreign interest rates is

[33] The raw series were seasonally adjusted and transformed to real terms. We took logs (except for the $TB/Y$ ratio) and applied the Hodrick–Prescott filter with a smoothing parameter of 1600.

[34] Unsal (2013) and Neumeyer and Perri (2005) chose Argentina, Brazil, Korea, Mexico, and the Philippines as emerging economies.

[35] The vulnerability of emerging economies to foreign interest shocks was documented by many previous studies. See, for example, Calvo et al. (1993), Dooley et al. (1996), Fernandez-Arias (1996), and Frankel and Okongwu (1996).

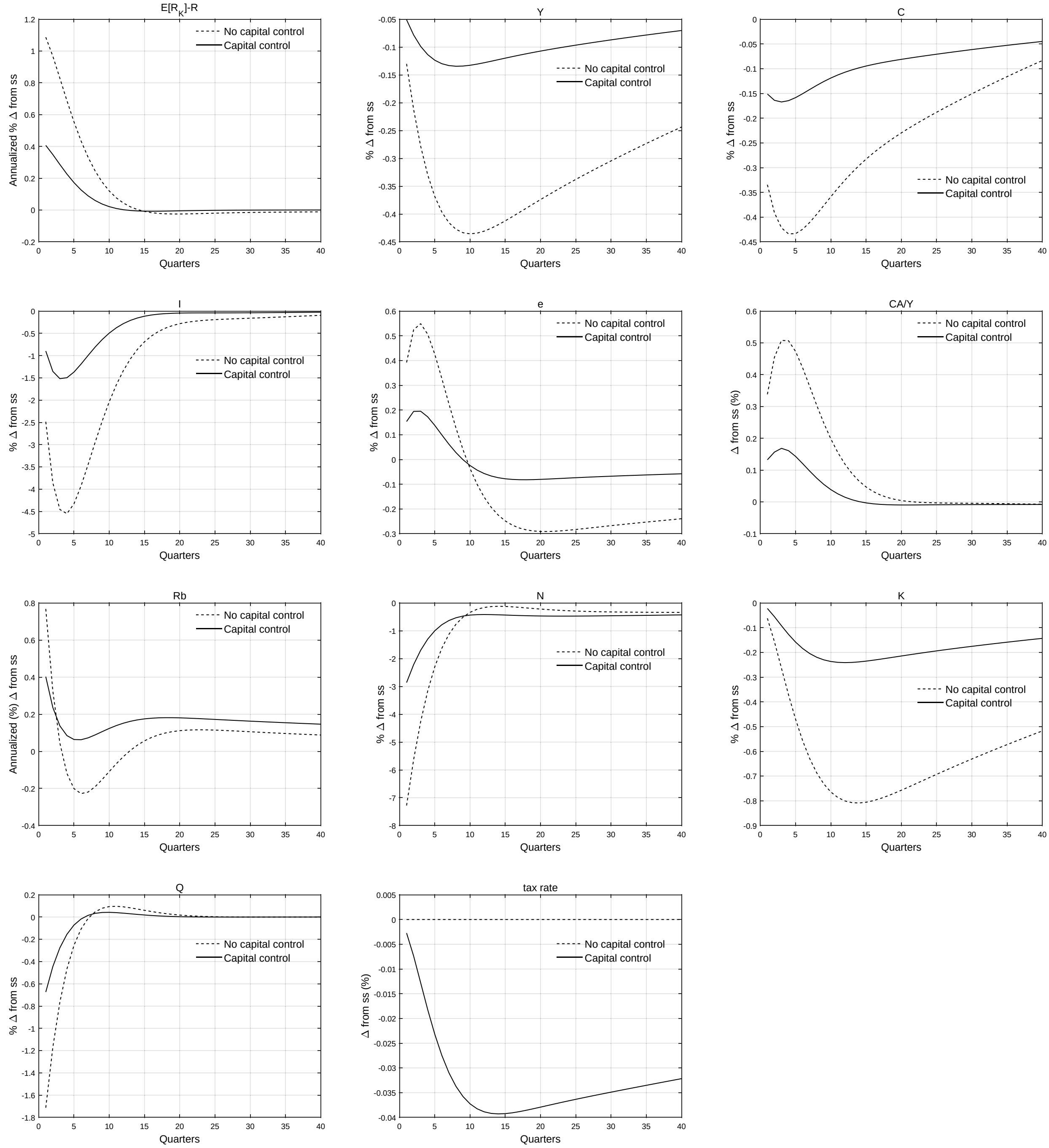



**Fig. 2.** Impulse responses to an increase in the foreign interest rate, with and without capital controls ($\tau_b = 0$ or 0.01, $\chi = 0.43$).

considered as the exogenous shock.

### 3.1. Impulse responses with and without capital controls

We consider a 0.24% unanticipated annual increase in foreign interest rates $R^*$ as an initiating disturbance. Fig. 2 shows the impulse responses with and without a low (not necessarily optimal) degree of capital controls under the benchmark degree of financial frictions ($\chi = 0.43$). The solid curve represents the impulse responses with the capital control rule of $\tau_b = 0.01$, while the dotted curve represents those without it.

