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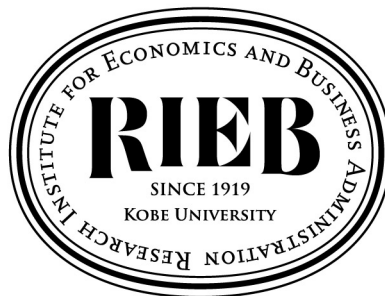
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**Capital Controls, Monetary Policy,
and Balance Sheets
in a Small Open Economy**

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Capital Controls, Monetary Policy, and Balance Sheets in a Small Open Economy*

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Abstract

We develop a small open economy, New Keynesian model that incorporates a financial accelerator in combination with liability dollarization. Applying a Ramsey-type analysis, we compare the welfare implications of an optimal monetary policy under flexible exchange rates and an optimal capital control policy under fixed exchange rates. In an economy without the financial accelerator, an optimal monetary policy under flexible exchange rates is superior to an optimal capital control policy under fixed exchange rates. In contrast, in an economy with the financial accelerator, an optimal capital control under fixed exchange rates yields higher welfare than an optimal monetary policy under flexible exchange rates.

Keywords: capital control; monetary policy; balance sheets; Ramsey policy; exchange rate regimes; small open economy; nominal rigidities; New Keynesian; DSGE; welfare comparison; incomplete markets; financial accelerator; financial frictions.

JEL Classification: E44, E52, F32, F38, F41.

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1 Introduction

Although capital controls are not a new policy instrument, it is not until the recent global financial crisis that the potential effects of capital control policies have been rigorously examined from the theoretical perspective as one of the most important topics in international finance.¹ Given the recent financial crisis, volatile international capital movements in emerging market economies have been the subject of rigorous discussion among concerned policymakers and economists. Volatile capital flows amplify boom-bust cycles and destabilize emerging market economies. The recent global financial crisis led to a reconsideration of the merits of capital account restrictions. An increasing number of policymakers believe that capital controls can effectively stabilize economies against volatile capital flows. In fact, some emerging market countries have recently responded to instability by imposing capital controls.² As well known, even the IMF, a former critic of capital controls, has been forced to reconsider such measures as an important policy response to volatile capital flows under certain circumstances.³

Against this background, there has emerged a rapidly growing body of literature related to capital controls.⁴ Jeanne and Korinek (2010) and Bianchi (2011) show that there are pecuniary externalities associated with financial crises and provide a rationale for prudential capital controls. Using a two-country model,

¹An exception is Kitano (2004). Kitano (2004) shows that capital controls not only stem the capital inflow but also reverse the associated macroeconomic effects, and are effective measures against the capital inflow problem.

²For details, see, for example, Jongwanich and Kohpaiboon (2012), Ahmed and Zlate (2014), Forbes et al. (2016), and Ghosh et al. (2017).

³For details on the IMF position, see Ostry et al. (2010) and Ostry et al. (2012).

⁴For details, see, for example, Korinek (2011) or Jeanne et al. (2012). For the earlier literature on capital controls, see the introduction in Kitano (2011). Kitano (2011) shows that there exists an optimal degree of capital-account restriction that achieves a higher level of welfare than that under perfect capital mobility, if the economy has costly financial intermediaries.

Brunnermeier and Sannikov (2014) show that pecuniary externalities can lead to constrained inefficient outcomes and capital controls can be welfare improving.⁵

In recent years, an increasing number of studies examine the effects of capital controls as a regular instrument of economic policy from a broader perspective (e.g., Schmitt-Grohé and Uribe (2016), Farhi and Werning (2012), De Paoli and Lipinska (2013), and Kitano and Takaku (2017c)).^{6 7} For example, Kitano and Takaku (2017a) show that as the degree of financial frictions between banks and foreign creditors increases, more aggressive capital controls are appropriate.

Another strand of the literature focuses the relationship between capital controls and various types of monetary policies (Davis and Presno (2014), Liu and Spiegel (2015), Chang et al. (2015), and Agénor and Jia (2015)). For example, Kitano and Takaku (2017b) show that capital controls can play an alternative role to the direct credit policy in mitigating the contraction after a crisis.

Our paper is most closely related to De Paoli and Lipinska (2013), Davis and Presno (2014), and Liu and Spiegel (2015) in that we too apply a Ramsey-type analysis for capital controls. However, we examine optimal capital controls in models that highlight balance sheet effects in the presence of liability dollarization.⁸ Therefore, our paper is also rather closely related to Céspedes et al. (2004),

⁵Benigno et al. (2013) consider both ex-ante and ex-post policies in a model with pecuniary externalities. They show that the design of ex-ante policies depends on that of ex-post policies.

⁶Ostry 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).

⁷Kitano and Takaku (2017c) 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.

⁸Emerging economies have difficulty in borrowing abroad in their own currencies, and face a mismatch in the currency denomination of their liabilities and assets. 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

Devereux et al. (2006), and Elekdağ and Tchakarov (2007). Building upon the framework developed by Bernanke et al. (1999), Céspedes et al. (2004), Devereux et al. (2006), and Elekdağ and Tchakarov (2007) incorporate a financial accelerator coupled with liability dollarization, in which foreign debt is denominated in foreign currency (not domestic currency). In these models, the financial accelerator works through an endogenous risk premium that is linked to the balance sheets of entrepreneurs. These balance sheets are also vulnerable to exchange rate fluctuations owing to the problem of liability dollarization.

Céspedes et al. (2004) and Devereux et al. (2006) find that the conventional wisdom, that the flexible exchange rate is preferable to the fixed exchange rate, holds in spite of the financial accelerator effects. Elekdağ and Tchakarov (2007) also confirm that the flexible exchange rate regime has better welfare properties than the fixed exchange rate regime when the country has perfect access to international capital markets. However, when their model incorporates a financial accelerator and the leverage ratio exceeds a threshold, they find that the fixed exchange rate regime could become welfare superior.

We develop a small open economy, New Keynesian model with and without a financial accelerator mechanism, the model structure of which is basically similar to Céspedes et al. (2004), Devereux et al. (2006), and Elekdağ and Tchakarov (2007). We then apply a Ramsey-type analysis and examine the welfare implications of capital control policies.

In the case without the financial accelerator, we compare three cases: optimal monetary policy under flexible exchange rates, optimal capital control policy (on

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).

households) under fixed exchange rates, and fixed exchange rates (without capital controls). Our Ramsey-type analysis results indicate that although the optimal capital control policy significantly improves welfare under fixed exchange rates, the optimal monetary policy is the most welfare-maximizing in an economy without the financial accelerator.

In the case with the financial accelerator, we compare the following five cases: an optimal monetary policy under flexible exchange rates, fixed exchange rates (without capital controls), an optimal capital control policy on entrepreneurs, an optimal capital control policy on households, and an optimal capital control policy on both entrepreneurs and households under fixed exchange rates. Our analysis results indicate that the optimal monetary policy still outperforms the optimal capital control policy on households. However, the optimal capital control policy on entrepreneurs outperforms the optimal monetary policy. The most welfare-maximizing is the optimal capital control policy on both entrepreneurs and households.

The intuition underlying our analysis results is straightforward. Entrepreneurs finance investment partly with foreign borrowing, which is subject to financial frictions in the presence of balance sheet vulnerabilities. In an economy with a financial accelerator, the key variable is the foreign interest rate augmented by an external finance premium. Monetary policy works only through domestic interest rates. However, capital controls on entrepreneurs have a direct control on the key variable of interest rates at which entrepreneurs borrow abroad. Therefore, capital controls can be welfare improving in an economy with financial frictions.