An exogenous increase in the foreign interest rate raises the bank's foreign borrowing cost $R_b$, which reduces the bank's net worth

$N$. The decline in the net worth $N$ tightens the bank's borrowing constraint, which reduces the bank's assets $S(=K)$ (or capital). With this tightening, the decline in net worth $N$ also raises the spread between the expected return on capital and the riskless interest rate $E[R_k] - R$. The rise in the spread $E[R_k] - R$ raises the cost of credit for non-financial borrowers. The increase in the cost of capital in turn causes a drop in output $Y$ and investment $I$, which causes a decline in the price of capital $Q$. The decline in the price of capital $Q$ exacerbates the deterioration of the capital value $QK$ (or bank assets), which worsens the bank's balance sheet and causes the spread to increase further. In this way, in the presence of financial frictions, the effects of an exogenous increase in foreign interest rates on output and the other main variables are amplified through the bank's balance sheet. As for the open economy related variables, a larger fall in investment compared to that in output creates an excess supply of domestic goods and then a depreciation of the real exchange rate $e$, which is associated with a surplus in the current account $CA/Y$.

Fig. 2 shows that the capital control rule mitigates the increase in the spread $E[R_k] - R$ and dampens the decline in output $Y$ and investment $I$. The capital control rule also mitigates the declines in the other main variables such as $Q$, $C$, and $K$. In addition, the capital control rule significantly reduces the size of the fluctuations in the real exchange rate $e$ and the ratio of the current account to output $CA/Y$.

### 3.2. Impulse responses with and without macroprudential regulation

Fig. 3 shows the impulse responses with and without a low (not necessarily optimal) degree of macroprudential regulation under the benchmark degree of financial frictions ($\chi = 0.43$). In Fig. 3, the solid curve represents the impulse responses with the macroprudential regulation rule of $\tau_k = 0.01$, and the dotted curve represents those without it.

As Fig. 3 makes clear, the macroprudential regulation rule mitigates the increase in the spread $E[R_k] - R$ and dampens the decline in output $Y$ and investment $I$. It also mitigates the decline in the other main variables such as $Q$, $C$, and $K$. The macroprudential regulation rule also significantly reduces the size of the fluctuations in the real exchange rate $e$ and the ratio of the current account to output $CA/Y$.

Therefore, we can say that both the capital control and macroprudential rules have basically the same role of mitigating the external shock and making the economy more stable.

### 3.3. Welfare analysis

We next examine the welfare-improving effects of capital controls and macroprudential regulation. For policy evaluation, we compute the welfare level associated with a particular policy rule and compare it to that in a no-policy case. Using the perturbation method in Schmitt-Grohé and Uribe (2004), we perform a second-order approximation of the model.[36] As in Schmitt-Grohé and Uribe (2006), we then consider expected welfare conditional on the initial state, that is, the non-stochastic steady state. The welfare associated with a particular value of $\tau_b$ in the capital control rule (40) or/and $\tau_k$ in the macroprudential rule (41) conditional on the non-stochastic steady states is defined as

$$\mathcal{W}_0 \equiv E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, L_t) = E_0 \sum_{t=0}^{\infty} \beta^t U((1+\epsilon_i)C, L), \quad (55)$$

where $C$ and $L$ are their non-stochastic steady states. We evaluate the welfare-improving effect of the capital control rule (40) or/and the macroprudential rule (41) by comparing the value of $\epsilon_i$ associated with each value of $\tau_b$ or/and $\tau_k$ to that in the no policy case (i.e., $\tau_b = \tau_k = 0$).

Figs. 4a and 4b show the welfare curves associated with different values of $\tau_b$ and $\tau_k$, respectively. In Figs. 4a and 4b, the horizontal axes are $\tau_b$ and $\tau_k$, and the vertical axes are $\epsilon$, which denotes the difference between the value of $\epsilon_i$ associated with each value of $\tau_b$ or/and $\tau_k$ and that in the no policy case. We show the welfare curves corresponding to three different degrees of financial frictions $\chi$: the thin dotted curve ($\chi = 0.33$), the bold curve ($\chi = 0.43$), and the bold dotted curve ($\chi = 0.53$). A higher value of $\chi$ indicates a higher degree of financial friction between banks and foreign investors.

In Figs. 4a and 4b, we see some range in $\tau_b$ or $\tau_k$ that improves welfare levels compared to the no-policy case. Comparing the three welfare curves, we also see that the welfare-improving effect of capital controls and macroprudential regulation become larger as the degree of financial frictions increases.

The intuition why capital controls and macroprudential regulation are effective is quite straightforward. In frictionless economies, the credit spread is always zero. However, in a model with financial frictions, when the credit spread widens, the equilibrium allocation is not efficient due to the credit distortion (Nispi Landi, 2017; De Paoli and Paustian, 2017). As we argue in Sections 3.1 and 3.2, the capital control and macroprudential rules mitigate the increase in the credit spread due to the external shock. These two policies stabilize the distortions created by credit frictions.

The intuition for the key results is also related to Gertler et al. (2012)'s argument: "due to the role of asset prices in affecting borrowing constraint, there exists a pecuniary externality which banks do not properly internalize when deciding their balance sheet structure" (p.530). The two policies of capital controls and macroprudential regulation internalize the above-mentioned externality due to financial frictions, and, therefore, they are effective in addressing the amplification effect of financial frictions.