The remainder of the paper is organized as follows. In Section 2, we present a sticky price, small open economy model with and without a financial accelerator

in combination with liability dollarization. In Section 3, we perform a comparative analysis of welfare for alternative policy regimes in this economy. For the economy without the financial accelerator, we compare (i) the flexible exchange rate regime accompanied by an optimal monetary policy, (ii) the fixed exchange rate regime accompanied by optimal capital controls on households, and (iii) the fixed exchange rate regime (without capital controls). For the economy with the financial accelerator, we compare (i) the fixed exchange rate regime accompanied by optimal capital controls on households and entrepreneurs, (ii) the fixed exchange rate regime accompanied by optimal capital controls on entrepreneurs, (iii) the flexible exchange rate regime accompanied by an optimal monetary policy, (iv) the fixed exchange rate regime accompanied by optimal capital controls on households, and (v) the fixed exchange rate regime (without capital controls). In Section 4, we check the robustness of our results. In the previous section, we show the welfare rankings for three shocks together: productivity shock, export shock, and foreign interest rate shock. In this section, we show that our results are robust even when we consider these shocks individually. Conclusions are presented in Section 5.

2 Model

We employ the small open economy structure developed by Galí and Monacelli (2005) and Faia and Monacelli (2008). The small open economy model incorporates a financial accelerator a la Bernanke et al. (1999) in combination with liability dollarization. Our model is close to those in Céspedes et al. (2004), Devereux et al. (2006), and Elekdağ and Tchakarov (2007). The small open economy consists of households, production firms, entrepreneurs, and the government.

2.1 Households

A representative household maximizes its expected lifetime utility:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{C_t^{1-\sigma}}{1-\sigma} - \frac{L_t^{1+\phi}}{1+\phi} \right\}, \quad (1)$$

where E_t denotes the mathematical expectations operator conditional on information available at time t , $\beta \in (0, 1)$ is the discount factor, C_t signifies a composite consumption index, and L_t represents labor effort. Households consume differentiated goods (produced by both domestic and foreign firms). The composite consumption index C_t is given by

$$C_t \equiv \left[(1-\gamma)^{\frac{1}{\eta}} C_{H,t}^{\frac{\eta-1}{\eta}} + \gamma^{\frac{1}{\eta}} C_{F,t}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}. \quad (2)$$

$\eta (> 0)$ is the elasticity of substitution between domestic and foreign goods, and $\gamma \in (0, 1)$ represents the measure of openness. $C_{H,t}$ and $C_{F,t}$ are, respectively, the indices for consumption of domestic and foreign goods, expressed by

$$C_{H,t} \equiv \left[\int_0^1 C_{H,t}(j)^{\frac{\varepsilon-1}{\varepsilon}} dj \right]^{\frac{\varepsilon}{\varepsilon-1}}; \quad C_{F,t} \equiv \left[\int_0^1 C_{F,t}(j)^{\frac{\varepsilon-1}{\varepsilon}} dj \right]^{\frac{\varepsilon}{\varepsilon-1}}, \quad (3)$$

where $\varepsilon (> 1)$ is the parameter for the elasticity of substitution among differentiated goods. A household's optimal expenditure allocation in each goods category yields the demand functions for domestic and foreign differentiated goods:

$$C_{H,t}(j) = \left(\frac{P_{H,t}(j)}{P_{H,t}} \right)^{-\varepsilon} C_{H,t}; \quad C_{F,t}(j) = \left(\frac{P_{F,t}(j)}{P_{F,t}} \right)^{-\varepsilon} C_{F,t}, \quad (4)$$

where $P_{H,t}(j)$ and $P_{F,t}(j)$ denote the domestic-currency-denominated prices of differentiated goods j produced by domestic and foreign firms, respectively. $P_{H,t}$ and $P_{F,t}$ are the domestic and import price indices, respectively:

$$P_{H,t} \equiv \left[\int_0^1 P_{H,t}(j)^{1-\varepsilon} dj \right]^{\frac{1}{1-\varepsilon}}; \quad P_{F,t} \equiv \left[\int_0^1 P_{F,t}(j)^{1-\varepsilon} dj \right]^{\frac{1}{1-\varepsilon}}. \quad (5)$$

From Eq. (5), we obtain

$$\int_0^1 P_{H,t}(j) C_{H,t}(j) dj = P_{H,t} C_{H,t}; \quad \int_0^1 P_{F,t}(j) C_{F,t}(j) dj = P_{F,t} C_{F,t}. \quad (6)$$

The optimal expenditure allocation between domestic and imported goods gives

$$C_{H,t} = (1 - \gamma) \left(\frac{P_{H,t}}{P_t} \right)^{-\eta} C_t; \quad C_{F,t} = \gamma \left(\frac{P_{F,t}}{P_t} \right)^{-\eta} C_t, \quad (7)$$

where P_t represents the consumer price index (CPI):

$$P_t \equiv \left[(1 - \gamma) P_{H,t}^{1-\eta} + \gamma P_{F,t}^{1-\eta} \right]^{\frac{1}{1-\eta}}. \quad (8)$$

From Eqs. (7) and (8), we obtain

$$P_{H,t} C_{H,t} + P_{F,t} C_{F,t} = P_t C_t. \quad (9)$$

Households have access to domestic and international financial markets. A

household's budget constraint in period t is given as

$$P_t C_t + (1+i_{t-1})A_{t-1} + (1+\tau_{h,t-1})(1+i_{t-1}^*)\mathcal{E}_t B_{t-1} + P_t \frac{\psi_B}{2} (B_t - B)^2 = A_t + \mathcal{E}_t B_t + W_t L_t + T_{h,t} + \Pi_t^F. \quad (10)$$

Herein, A_t is the domestic currency debt position, B_t is the foreign currency debt position, i_t is the interest rate of domestic currency assets, i_t^* is the interest rate of foreign currency assets, and \mathcal{E}_t is the nominal exchange rate (in terms of the domestic currency).⁹ W_t is the nominal wage, Π_t^F is dividends from firms, $\tau_{h,t}$ is the tax on the foreign currency debt of households, and $T_{h,t}$ is the lump-sum transfer. $P_t \psi_B (B_t - B)^2 / 2$ is the portfolio adjustment costs, which induce the stationarity of the equilibrium dynamics in the small open economy.¹⁰

The households' optimality conditions are given by

$$\lambda_t^h = C_t^{-\sigma}, \quad (11)$$

$$\lambda_t^h = \frac{L_t^\phi}{W_t/P_t}, \quad (12)$$

$$1 = \beta(1+i_t)E_t \left\{ \frac{\lambda_{t+1}^h}{\lambda_t^h} \frac{P_t}{P_{t+1}} \right\}, \quad (13)$$

⁹The position of the domestic asset A_t turns out to be zero in equilibrium in our model. However, the inclusion of the domestic asset A_t enables us to introduce the domestic interest rate i_t into the model as in Eq.(10). Following Devereux et al. (2006) and Elekdag and Tchakarov (2007), we therefore include the domestic asset A_t so that we can analyze the effect of monetary policy of changing the domestic interest rate i_t .

¹⁰The small open economy model with incomplete asset markets features equilibrium dynamics that possess a random walk component (Schmitt-Grohé and Uribe (2003)). To yield stationarity of the equilibrium dynamics in a small open economy, Neumeyer and Perri (2005) use a model with convex portfolio adjustment costs. The portfolio adjustment cost is often used for "closing" a small open economy. Schmitt-Grohé and Uribe (2003) present alternative approaches to induce stationarity.

and

$$1 = \beta(1 + \tau_{h,t})(1 + i_t^*) \left[1 - \frac{\psi_B P_t (B_t - B)}{\mathcal{E}_t} \right]^{-1} E_t \left\{ \frac{\lambda_{t+1}^h}{\lambda_t^h} \frac{P_t}{P_{t+1}} \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} \right\}. \quad (14)$$

Combining (13) and (14) yields the interest parity condition:

$$(1 + i_t) E_t \left\{ \frac{\lambda_{t+1}^h}{\lambda_t^h} \frac{P_t}{P_{t+1}} \right\} = (1 + \tau_{h,t})(1 + i_t^*) \left[1 - \frac{\psi_B P_t (B_t - B)}{\mathcal{E}_t} \right]^{-1} E_t \left\{ \frac{\lambda_{t+1}^h}{\lambda_t^h} \frac{P_t}{P_{t+1}} \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} \right\}. \quad (15)$$