[36] Kim and Kim (2003) show that second-order solutions are necessary, since conventional linearization may generate spurious welfare reversals when long-run distortions exist in the model. We conduct the second-order computation with Dynare. See Adjemian et al. (2011) for details.

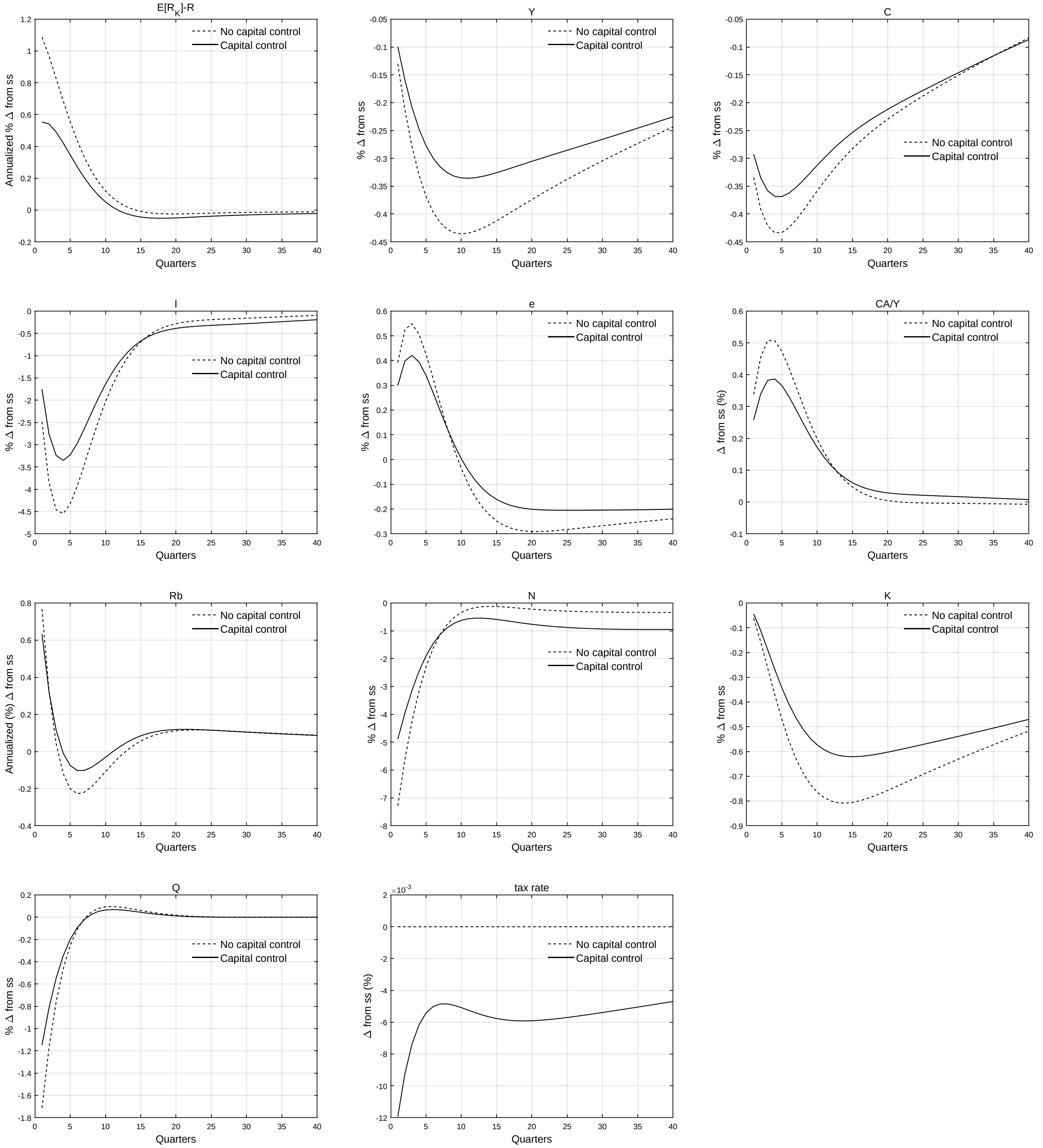
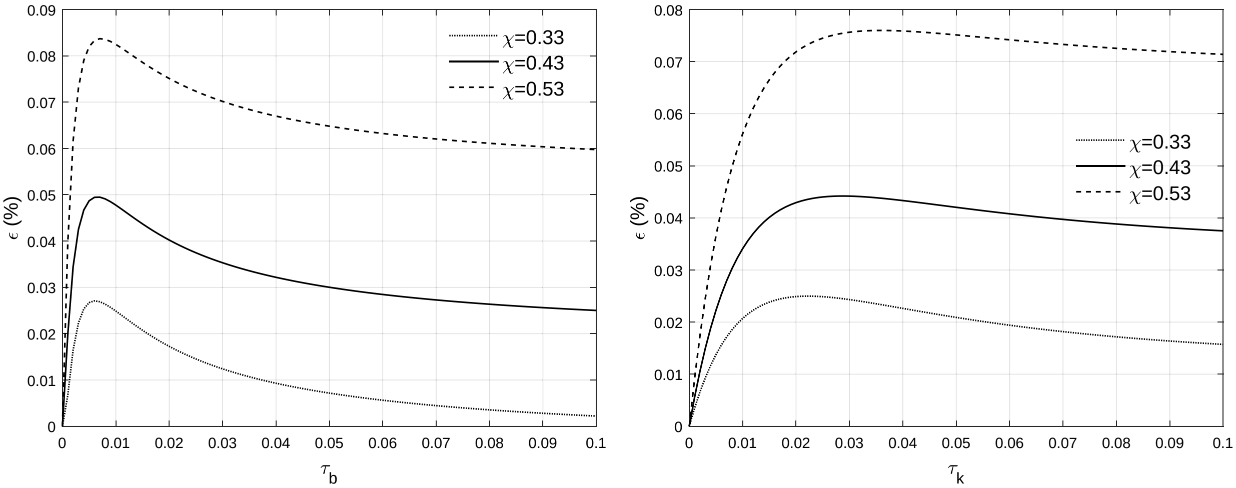