Since we assume that the law of one price holds for individual goods, the terms of trade are given as

$$S_t \equiv \frac{P_{F,t}}{P_{H,t}} = \frac{\mathcal{E}_t P_t^*}{P_{H,t}}, \quad (16)$$

where P_t^* denotes the CPI in the foreign country (in terms of foreign currency).¹¹

It follows from (16) that

$$\frac{S_t}{S_{t-1}} = \frac{\Delta \mathcal{E}_t}{\Pi_{H,t}}, \quad (17)$$

where $\Delta \mathcal{E}_t \left(\equiv \frac{\mathcal{E}_t}{\mathcal{E}_{t-1}} \right)$ and $\Pi_{H,t} \left(\equiv \frac{P_{H,t}}{P_{H,t-1}} \right)$ denote the depreciation rate of the nominal exchange rate and the rate of domestic inflation, respectively. It follows from CPI (8) and (16) that

$$\frac{P_t}{P_{H,t}} = [(1 - \gamma) + \gamma S_t^{1-\eta}]^{\frac{1}{1-\eta}} \equiv g(S_t). \quad (18)$$

From (18), CPI inflation $\Pi_t \left(\equiv \frac{P_t}{P_{t-1}} \right)$ is expressed as

$$\Pi_t = \Pi_{H,t} \frac{g(S_t)}{g(S_{t-1})}. \quad (19)$$

¹¹Without loss of generality, we assume that P_t^* is exogenous and constant (= 1) for all t .

From (16) and (18), we obtain the real exchange rate q_t as the function of S_t :

$$q_t \equiv \frac{\mathcal{E}_t P_t^*}{P_t} = \frac{S_t}{g(S_t)} \equiv q(S_t). \quad (20)$$

2.2 Production firms

Monopolistically competitive firms produce differentiated goods by using capital and labor. Each monopolistic firm j in the home economy produces a differentiated good. The firm's production function is given by

$$Y_t(j) = Z_t K_t(j)^\alpha L_t(j)^{1-\alpha}, \quad (21)$$

where $Y_t(j)$, $K_t(j)$, $L_t(j)$, and Z_t denote the firm's output level, its capital and labor inputs, and a stochastic productivity shock, respectively.

From the first-order conditions associated with the firm's cost minimization problem, we obtain

$$(1 - \alpha) \left(\frac{R_t}{P_{H,t}} \right) K_t(j) = \alpha \left(\frac{W_t}{P_{H,t}} \right) N_t(j), \quad (22)$$

where R_t is the rental rate of capital. The firm's cost minimization implies that the firm's real marginal cost is given by

$$MC_t(j) = MC_t = \frac{(R_t/P_{H,t})^\alpha (W_t/P_{H,t})^{1-\alpha}}{Z_t \alpha^\alpha (1 - \alpha)^{1-\alpha}}. \quad (23)$$

The capital accumulation process in the economy is given as

$$K_{t+1} = \left[\frac{I_t}{K_t} - \frac{\phi_I}{2} \left(\frac{I_t}{K_t} - \delta \right)^2 \right] K_t + (1 - \delta)K_t, \quad (24)$$

where I_t is aggregate investment and δ is the depreciation rate of capital. $\frac{\phi_I}{2} \left(\frac{I_t}{K_t} - \delta \right)^2 K_t$ denotes the adjustment costs of capital, and ϕ_I is its parameter value.¹² I_t is composed of domestic and imported goods:

$$I_t \equiv \left[(1 - \gamma)^{\frac{1}{\eta}} I_{H,t}^{\frac{\eta-1}{\eta}} + \gamma^{\frac{1}{\eta}} I_{F,t}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}, \quad (25)$$

where $I_{H,t}$ and $I_{F,t}$ are represented by

$$I_{H,t} \equiv \left[\int_0^1 I_{H,t}(j)^{\frac{\varepsilon-1}{\varepsilon}} dj \right]^{\frac{\varepsilon}{\varepsilon-1}}; \quad I_{F,t} \equiv \left[\int_0^1 I_{F,t}(j)^{\frac{\varepsilon-1}{\varepsilon}} dj \right]^{\frac{\varepsilon}{\varepsilon-1}}. \quad (26)$$

From the optimal allocation of expenditure in each goods category, we obtain the following demand functions:

$$I_{H,t}(j) = \left(\frac{P_{H,t}(j)}{P_{H,t}} \right)^{-\varepsilon} I_{H,t}; \quad I_{F,t}(j) = \left(\frac{P_{F,t}(j)}{P_{F,t}} \right)^{-\varepsilon} I_{F,t}. \quad (27)$$

The optimal allocation of expenditures between domestic and imported goods yields

$$I_{H,t} = (1 - \gamma) \left(\frac{P_{H,t}}{P_t} \right)^{-\eta} I_t; \quad I_{F,t} = \gamma \left(\frac{P_{F,t}}{P_t} \right)^{-\eta} I_t. \quad (28)$$

¹²The capital (or investment) adjustment cost is widely adopted in dynamic stochastic general equilibrium (DSGE) models, mainly because it generally improves their empirical fit (e.g., Christiano et al. (2005)). Without the adjustment cost, investment would respond to shocks too much compared to empirical evidence. The capital adjustment cost is also important to obtain the price of capital and to generate movements of asset prices. Changes in asset prices provide an amplification mechanism in models with financial frictions (Kiyotaki and Moore (1997); Bernanke et al. (1999)).

From the profit-maximization problem of capital producers, we can obtain the (nominal) price of capital Q_t :

$$Q_t = P_{H,t} \left[1 - \phi_I \left(\frac{I_t}{K_t} - \delta \right) \right]^{-1}. \quad (29)$$

2.3 Price setting

Following Calvo (1983), we assume that in each period, a fraction $1 - \zeta$ of monopolistically competitive firms change their prices, whereas a fraction ζ do not change their prices. This implies that we can express the domestic price index as

$$P_{H,t} \equiv \left[\zeta P_{H,t-1}^{1-\varepsilon} + (1 - \zeta) \bar{P}_{H,t}^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}}, \quad (30)$$

where $\bar{P}_{H,t}$ denotes the price reset in period t . From (30), we obtain

$$1 = \zeta \Pi_{H,t}^{-1+\varepsilon} + (1 - \zeta) \tilde{P}_{H,t}^{1-\varepsilon}, \quad (31)$$

where $\tilde{P}_{H,t} \equiv \frac{\bar{P}_{H,t}}{P_{H,t}}$.

Each firm resets its price to maximize the present discounted value of its profit stream:

$$\max_{\bar{P}_{H,t}} \sum_{k=0}^{\infty} \zeta^k E_t \{ \Lambda_{t,t+k} [Y_{t+k|t} (\bar{P}_{H,t} - MC_{t+k|t}^n)] \}, \quad (32)$$

subject to

$$Y_{t+k|t} = \left(\frac{\bar{P}_{H,t}}{P_{H,t+k}} \right)^{-\varepsilon} Y_{t+k}, \quad (33)$$

where $Y_{t+k|t}$ and $MC_{t+k|t}^n$ represent the output level and the nominal marginal cost, respectively, in $t+k$ for a firm that last reset its price in period t . $\Lambda_{t,t+k} \equiv$

$\beta^k \frac{\lambda_{t+k}^h}{\lambda_t^h} \frac{P_t}{P_{t+k}}$ is the discount factor. Y_{t+k} is the aggregate output level in period $t+k$.