**Fig. 3.** Impulse responses to an increase in the foreign interest rate, with and without macroprudential regulation ($\tau_k = 0$ or 0.01, $\chi = 0.43$).

### *3.4. Employing both capital controls and macroprudential regulation*

In the previous section, we examine the welfare-improving effect of capital controls and macroprudential regulation separately. In this section, we examine the case in which policymakers employ both capital controls and macroprudential regulation. Fig. 5 plots the maximum welfare gains from combining different values of $\tau_b$ and $\tau_k$ in the benchmark case (i.e., $\chi = 0.43$). Fig. 5 shows that the optimal combination of $\tau_b$ and $\tau_k$ yields a higher level of welfare compared to the case of optimizing either $\tau_b$ or $\tau_k$. This result is consistent with Korinek and Sandri (2016)'s finding that it is optimal to impose both capital controls and macroprudential regulation.




(a) Capital controls (b) Macroprudential regulation

**Fig. 4.** Welfare curves with varying $\tau_b$ and $\tau_k$.

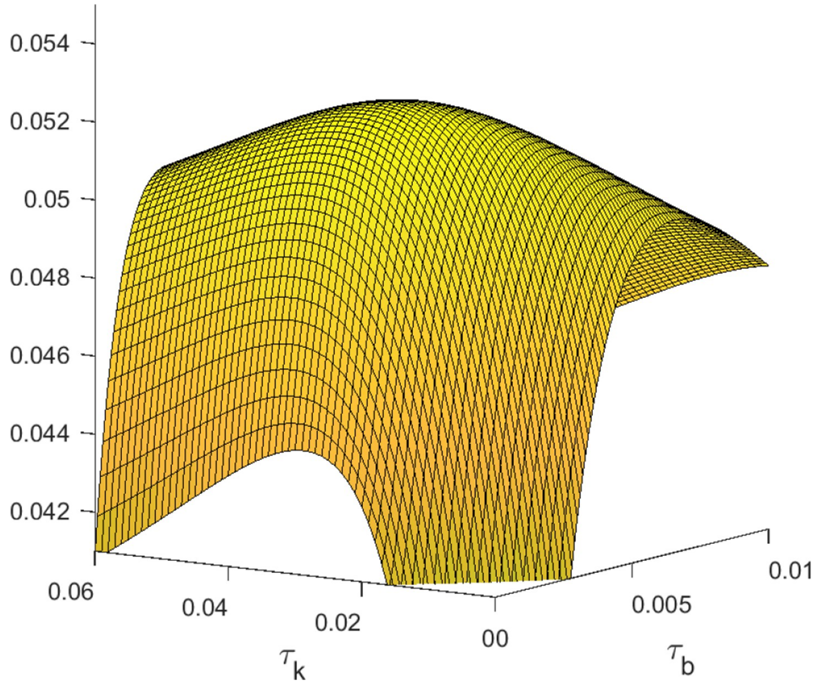


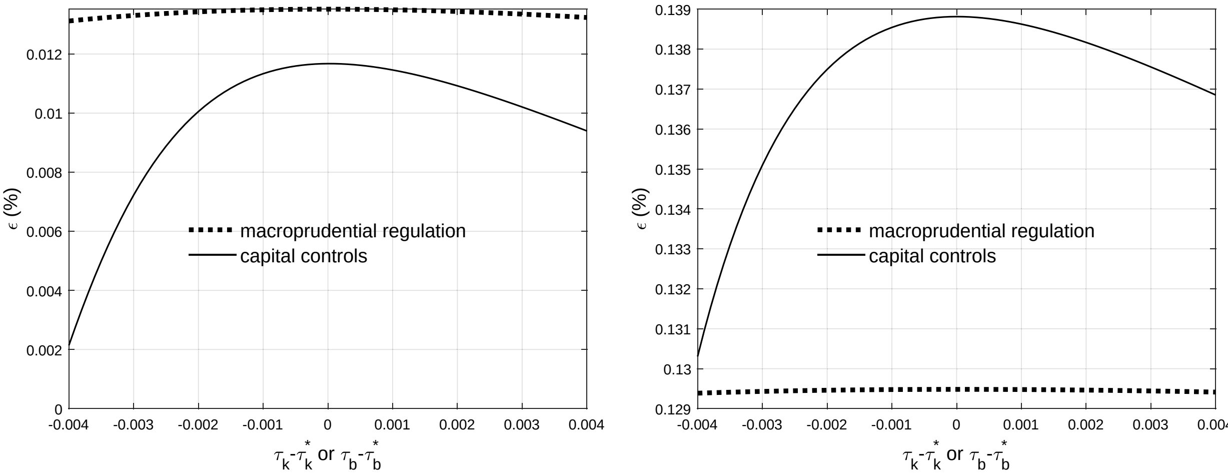

**Fig. 5.** Maximum welfare gains under both capital controls and macroprudential regulation ($\chi = 0.43$).

### 3.5. Capital controls versus macroprudential regulation

We now return to the case in which policymakers employ either capital controls or macroprudential regulation and compare the welfare-improving effects of these two policies under different degrees of financial frictions. In other words, we examine how the degree of financial frictions between banks and foreign investors affects the welfare ranking of these two policies.

Fig. 6a plots the welfare curves with varying values of $\tau_b$ and $\tau_k$ in the case of low financial friction ($\chi = 0.23$). In contrast, Fig. 6b plots the welfare curves with varying values of $\tau_b$ and $\tau_k$ in the case of high friction ($\chi = 0.63$). In both Fig. 6a and 6b, the horizontal axis is $\tau_k - \tau_k^*$ or $\tau_b - \tau_b^*$, where $\tau_k^*$ or $\tau_b^*$ denotes the optimal value of $\tau_k$ or $\tau_b$ that achieves the maximum welfare gain.[37] In Fig. 6a, the maximum welfare gain from the optimal value of $\tau_k$ is higher than that from the optimal value of $\tau_b$, which indicates that under low