From the first-order condition associated with the above problem, we obtain the optimal price:

$$\tilde{P}_{H,t} = \frac{\varepsilon}{\varepsilon - 1} \frac{\sum_{k=0}^{\infty} \zeta^k E_t \left\{ \Lambda_{t,t+k} \left(\frac{P_{H,t}}{P_{H,t+k}} \right)^{-\varepsilon-1} Y_{t+k} MC_{t+k|t} \right\}}{\sum_{k=0}^{\infty} \zeta^k E_t \left\{ \Lambda_{t,t+k} \left(\frac{P_{H,t}}{P_{H,t+k}} \right)^{-\varepsilon} Y_{t+k} \right\}}, \quad (34)$$

which can be rewritten as

$$\tilde{P}_{H,t} = \frac{\varepsilon}{\varepsilon - 1} \frac{X_t^1}{X_t^2}, \quad (35)$$

where

$$X_t^1 = Y_t MC_t + \zeta E_t \left\{ \Lambda_{t,t+1} \Pi_{H,t+1}^{\varepsilon+1} X_{t+1}^1 \right\}, \quad (36)$$

and

$$X_t^2 = Y_t + \zeta E_t \left\{ \Lambda_{t,t+1} \Pi_{H,t+1}^{\varepsilon} X_{t+1}^2 \right\}. \quad (37)$$

2.4 Entrepreneurs

Entrepreneurs have available net worth N_t denominated in domestic currency. To finance the difference between their expenditures on capital goods and their net worth, entrepreneurs borrow from foreign lenders. That is, the entrepreneur finances investment partly with foreign currency denominated debt. The entrepreneur's balance sheet is therefore given by

$$P_{H,t} N_t = Q_t K_{t+1} - \mathcal{E}_t D_t, \quad (38)$$

where D_t is the entrepreneur's foreign currency debt position. Note that an unanticipated depreciation reduces net worth in the balance sheet (38), which reflects

the problem of liability dollarization in emerging market economies.

Following Bernanke et al. (1999), we assume that foreign lenders charge an external finance premium to entrepreneurs owing to asymmetric information. Entrepreneurs choose D_t and K_{t+1} so that the expected return on capital (R^K) equals the cost of foreign borrowing:

$$R_{t+1}^K = (1 + \tau_{e,t})(1 + i_t^*) \left(\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} \right) F_t, \quad (39)$$

where F_t is the external finance premium and $\tau_{e,t}$ is a tax on the entrepreneur's foreign borrowing. Following Céspedes et al. (2004), we assume that the external finance premium is an increasing function of the value of capital relative to net worth:

$$F_t = \Psi \left(\frac{Q_t K_{t+1}}{P_{H,t} N_t} \right), \quad \Psi(1) = 1, \quad \Psi'(\cdot) > 1, \quad (40)$$

where the functional form for Ψ is given by $\Psi(g) = g^\mu$ ($\mu > 0$).¹³

At the beginning of each period, entrepreneurs collect returns from capital and repay their foreign debt. Following Céspedes et al. (2004) and Elekdağ and Tchakarov (2007), we assume that entrepreneurs consume a fraction $1 - \omega$ of the remainder on imports. The evolution of net worth is thus given as

$$P_{H,t} N_t = \omega [R_t^K Q_{t-1} K_t - (1 + \tau_{e,t-1})(1 + i_{t-1}^*) F_{t-1} \mathcal{E}_t D_{t-1} + T_{e,t}], \quad (41)$$

¹³Bernanke et al. (1999) show that given the assumptions related to the agency problem including the characteristics of the distribution of an idiosyncratic return shock, parameter values associated with monitoring costs, and constant returns to scale in production and monitoring costs, the agency problem implies that the external finance premium is an increasing function of the ratio of capital to net worth as in Eq.(40). Especially, the assumption of constant returns to scale in production and monitoring costs is important for the aggregation so that the value of capital relative to net worth and the external premium become equal across all entrepreneurs.

where $T_{e,t}$ denotes a lump-sum transfer from the government.

Finally, the return on capital for entrepreneurs R_{t+1}^K is expressed by the sum of the rental rate of capital R_{t+1} and the return from capital investment, divided by the original price of capital Q_t :

$$R_{t+1}^K = \frac{R_{t+1}}{Q_t} + \frac{Q_{t+1}}{Q_t} \left[(1 - \delta) + \phi_I \left(\frac{I_{t+1}}{K_{t+1}} - \delta \right) \frac{I_{t+1}}{K_{t+1}} - \frac{\phi_I}{2} \left(\frac{I_{t+1}}{K_{t+1}} - \delta \right)^2 \right]. \quad (42)$$

2.5 Government

We assume that the government transfers the collected tax on foreign debt to households and entrepreneurs in a lump-sum manner. The government's budget constraints are thus given by

$$\tau_{h,t-1}(1 + i_{t-1}^*)\mathcal{E}_t B_{t-1} = T_{h,t} \quad (43)$$

and

$$\tau_{e,t-1}(1 + i_{t-1}^*)F_{t-1}\mathcal{E}_t D_{t-1} = T_{e,t}. \quad (44)$$

2.6 Equilibrium and exogenous shocks

The market clearing for domestic goods requires

$$P_{H,t}Y_t = P_{H,t}C_{H,t} + P_{H,t}I_{H,t} + \mathcal{E}_t EX_t, \quad (45)$$

where EX_t denotes demand for exports, which is assumed to be an exogenous stochastic process. Dividing both sides of (45) by $P_{H,t}$ we obtain

$$Y_t = C_{H,t} + I_{H,t} + S_t EX_t \quad (46)$$

$$= (1 - \gamma)g(S_t)^\eta(C_t + I_t) + S_t EX_t, \quad (47)$$

where we derive the second equality by considering the demand functions (7), (18), and (28).

From Eq.(21) and the fact that the production function is homogeneous with degree 1, we obtain

$$\int_0^1 Y_t(j) dj = Z_t K_t^\alpha L_t^{1-\alpha}, \quad (48)$$

where $K_t = \int_0^1 K_t(j) dj$ and $L_t = \int_0^1 L_t(j) dj$. From the demand function for differentiated goods, we obtain

$$\int_0^1 \left(\frac{P_{H,t}(j)}{P_{H,t}} \right)^{-\varepsilon} Y_t dj = Z_t K_t^\alpha L_t^{1-\alpha}. \quad (49)$$

We define $\theta_t \equiv \int_0^1 \left(\frac{P_{H,t}(j)}{P_{H,t}} \right)^{-\varepsilon} dj$, which can be expressed as¹⁴

$$\theta_t = (1 - \zeta) \tilde{P}_{H,t}^{-\varepsilon} + \zeta \Pi_{H,t}^\varepsilon \theta_{t-1}. \quad (50)$$

Then, we can rewrite (49) as

$$Y_t = \theta_t^{-1} Z_t K_t^\alpha L_t^{1-\alpha}, \quad (51)$$

¹⁴For the derivation of (50), see Schmitt-Grohé and Uribe (2006).

where θ_t measures the resource costs induced by price dispersion in the Calvo model.

The productivity shock Z_t , export shock EX_t , and foreign (nominal) interest-rate shock i_t^* are exogenously evolving according to the following processes:

$$\log Z_t = (1 - \rho_z) \log Z + \rho_z \log Z_{t-1} + \varepsilon_{z,t}, \quad \varepsilon_{z,t} \sim i.i.d. N(0, \sigma_z^2), \quad (52)$$

$$\log EX_t = (1 - \rho_{ex}) \log EX + \rho_{ex} \log EX_{t-1} + \varepsilon_{ex,t}, \quad \varepsilon_{ex,t} \sim i.i.d. N(0, \sigma_{ex}^2), \quad (53)$$

and

$$i_t^* = (1 - \rho_i) i_t^* + \rho_i i_{t-1}^* + \varepsilon_{i,t}, \quad \varepsilon_{i,t} \sim i.i.d. N(0, \sigma_i^2). \quad (54)$$

The equilibrium of this economy is a set of stationary stochastic processes $\{ C_t, L_t, B_t, \Pi_t, S_t, \frac{P_t}{P_{H,t}}, \Pi_{H,t}, q_t, Y_t, MC_t, K_t, I_t, \frac{Q_t}{P_{H,t}}, \tilde{P}_{H,t}, N_t, R_t^K, F_t, D_t, \frac{R_t}{P_t}, \frac{W_t}{P_t}, X_t^1, X_t^2, \theta_t, i_t, \mathcal{E}_t \}_{t=0}^\infty$ satisfying Eqs. (10)-(14), (17)-(20), (22)-(24), (29), (35)-(37), (38)-(42), (47), (50), and (51) (combined with the equations for other variables), given initial values for B_{-1} , K_0 , N_{-1} , and D_{-1} , and exogenous stochastic processes Z_t , EX_t , and i_t^* .