[37] The zero in the horizontal axis indicates that $\tau_k$ (or $\tau_b$) is $\tau_k^*$ (or $\tau_b^*$) that achieves the maximum welfare gain.




(a) $\chi = 0.23$ (b) $\chi = 0.63$

**Fig. 6.** Welfare curves with varying $\tau_b$ and $\tau_k$.
Note) The horizontal axis is $\tau_k - \tau_k^*$ or $\tau_b - \tau_b^*$, where $\tau_k^*$ or $\tau_b^*$ denotes the optimal value of $\tau_k$ or $\tau_b$ that achieves the maximum welfare gain.

financial frictions in foreign borrowing, macroprudential regulation is more appropriate than capital controls. In contrast, in Fig. 6b, the maximum welfare gain from the optimal value of $\tau_b$ is higher than that from the optimal value of $\tau_k$, which indicates that under high financial frictions in foreign borrowing, capital controls are more appropriate than macroprudential regulation.

Fig. 7 shows the maximum welfare gain from capital controls and macroprudential regulation under different degrees of financial frictions ($\chi$). In Fig. 7, the solid curve represents the maximum welfare gain from capital controls, and the dotted curve represents the maximum welfare gain from macroprudential regulation. In Fig. 7, we should note that under low financial frictions (i.e., if $\chi$ is small), the maximum welfare gain from macroprudential regulation is higher than that from capital controls, whereas under high frictions (i.e., if $\chi$ is large), the maximum welfare gain from capital controls is higher than that from macroprudential regulation. That is, if the degree of financial frictions in foreign borrowing is low, macroprudential regulation is more appropriate than capital controls. However, if the degree of financial frictions in foreign borrowing is high, capital controls are more appropriate than macroprudential regulation.

Although our study is rather theory-motivated, it might be interesting to take the parameter values $\chi$ in Table 1 into account when comparing these two policies. Among the eight emerging countries in Table 1, three countries (Argentina, Brazil, and Turkey) are in the region where capital controls are better than macroprudential regulation, while five countries (the Philippines, Indonesia,

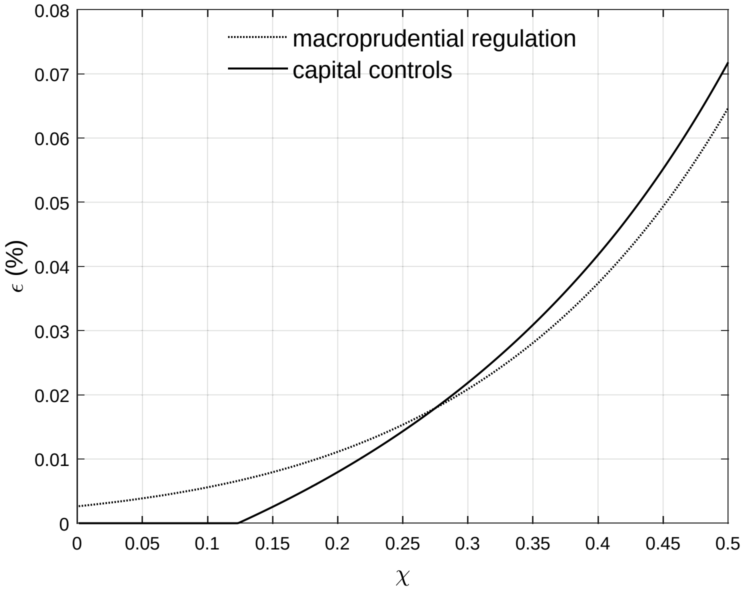



**Fig. 7.** Maximum welfare gains from capital controls and macroprudential regulation under different degrees of financial frictions ($\chi$).