2.7 Optimal Ramsey policies

We consider optimal Ramsey monetary and capital control policies. We obtain the Ramsey optimal policies by setting up a Lagrangian problem in which the social planner maximizes the conditional lifetime utility of the representative household subject to the first-order conditions of the private agents and the market-clearing conditions of the economy. We compute this numerically using the Matlab proce-

dures developed by Levin et al. (2006).¹⁵

We let x_t denote the $N \times 1$ vector of endogenous variables. Except for the policy instrument, the remaining $N - 1$ endogenous variables in x_t satisfy the $N - 1$ structural conditions, which is expressed with

$$E_t f(x_t, x_{t+1}, \zeta_t) = 0, \quad (55)$$

where the vector ζ_t denotes the exogenous variables. We derive the optimal Ramsey policy from the maximization problem:

$$\begin{aligned} \max_{\{x_t\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} \beta^t U(x_t, \zeta_t) \\ s.t. \quad E_t f(x_t, x_{t+1}, \zeta_t) = 0. \end{aligned} \quad (56)$$

We set up a Lagrangian problem:

$$\mathcal{L}_0 = E_0 \sum_{t=0}^{\infty} \beta^t \{U(x_t, \zeta_t) + \lambda'_t f(x_t, x_{t+1}, \zeta_t)\}, \quad (57)$$

where λ_t denotes the Lagrange multipliers associated with the first-order conditions of the private agents and the market-clearing conditions of the economy in (55). Taking derivatives of \mathcal{L}_0 with respect to the N endogenous variables, we obtain the N first order conditions which are characterized by the following equation:¹⁶

$$U_1(x_t, \zeta_t) + E_t \lambda'_t f_1(x_t, x_{t+1}, \zeta_t) + \beta^{-1} \lambda'_{t-1} f_2(x_{t-1}, x_t, \zeta_{t-1}) = 0. \quad (58)$$

¹⁵Levin et al. (2006)'s program reads a Dynare model file and generates the first-order conditions of a Ramsey policymaker. See Adjemian et al. (2011) for details on Dynare.

¹⁶The first order necessary condition for optimality at $t = 0$ is (58) with $\lambda_{-1} = 0$.

Taking derivatives of \mathcal{L}_0 with respect to λ_t , we obtain the $N - 1$ equilibrium conditions in the private sector in (55). The Ramsey equilibrium process is therefore characterized by the $N - 1$ equations, (55), and the N equations (58). We have the N elements of x and the $N - 1$ multipliers, λ . In total, there are $2N - 1$ variables and $2N - 1$ equations.

In Section 3, we will examine the optimal Ramsey monetary and capital control policies. In the peg case without capital controls (i.e, $\mathcal{E}_t = \bar{\mathcal{E}}$, and $\tau_{h,t} = \tau_{e,t} = 0$ for all t), we have N endogenous variables and N equilibrium conditions. In the peg case with the optimal capital control policies, we include $\tau_{h,t}$ and/or $\tau_{e,t}$ in the endogenous variables and obtain the Ramsey capital control policies by letting $\tau_{h,t}$ and/or $\tau_{e,t}$ be policy instruments. In this case, we have $N - 1$ (or $N - 2$) equilibrium conditions for N endogenous variables. Including the $N - 1$ (or $N - 2$) multipliers, in total, we have $2N - 1$ (or $2N - 2$) variables and $2N - 1$ (or $2N - 2$) equations. In the flexible exchange rate case in which \mathcal{E}_t is included in the endogenous variables, we let i_t be a policy instrument and obtain the Ramsey monetary policy. In this case, we have $N - 1$ equilibrium conditions for N endogenous variables. Including the $N - 1$ multipliers, in total, we have $2N - 1$ variables and $2N - 1$ equations.

2.8 Parameterization

We choose standard parameter values given in the relevant literature, which are summarized in Table 1. Following many previous studies, we set the quarterly discount factor β to 0.99. Following Elekdağ and Tchakarov (2007) and Devereux et al. (2006), we set the inverse of intertemporal elasticity of substitution σ , elasticity of labor supply ϕ , and capital adjustment cost parameter ψ^K to 2, 1, and

12, respectively. We set capital share in production α to 0.32 as in Schmitt-Grohé and Uribe (2003). Following Kollmann (2002) and Devereux et al. (2006), we set the quarterly depreciation rate δ to 0.025. Following Galí and Monacelli (2005), we set the elasticity of substitution among differentiated goods ϵ and fraction of firms that do not reset their prices ζ to 6 and 0.75, respectively. As in Ravenna and Natalucci (2008), we set the elasticity of substitution between domestic and foreign goods η to 1.5. With respect to the degree of openness γ , we follow Cook (2004) and set it to 0.28. The parameter for bond adjustment cost ψ^B and steady state debt ratio to GDP $\frac{B}{Y}$ are set to 0.0007 and 0.4, respectively, as in Devereux et al. (2006). We set the steady state level of leverage ratio $\frac{QK}{P_H N}$ at 2.2, which is higher than in Bernanke et al. (1999) who use 2, but not as high as in Devereux et al. (2006) who use 3. Following Cespedes et al. (2000) and Merola (2010), we set the elasticity of external finance premium to leverage ratio μ to 0.02.¹⁷ We use the same values as in Elekdağ and Tchakarov (2007) for the exogenous shocks. The persistence and the standard deviation of the productivity shock (ρ_z and σ_z) are set to 0.8 and 0.02, respectively. The persistence and the standard deviation of the export shock (ρ_{ex} and σ_{ex}) are set to 0.5 and 0.06, respectively. The persistence and the standard deviation of the foreign interest shock (ρ_i and σ_i) are set to 0.8 and 0.003, respectively.

2.9 Welfare evaluation

We calculate and compare welfare levels under alternative policy regimes. Since there exist households and entrepreneurs in our model, the overall welfare mea-

¹⁷Using a maximum-likelihood procedure and post-1979 US data, Christensen and Dib (2008) report a higher estimated value of 0.042 for this parameter.

Table 1: Parameterization.

Parameters	Value	
β	0.99	Discount factor
σ	2	Inverse of intertemporal elasticity of substitution
ϕ	1	Elasticity of labor supply
ψ^K	12	Capital adjustment cost parameter
α	0.32	Share of capital in output
δ	0.025	Depreciation rate of capital
ϵ	6	Elasticity of substitution among differentiated goods
ζ	0.75	Fraction of firms that do not reset their prices
η	1.5	Elasticity of substitution between domestic and foreign goods
γ	0.28	Degree of openness
ψ^B	0.0007	Parameter for bond adjustment cost
$\frac{B}{Y}$	0.4	Steady-state ratio of debt to GDP
$\frac{QK}{P_{HN}}$	2.2	Steady-state ratio of capital to net worth
μ	0.02	Elasticity of external finance premium
ρ_Z	0.8	Persistence: productivity shock
σ_Z	0.02	Standard deviation: productivity shock
ρ_{ex}	0.5	Persistence: export shock
σ_{ex}	0.06	Standard deviation: export shock
ρ_i	0.8	Persistence: foreign interest rate shock
σ_i	0.003	Standard deviation: foreign interest rate shock

sure of the economy is the weighted sum of households' and entrepreneurs' welfare. However, as argued by Bernanke et al. (1999), we can reasonably assume that the fraction of entrepreneurs' consumption is negligible. Following Faia and Monacelli (2005) and Elekdag and Tcharkarov (2007), we therefore assume that the entrepreneurs' share of consumption is negligible and the overall welfare measure of the economy corresponds to the households' welfare level. We let V_0^a denote the conditional welfare level associated with case (a) ($a=i, ii, iii\dots$):

$$\begin{aligned} V_0^a &\equiv E_0 \sum_{t=0}^{\infty} \beta^t U(C_t^a, L_t^a), \\ &= E_0 \sum_{t=0}^{\infty} \beta^t U((1 - \lambda^a)C, L). \end{aligned} \tag{59}$$

Here, λ^a is the welfare cost of adopting policy (a) on the condition of the calibrated steady state. The conditional welfare measure is obtained using the second-order perturbation methods as described in Schmitt-Grohé and Uribe (2004) and Schmitt-Grohé and Uribe (2007).¹⁸ We let the most welfare-maximizing case be the reference case (*ref*). Therefore, $\lambda^a - \lambda^{ref}$ is the welfare loss in each case, which is the fraction of consumption that compensates a household to a level that is considered as well off under policy (a) as in the reference case (*ref*).