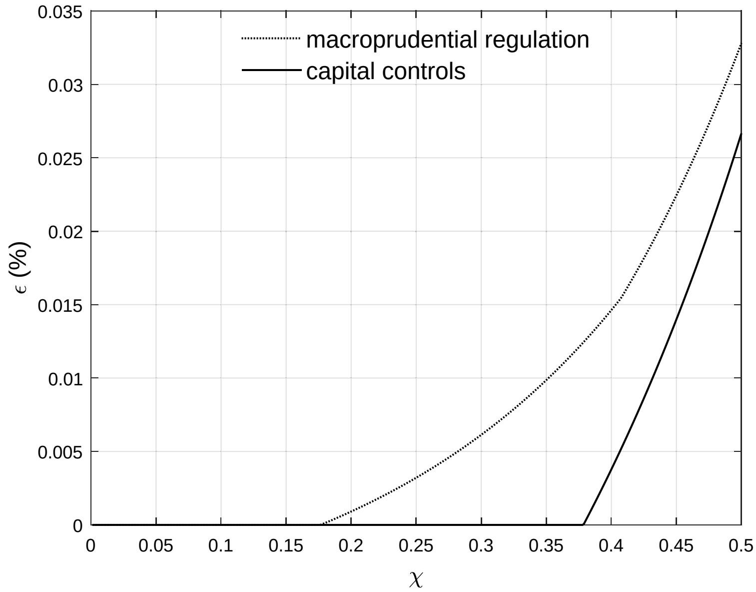



**Fig. 8.** Maximum welfare gains from capital controls and macroprudential regulation under different degrees of financial frictions ($\chi$): No-liability dollarization case.

Malaysia, Korea, and Thailand) are in the region where the opposite is true in Fig. 7. This result reflects the fact that we calibrate the parameter values $\chi$ using the "JPM EMBI Global Diversified - Stripped Spread" data. It may be noteworthy that the average of $\chi$ among the eight emerging countries is 0.43 in Table 1, and capital controls are better than macroprudential regulation when $\chi$ is 0.43 in Fig. 7.

### 3.6. Capital controls versus macroprudential regulation in the no-liability dollarization case

In the previous sections, we consider an economy where banks face the liability dollarization problem. In the liability dollarization economy, a depreciation in the domestic currency has a direct negative impact on the bank's balance sheet because it increases the foreign debt burden in domestic currency terms. In contrast, when banks' liabilities are not dollarized, the exchange rate change has no such direct valuation effect on the bank's balance sheet. In the liability dollarization economy, therefore, the exchange rate amplifies the effect of a foreign interest rate shock on the economy through the bank balance sheet channel. However, in the no-liability dollarization economy, there is no amplification effect from the exchange rate on the bank's balance sheet. Appendix A.2 provides formal expressions for the no-liability dollarization case. In this section, we examine how the welfare-improving effects of capital controls and macroprudential regulation would differ between a liability dollarization economy and a no-liability dollarization economy.

Fig. 8 plots the welfare gain curves of capital controls and macroprudential regulation in the no-liability dollarization economy. In Fig. 8, both the welfare-improving effects of capital controls and macroprudential regulation become larger as the degree of financial frictions increases. However, the welfare-improving effect of macroprudential regulation is always larger than that of capital controls in the same region of $\chi$ in Fig. 7. This result suggests that in the no-liability dollarization economy, macroprudential regulation is more appropriate than capital controls.

As we argue in Section 3.3, Gertler et al. (2012)'s argument intuitively explains why capital controls and macroprudential regulation are effective means to address the amplification effect of financial frictions in our model. Although the price of capital $Q_t$ and the real exchange rate $e_t$ in banks' balance sheets are given to banks, the banks' decisions about their balance sheet structures affect these prices. Capital controls and macroprudential regulation can internalize the pecuniary externality that banks do not properly internalize.

Capital controls are not as good as macroprudential regulation in a no-liability dollarization economy, since the banks' balance sheets do not include exchange rates and there is no direct valuation effect from exchange rates on the banks' balance sheets. Capital controls regulate the foreign borrowing that amplifies the effect of exchange rates on the banks' balance sheets. Therefore, if the amplification effect of the exchange rate through the bank balance sheet channel is small, the role of capital controls subsides.[38]

Our finding that macroprudential regulation is more appropriate than capital controls in a no-liability dollarization economy is

[38] Although it is not shown here, we confirm that the size of the reduction in the volatility of exchange rate due to the optimal capital controls in the liability dollarization case is larger than that in the no-liability dollarization case, which implies that the stabilization of the exchange rate is more critical in the liability dollarization case.

consistent with Korinek and Sandri (2016)'s finding that in advanced economies with more limited risk of exchange rate fluctuations, the role of capital controls subsides. However, note that we can compare the liability dollarization case and the no-liability dollarization case only by introducing a banking sector into the model and considering that the bank's balance sheet can deteriorate due to exchange rate depreciation.

## 4. Conclusion

We compare the welfare-improving effect of capital controls to that of macroprudential regulation in a small open economy augmented with a banking sector. Our main finding is that the desirability of capital controls over macroprudential regulation depends on the degree of financial friction between domestic banks and foreign investors. Under low degrees of financial friction in foreign borrowing, macroprudential regulation is more appropriate than capital controls. In contrast, under high degrees of financial friction in foreign borrowing, capital controls are more appropriate than macroprudential regulation. Moreover, we find that the policy choice between capital controls and macroprudential regulation depends on the presence of liability dollarization. In an economy without the liability dollarization, macroprudential regulation is more welfare improving than capital controls. We would like to emphasize that it is possible to obtain these results only by incorporating a banking sector into a small open model and considering the bank balance sheet channel.

Since our motivation in this study is to examine how these two policies achieve macroeconomic stabilization to an external shock and compare their welfare improving effects, we do not consider how these two policies affect the economy's steady state allocation. Although our numerical analysis in the neighborhood of the steady state in which $\mathcal{T}^b = \mathcal{T}^k = 0$ (not shown in this paper) suggests that capital controls and macroprudential policy are welfare improving even in the steady state, the steady state analysis including whether optimal tax rates exist or not is beyond the scope of this study. We would like to leave a more general argument on the steady state analysis as a subject for future research.

As we argue in the main text, policymakers are concerned that prospective increases in the US policy rate may cause massive capital outflows from emerging economies, which is one of the main topics discussed at the G20 summit in 2016. In addition, the vulnerability of emerging economies to foreign interest shocks was documented by many previous studies. Therefore, in our analysis, an increase in foreign interest rates is considered as the exogenous shock. However, in general, it would be ideal to examine policy implications under many different type of shocks (e.g., Mimir and Sunel, 2019). We leave this as a subject for future research.

The parameter values of $\chi$ in Table 1 indicate that $\chi$ is positive, which implies that foreign funds are easier to divert than domestic funds. We calibrated the parameter values of $\chi$ for the emerging countries in Table 1 based on our model. However, it might be interesting to investigate an empirical way to estimate $\chi$ more directly from data. As for empirical validation, it would be also interesting to examine whether the actual policy behavior of emerging countries depends on the key variables in our analysis.

## Appendix A

### *A1. Derivation of equations in Section 2.2*

We denote the bank's maximized objective as $V_t(s_t, b_t, d_t)$ given an asset and liability configuration $(s_t, b_t, d_t)$. The bank's value in period $t-1$ satisfies the Bellman equation:

$$V_t(s_t, b_t, d_t) = E_t \Lambda_{t,t+1} \left\{ (1-\sigma) n_{t+1} + \sigma \max_{s_{t+1}, b_{t+1}} V_t(s_{t+1}, b_{t+1}, d_{t+1}) \right\}. \tag{A.1}$$

We propose and verify that the value function is linear in $s_t$, $b_t$, and $d_t$:

$$V_t(s_t, b_t, d_t) = \mathcal{V}_{s,t} s_t - \mathcal{V}_{b,t} b_t - \mathcal{V}_t d_t, \tag{A.2}$$

where $\mathcal{V}_{s,t}$ is the marginal value of assets, $\mathcal{V}_{b,t}$ is the marginal cost of international borrowing, and $\mathcal{V}_t$ is the marginal cost of deposits. Substituting Eq. (8) into (A.2), we obtain

$$\begin{aligned} V_t(s_t, b_t, n_t) &= \mathcal{V}_{s,t} s_t - \mathcal{V}_{b,t} b_t - \mathcal{V}_t (Q_t s_t - e_t b_t - n_t), \\ &= \mu_t Q_t s_t + \mu_{b,t} e_t b_t + \mathcal{V}_t n_t, \end{aligned} \tag{A.3}$$

where $\mu_t \equiv \frac{\mathcal{V}_{s,t}}{Q_t} - \mathcal{V}_t$, and $\mu_{b,t} \equiv \mathcal{V}_t - \frac{\mathcal{V}_{b,t}}{e_t}$.

Maximizing the value function (A.3) subject to the incentive constraint (11) (and (13)) yields the following first-order conditions:

$$(1+\lambda_t)\mu_t = \Theta \lambda_t, \tag{A.4}$$

$$(1+\lambda_t)\mu_{b,t} = \chi \Theta \lambda_t, \tag{A.5}$$

and

$$(\Theta - \mu_t) Q_t s_t + (\chi \Theta - \mu_{b,t}) e_t b_t = \mathcal{V}_t n_t, \tag{A.6}$$

where $\lambda_t$ is the Lagrange multiplier for the incentive constraint (11).