3 Results

In this section, we present the main results of our analysis. We evaluate the welfare implications of alternative policy and exchange rate regimes with and without the financial accelerator. In Section 3.1, we consider an economy without the financial

¹⁸Kim and Kim (2003) reveal that second-order solutions are necessary because conventional linearization may generate spurious welfare reversals.

accelerator and compare the welfare consequences of an optimal monetary policy under flexible exchange rates (policy instrument i_t), an optimal capital control policy on households under fixed exchange rates (policy instrument τ_h , $\mathcal{E}_t = \bar{\mathcal{E}}$ for all t), and a peg regime without an optimal capital control policy ($\mathcal{E}_t = \bar{\mathcal{E}}$ for all t). In Section 3.2, we analyze an economy with the financial accelerator and compare the welfare consequences of an optimal monetary policy under flexible exchange rates (policy instrument i_t), an optimal capital control policy on households under fixed exchange rates (policy instrument τ_h , $\mathcal{E}_t = \bar{\mathcal{E}}$ for all t), an optimal capital control policy on entrepreneurs (policy instrument τ_e , $\mathcal{E}_t = \bar{\mathcal{E}}$ for all t), optimal capital control policies on households and entrepreneurs (policy instruments τ_h and τ_e , $\mathcal{E}_t = \bar{\mathcal{E}}$ for all t), and a peg regime without optimal capital control policy ($\mathcal{E}_t = \bar{\mathcal{E}}$ for all t).

3.1 No financial accelerator

Following Devereux et al. (2006), we also examine the model without entrepreneurs in order to explore the importance of the balance sheet effect. In this case, households accumulate capital without the external finance premium. The Appendix explains the model without entrepreneurs in detail.

We compare welfare levels in an economy without the financial accelerator in the following cases: (i) an optimal monetary policy under flexible exchange rates (policy instrument i_t), (ii) an optimal capital control policy under fixed exchange rates (policy instrument τ_h , $\mathcal{E}_t = \bar{\mathcal{E}}$ for all t), and (iii) a fixed exchange rate regime (without capital controls, $\mathcal{E}_t = \bar{\mathcal{E}}$ for all t). Since the optimal monetary policy case under flexible exchange rates (i) turns out to be the most welfare-maximizing, we

Table 2: Conditional welfare costs: No financial accelerator

	(i) Mon.	(ii) Cap. Con.	(iii) Fixed ER
Welfare Cost: $(\lambda^a - \lambda^{ref}) \times 100$	0	0.106	0.306

Note) The conditional welfare costs in (ii) and (iii) are measured with the most welfare-maximizing case (i) being the reference case.

let (i) to be the reference case (*ref*).

The conditional welfare costs in each case (i, ii, and iii) compared with the reference case (*ref*) are shown in Table 2. The welfare cost in the case of an optimal capital control policy under fixed exchange rates (ii) is 0.106%, whereas the welfare cost in the fixed exchange rate regime (iii) is 0.306%. Hence, we can say that the optimal capital control policy more than halves the welfare gap between the flexible exchange rate case (i) and the fixed exchange rate case (iii). However, it is obvious that the optimal monetary policy under flexible exchange rates (i) outperforms the optimal capital control policy under fixed exchange rates (ii) in an economy without the financial accelerator.

Tables 3 and 4 show the means and standard deviations of the main variables in the case without the financial accelerator. Since the capital control policy is adopted only in case (ii), by definition, the means and standard deviations of τ_h in cases (i) and (iii) are zero in Tables 3 and 4. Since the fixed exchange rate eliminates the volatility of the nominal exchange rate, by definition, the standard deviation of $\Delta\mathcal{E}$ in cases (ii) and (iii) is zero in Table 4. Further, note that since the optimal monetary policy under flexible exchange rates (i) is an “inward looking” policy, it has the lowest domestic price inflation (Π_H) volatility among the three regimes in Table 4. In contrast, since the optimal capital control policy under

Table 3: Means: No financial accelerator

	(i) Mon.	(ii) Cap. Con.	(iii) Fixed ER
Y	1.8042	1.8042	1.7987
C	1.4571	1.4565	1.4535
I	0.3426	0.3422	0.3420
L	0.6943	0.6944	0.6944
$\Delta\mathcal{E}$	1.0000	1.0000	1.0000
S	0.9968	0.9967	0.9945
Π	1.0000	1.0000	1.0000
Π_H	1.0000	1.0000	1.0000
i_d	0.0099	0.0099	0.0100
τ_h	0.0000	-0.0001	0.0000

fixed exchange rates (ii) and the fixed exchange rate regime (iii) are “outward looking” policies, the terms of trade (S) in (ii) and (iii) are more stabilized (i.e., the standard deviations of S in (ii) and (iii) are smaller) compared to that in case (i) in Table 4.

3.2 With financial accelerator

We next consider alternative policies in an economy with the financial accelerator. We compare the welfare levels in the following cases: (i) optimal capital controls on both households and entrepreneurs under fixed exchange rates (policy instruments τ_h and τ_e , $\mathcal{E}_t = \bar{\mathcal{E}}$ for all t), (ii) optimal capital controls on entrepreneurs under fixed exchange rates (policy instrument τ_e , $\mathcal{E}_t = \bar{\mathcal{E}}$ for all t), (iii) an optimal monetary policy under flexible exchange rates (policy instrument i_t), (iv) optimal capital controls on households under fixed exchange rates (policy instrument τ_h , $\mathcal{E}_t = \bar{\mathcal{E}}$ for all t), and (v) a fixed exchange rate regime (without capital controls, $\mathcal{E}_t = \bar{\mathcal{E}}$ for all t). Since optimal capital controls on both households and entrepreneurs under

Table 4: Standard Deviations (%): No financial accelerator

	(i) Mon.	(ii) Cap. Con.	(iii) Peg
Y	3.55	3.21	2.97
C	1.67	2.06	1.40
I	7.60	10.13	6.17
L	0.86	1.93	3.62
$\Delta\mathcal{E}$	2.75	0.00	0.00
S	4.06	2.14	2.63
Π	0.79	0.19	0.59
Π_H	0.05	0.27	0.81
i_d	1.00	0.96	0.50
τ_h	0.00	1.05	0.00

fixed exchange rates (i) is the most welfare-maximizing, we let (i) be the reference case (*ref*).

We show the welfare ranking for the alternative regimes in Table 5. It should be noted that the optimal monetary policy under flexible exchange rates (iii), which was the most welfare-maximizing in the previous subsection 3.1 for the economy without the financial accelerator, is now ranked third. As argued above, the most welfare-maximizing is optimal capital controls on both households and entrepreneurs under fixed exchange rates (i). Optimal capital controls on households (iv) improves the welfare level of the economy under fixed exchange rates (v). However, the welfare-improving effect of optimal capital controls on households (iv) is limited. Optimal capital controls on households (iv) is inferior to the optimal monetary policy under flexible exchange rates (iii). In contrast, optimal capital controls on entrepreneurs (ii) outperforms the optimal monetary policy (iii). Further, optimal capital controls on entrepreneurs (ii) is second only to the most welfare-maximizing case (i).

Table 5: Conditional welfare costs: With financial accelerator

	(i) Cap. Con. ent. & hous.	(ii) Cap. Con. ent.	(iii) Mon.	(iv) Cap. Con. hous.	(v) Peg
Welfare Cost: $(\lambda^a - \lambda^{ref}) \times 100$	0	0.215	1.624	1.900	2.385

Note) The conditional welfare costs in (ii) to (v) are measured with the most welfare-maximizing case (i) being the reference case.

Tables 6 and 7 show the means and standard deviations of the main variables in the case with the financial accelerator. Comparing column (v) in Table 7 to column (iii) in Table 4, we can see that the standard deviations of Y , C , I , L , S , Π , and Π_H in column (v) are larger, which implies that the introduction of a financial accelerator mechanism into an economy increases the volatilities of the economy to the same shocks. Figure 1 represents the impulse responses of Y , C , I , L , S , Π , and Π_H to a foreign interest rate shock in the peg case with and without the financial accelerator. From Figure 1, we can also confirm that the financial accelerator makes the economy more volatile. It should be noted that in Table 6, the mean of the external finance premium F is the lowest in case (ii) and second-lowest in case (i). We can say that capital controls on entrepreneurs curtail the external finance premium level more significantly than a monetary policy or capital controls on households.

The intuition underlying our analysis results is as follows. Entrepreneurs finance investment partly with foreign borrowing, which is subject to financial frictions. Entrepreneurs borrow abroad at an interest rate, which is equal to the foreign interest rate, adjusted for expected exchange rate fluctuations, and aug-

Table 6: Means: With financial accelerator

	(i) Cap. Con. ent. & hous.	(ii) Cap. Con. ent.	(iii) Mon.	(iv) Cap. Con. hous.	(v) Peg
Y	1.7327	1.7295	1.7136	1.7065	1.6948
C	1.2672	1.2647	1.2533	1.2495	1.2409
I	0.2348	0.2341	0.2238	0.2204	0.2163
L	0.7819	0.7825	0.7865	0.7874	0.7894
$\Delta\mathcal{E}$	1.0000	1.0000	1.0001	1.0000	1.0000
S	0.9966	0.9957	0.9958	0.9935	0.9915
Π	1.0000	1.0000	1.0001	1.0000	1.0000
Π_H	1.0000	1.0000	1.0001	1.0000	1.0000
i_d	0.0098	0.0100	0.0099	0.0096	0.0100
F	1.0109	1.0107	1.0153	1.0164	1.0173
τ_h	-0.0002	0.0000	0.0000	-0.0002	0.0000
τ_e	0.0031	0.0034	0.0000	0.0000	0.0000

Table 7: Standard Deviations (%): With financial accelerator

	(i) Cap. Con. ent. & hous.	(ii) Cap. Con. ent.	(iii) Mon.	(iv) Cap. Con. hous.	(v) Peg
Y	2.83	3.13	3.77	2.88	3.52
C	2.69	1.69	2.04	3.17	2.04
I	7.12	10.23	9.17	8.73	11.02
L	3.35	3.48	2.43	3.90	4.50
$\Delta\mathcal{E}$	0.00	0.00	4.61	0.00	0.00
S	1.75	2.81	5.13	1.91	2.85
Π	0.21	0.57	1.46	0.19	0.65
Π_H	0.30	0.79	0.29	0.26	0.91
i_d	1.31	0.50	2.05	1.68	0.50
F	0.10	0.17	0.20	0.15	0.34
τ_h	1.40	0.00	0.00	1.85	0.00
τ_e	0.83	1.31	0.00	0.00	0.00

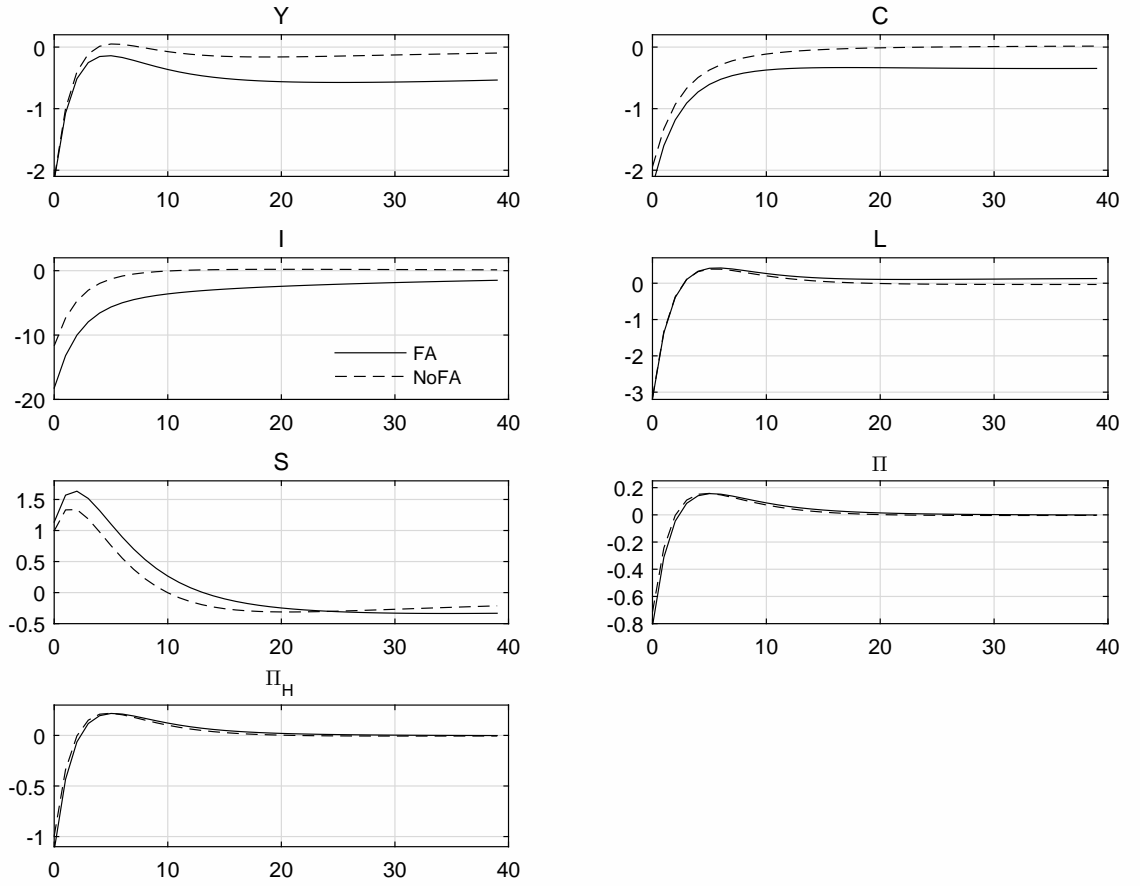


Figure 1: Model with (—) and without (---) the financial accelerator; Peg case: Impulse responses to a foreign interest rate shock

mented by an external finance premium. Although it affects the economy through domestic interest rates, a monetary policy does not directly affect the interest rate at which entrepreneurs borrow from abroad. In contrast, capital controls on entrepreneurs have a direct control on the interest rate at which entrepreneurs borrow from foreign lenders, and may yield higher welfare in an economy with the financial accelerator.

4 Sensitivity analysis

In this section, we examine the robustness of our analysis results in the previous section. In the previous section, we showed the welfare rankings in the case in which all the shocks are included. In this section, we will show that our results are robust even when we consider these shocks individually.

First, we considered the welfare rankings in an economy without the financial accelerator. Table 2 shows the welfare ranking in the case in which all the three shocks are included. The welfare rankings for the individual shocks, which are productivity shock, export shock, and foreign interest shock, are shown in Tables 8, 9, and 10, respectively. In Tables 8, 9, and 10, we can see that the optimal monetary policy under flexible exchange rates (i) outperforms the optimal capital control policy under fixed exchange rates (ii). The welfare rankings for individual shocks in Tables 8, 9, and 10 are then identical to that for all the shocks in Table 2. Therefore, we confirm that our results are robust even when we consider the individual shocks in an economy without the financial accelerator.