Combining Eqs. (A.4) and (A.5), we obtain

$$\mu_{b,t} = \chi\mu_t. \tag{A.7}$$

Defining $\phi_t$ and $\phi_{b,t}$, we can rewrite (A.6) as

$$Q_t s_t = \phi_t n_t - \frac{\phi_t}{\phi_{b,t}} e_t b_t, \tag{A.8}$$

with

$$\phi_t \equiv \frac{\mathcal{V}_t}{\Theta - \mu_t}, \tag{A.9}$$

and

$$\phi_{b,t} \equiv \frac{\mathcal{V}_t}{\chi\Theta - \mu_{b,t}}. \tag{A.10}$$

Substituting Eq. (A.8) into (A.3) and using (A.7), we can rewrite the value function with net worth $n_t$ as follows:

$$V_t(s_t, b_t, n_t) = (\phi_t \mu_t + \mathcal{V}_t) n_t. \tag{A.11}$$

Substituting Eqs. (A.11) and (9) into (A.1) and comparing it our yield from substituting (8) into (A.3), we verify that the value function is linear in $(s_t, b_t, d_t)$ if $\mu_t$, $\mu_{b,t}$, and $\mathcal{V}_t$ satisfy

$$\mu_t = E_t \Lambda_{t,t+1} \Omega_{t+1} [(1 - \mathcal{T}^k_{t+1}) R_{k,t+1} - R_{t+1}], \tag{A.12}$$

$$\mu_{b,t} = E_t \Lambda_{t,t+1} \Omega_{t+1} [R_{t+1} - (1 + \mathcal{T}^b_{t+1}) R_{b,t+1}], \tag{A.13}$$

and

$$\mathcal{V}_t = E_t \Lambda_{t,t+1} \Omega_{t+1} R_{t+1}, \tag{A.14}$$

where

$$\Omega_t \equiv (1 - \sigma) + \sigma(\phi_t \mu_t + \mathcal{V}_t). \tag{A.15}$$

Eqs. (A.3), (A.7), (A.8), (A.9), (A.10), (A.12), (A.13), (A.14), and (A.15) correspond to Eqs. (14), (24), (25), (19), (26), (15), (16), (17), and (18) in the main text, respectively.

### A2. Economy without liability dollarization

This appendix provides formal expressions for the no-liability dollarization case. In an economy without liability dollarization, the bank's foreign debt $b_t$ (and $B_t$) is denominated in the domestic currency. Therefore, the bank's balance sheet (8) and the evolution of the bank's net worth (9) change as follows:

$$Q_t s_t = n_t + b_t + d_t, \tag{A.16}$$

and

$$n_t = (1 - \mathcal{T}^k_t) R_{k,t} Q_{t-1} s_{t-1} - (1 + \mathcal{T}^b_t) R_{b,t} b_{t-1} - R_t d_{t-1} + \zeta_t, \tag{A.17}$$

Accordingly, the bank's incentive constraint (11) becomes

$$V_t(s_t, b_t, d_t) \geq \Theta(d_t + n_t) + \Theta^* b_t. \tag{A.18}$$

Eq. (13) also becomes

$$\begin{aligned} \Theta(d_t + n_t) + \Theta^* b_t &= \Theta(d_t + n_t) + \Theta(1 + \chi) b_t \\ &= \Theta(Q_t s_t + \chi b_t). \end{aligned} \tag{A.19}$$

The value function (A.3) and the definition of $\mu_{b,t}$ become

$$V_t(s_t, b_t, n_t) = \mu_t Q_t s_t + \mu_{b,t} b_t + \mathcal{V}_t n_t, \tag{A.20}$$

and

$$\mu_{b,t} \equiv \mathcal{V}_t - \mathcal{V}_{b,t}. \tag{A.21}$$

Eq. (A.6), and (A.8) become

$$(\Theta - \mu_t) Q_t s_t + (\chi\Theta - \mu_{b,t}) b_t = \mathcal{V}_t n_t, \tag{A.22}$$

and

$$Q_t s_t = \phi_t n_t - \frac{\phi_t}{\phi_{b,t}} b_t. \tag{A.23}$$

Eqs. (27), (28), (29), and (31) become

$$N_t = \frac{1}{\phi_t} Q_t S_t + \frac{1}{\phi_{b,t}} B_t, \tag{A.24}$$

$$D_t = -(1+\chi)B_t + (\phi_t - 1)N_t, \tag{A.25}$$

$$N_{e,t} = \sigma(R_{k,t}Q_{t-1}S_{t-1} - R_{b,t}B_{t-1} - R_t D_{t-1}), \tag{A.26}$$

and

$$N_t = (\sigma + \xi)R_{k,t}Q_{t-1}S_{t-1} - \sigma R_{b,t}B_{t-1} - \sigma R_t D_{t-1}. \tag{A.27}$$

The government's budget constraint (39) becomes

$$G_t + \mathcal{Z}_t = \mathcal{T}^k_t R_{k,t}Q_{t-1}S_{t-1} + \mathcal{T}^b_t R_{b,t}B_{t-1} + T_{h,t}. \tag{A.28}$$

The capital control rule (40) becomes

$$\mathcal{T}^b_t = \tau_b\left[\log\left(\frac{B_{t-1}}{B}\right)\right]. \tag{A.29}$$

The foreign debt (47) equation and the country-specific interest rate premium (48) become

$$B_t = R_{b,t}B_{t-1} - TB_t, \tag{A.30}$$

and

$$R^*_{b,t+1} = R^*_{t+1} + \psi\left[\exp\left\{\frac{g(q_t)B_t}{Y_t} - \frac{g(q)B}{Y}\right\} - 1\right]. \tag{A.31}$$

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