However, there are some notable differences among the three cases. Comparing Tables 8, 9, and 10, we can see that the welfare benefit of monetary policy (i.e., the

difference between (i) and (iii)) is the largest for the productivity shock but the smallest for the foreign interest shock. Another notable difference is that although the capital control policy is not as good as the monetary policy in any case, the capital control policy is the closest to the monetary policy for the foreign interest shock (i.e., (ii) in Table 10 is smaller than that in Tables 8 and 9).

Table 8: Conditional welfare costs: No financial accelerator – Productivity shock

	(i) Mon.	(ii) Cap. Con.	(iii) Fixed ER
Welfare Cost: $(\lambda^a - \lambda^{ref}) \times 100$	0	0.056	0.182

Table 9: Conditional welfare costs: No financial accelerator – Export shock

	(i) Mon.	(ii) Cap. Con.	(iii) Fixed ER
Welfare Cost: $(\lambda^a - \lambda^{ref}) \times 100$	0	0.044	0.075

Table 10: Conditional welfare costs: No financial accelerator – Foreign interest shock

	(i) Mon.	(ii) Cap. Con.	(iii) Fixed ER
Welfare Cost: $(\lambda^a - \lambda^{ref}) \times 100$	0	0.007	0.049

Next, we consider the welfare rankings in an economy with the financial accelerator. Table 5 shows the welfare ranking in the case in which all the three shocks are included. The welfare rankings for the individual shocks, which are productivity shock, export shock, and foreign interest shock, are shown in Tables 11, 12, and

13, respectively. In Tables 11, 12, and 13, we can see that the welfare rankings for individual shocks are identical to that for all the shocks in Table 5. Therefore, we confirm that our results are robust even when we consider the individual shocks in an economy with the financial accelerator.

However, there are some notable differences among the three cases. Comparing Tables 11, 12, and 13, we can see that the welfare benefit of capital controls (i.e., the difference between (i) and (v)) is the largest for the foreign interest shock. Another notable difference is that the monetary policy is furthest behind capital controls for the foreign interest shock (i.e., the difference between (i) and (iii) in Table 13 is larger than that in Tables 11 and 12).

Table 11: Conditional welfare costs: With financial accelerator – Productivity shock

	(i) Cap. Con. ent. & hous.	(ii) Cap. Con. ent.	(iii) Mon.	(iv) Cap. Con. hous.	(v) Peg
Welfare Cost: $(\lambda^a - \lambda^{ref}) \times 100$	0	0.123	1.663	1.741	1.922

Table 12: Conditional welfare costs: With financial accelerator – Export shock

	(i) Cap. Con. ent. & hous.	(ii) Cap. Con. ent.	(iii) Mon.	(iv) Cap. Con. hous.	(v) Peg
Welfare Cost: $(\lambda^a - \lambda^{ref}) \times 100$	0	0.049	1.630	1.757	1.871

Table 13: Conditional welfare costs: With financial accelerator – Foreign interest shock

	(i) Cap. Con. ent. & hous.	(ii) Cap. Con. ent.	(iii) Mon.	(iv) Cap. Con. hous.	(v) Peg
Welfare Cost: $(\lambda^a - \lambda^{ref}) \times 100$	0	0.043	1.800	1.870	2.064

5 Conclusion

We have developed a small open economy, New Keynesian model that highlights the vulnerability of balance sheets to exchange rate fluctuations. We then apply a Ramsey-type analysis and examine the welfare implications of optimal monetary and capital control policies. To our knowledge, our paper is the first that examines the welfare implications of optimal capital control policies in a small open economy, New Keynesian model that incorporates a financial accelerator coupled with liability dollarization.

In the case without the financial accelerator, we have compared three cases: an optimal monetary policy under flexible exchange rates, an optimal capital control policy (on households) under fixed exchange rates, and fixed exchange rates (without capital controls). Our Ramsey-type analysis results have shown that although the optimal capital control policy significantly improves welfare under fixed exchange rates, the optimal monetary policy is the most welfare-maximizing in an economy without the financial accelerator.

In the case with the financial accelerator, we compared five cases: an optimal monetary policy under flexible exchange rates, fixed exchange rates (without

capital controls), an optimal capital control policy on entrepreneurs, an optimal capital control policy on households, and an optimal capital control policy on both entrepreneurs and households under fixed exchange rates. Our results have shown that the optimal monetary policy still outperforms the optimal capital control policy on households. However, the optimal capital control policy on entrepreneurs outperforms the optimal monetary policy. The most welfare-maximizing is the optimal capital control policy on both entrepreneurs and households.

The intuition underlying our analysis results is straightforward. Entrepreneurs finance investment partly with foreign borrowing, which is subject to financial frictions. In an economy with a financial accelerator, the key variable is the foreign interest rate augmented by an external finance premium. Whereas monetary policy works through domestic interest rates, capital controls on entrepreneurs have a direct control on the interest rate at which entrepreneurs borrow from abroad. Hence, capital controls under fixed exchange rates can yield higher welfare in an economy with a financial accelerator coupled with liability dollarization.

As we mention in the introduction, Liu and Spiegel (2015) show that the welfare gain of capital controls depends on the presence of sterilization, and that capital controls and sterilization are complementary policies. Although it is beyond the scope of this study, their findings suggest that if we introduce sterilization into our model, it is highly likely that the welfare gain of capital controls becomes larger. Another useful extension would be to study the role of pecuniary externalities that lead borrowers to overborrow in a small open economy, as examined by Jeanne and Korinek (2010) and Bianchi (2011). If we incorporate the externalities associated with overborrowing into our model, it would magnify the financial-accelerator mechanism effect in an economy. It would be an interesting project to examine

the role of capital controls in an economy with a larger amplification effect due to pecuniary externalities. We leave these extensions for future research.

Appendix

In this appendix, we explain the differences between the models with and without entrepreneurs. In the economy without entrepreneurs, households directly make investment and accumulate capital. In this case, the households' budget constraint is given by

$$\begin{aligned} P_t C_t + P_t I_t + (1 + i_{t-1})A_{t-1} + (1 + \tau_{h,t-1})(1 + i_{t-1}^*)\mathcal{E}_t B_{t-1} + P_t \frac{\psi_B}{2} (B_t - B)^2 \\ = A_t + \mathcal{E}_t B_t + W_t L_t + R_t^K Q_{t-1} K_t + T_{h,t} + \Pi_t^F. \end{aligned} \quad (\text{A1})$$

Therefore, the optimal conditions associated with households' problem include the following equation:

$$1 = \beta E_t \left\{ \frac{\lambda_{t+1}^h}{\lambda_t^h} R_{t+1}^K \frac{P_t}{P_{t+1}} \right\}, \quad (\text{A2})$$

where R_t^K now denotes the return on capital for households.

Since there is no entrepreneurs in this economy, we omit the optimal conditions associated with entrepreneurs' problem (38)-(41). The equilibrium of the economy without entrepreneurs is therefore characterized by a set of stationary stochastic processes $\{ C_t, L_t, B_t, \Pi_t, S_t, \frac{P_t}{P_{H,t}}, \Pi_{H,t}, q_t, Y_t, MC_t, K_t, I_t, \frac{Q_t}{P_{H,t}}, \tilde{P}_{H,t}, R_t^K, \frac{R_t}{P_t}, \frac{W_t}{P_t}, X_t^1, X_t^2, \theta_t, i_t, \mathcal{E}_t \}_{t=0}^\infty$ satisfying Eqs. (11)-(14), (17)-(20), (22)-(24), (29), (35)-(37), (42), (47), (50), (51), (A1), and (A2) (combined with the equations for other variables), given initial values for B_{-1} , and K_0 , and exogenous stochastic processes Z_t , EX_t , and i_t^* .

In the peg case without capital controls (i.e, $\mathcal{E}_t = \bar{\mathcal{E}}$, and $\tau_h = 0$ for all t), we have 21 endogenous variables and the same number of conditions. In the peg case with the optimal capital control policy, we include τ_t^h in the endogenous variables and obtain the Ramsey capital control policy by letting τ_t^h be a policy instrument. In the flexible exchange rate case in which \mathcal{E}_t is included in the endogenous variables, we let i_t be a policy instrument and obtain the Ramsey monetary policy.

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