Flow-specific capital controls for China

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Abstract

This paper examines how flow-specific capital controls affect business cycle fluctuations and welfare in China. We develop an asymmetric two-country model to provide an emerging market perspective for China and introduce both inflow and outflow capital controls. The results indicate that flow-specific capital controls can effectively manage their respective capital flows, mitigate the effects of excess capital flows on business cycle fluctuations, and enhance welfare through the balance sheet and collateral constraint channels. Imposing controls on the real sector significantly impacts the dynamics of home and foreign credit and the real economy. In contrast, when controls are imposed on financial intermediaries, they have minimal effects on the dynamics of other financial and real variables. Lastly, flow-specific capital controls outperform tax-based capital controls in attenuating the effects of shocks and improving welfare.

Keywords: Capital controls, Emerging market, DSGE, China, Welfare, Real business cycle, Financial intermediation.

JEL Codes: E21, E32, E43, E44, E51, E52, F41

1 Introduction

Global imbalance increased significantly after the Global Financial Crisis (GFC). This led the International Monetary Fund (IMF) to change its institutional view on capital control, and announced that it now considered capital control an appropriate instrument for achieving financial and macroeconomic stability (IMF, 2011, 2012). As IMF (2012) stated, "there is no presumption that full liberalization is an appropriate goal for all countries at all times", which makes sense as a one-size-fits-all approach barely works. In March 2022, the IMF updated its institutional view on the liberalization and management of capital flows again (IMF, 2022), giving countries more freedom to use capital control: countries are allowed to use capital control as an instrument for financial and macroeconomic stability, even if there is no surge of capital flows. In the past, capital control is the last resort for managing capital flows and can only be implemented when there is a surge of capital flows.

The post GFC period has been characterised by a rise in emerging markets' use of foreign capital markets to meet their demand for credit. This reliance on foreign credit markets exposes emerging markets to external uncertainties and makes them vulnerable to output losses. It also increases the use of capital controls to deal with this external vulnerability (Fritz and Prates, 2014; Shin, 2014). The deployment of capital controls is usually motivated with reference to their effectiveness in curbing private optimal behaviour that results in socially sub-optimal overborrowing (see e.g., Brunnermeier and Sannikov, 2015).

China, the largest emerging market economy, experienced a significant increase in foreign liabilities since 2008 (see figure 4). In 2017Q3 the outstanding amount of U.S. dollar (USD)-denominated foreign liabilities of Chinese non-financial corporations was more than 5 times larger than in 2010Q1. In contrast, its domestic-currency denominated outstanding international debt has been relatively stable over the same period. While there has been a marked increase in the foreign liabilities in China since the GFC, the supply of foreign direct investment (FDI) from China to advanced countries has been increasing too (see. e.g., Turner, 2013). Due to data limitation, we only show China's outward foreign direct investment (FDI) flows to the United States (U.S.) and Germany in figure 5. The figure shows a significant increase in the outward FDI flows from China to the U.S. and Germany after the GFC. Here, although focusing on outward FDI flows precludes insights on whether China increased its purchases of advanced economy debt securities or equities, it can still serve as a proxy of its demand for advanced economy assets, since such investments reflect a lasting interest and control in an enterprise resident in a foreign country (Buckley et al., 2007).

With the increasing in both capital inflows and outflows, the Chinese regulatory authority is facing extreme challenges in managing its capital flows as it has always been tightly controlling its capital flows (Jeanne, 2012). As pointed out by Engle (2011), capital flows are not necessarily always driven by market fundamentals. Excess flows can be bubbles or waves of optimism and sometimes can be excessive risk-taking by local financial institutions. Capital market distortions caused by excess flows can have spillover effects on the real economy.

This paper tests the efficacy of flow-specific capital controls for China. To do so, we develop an asymmetric two-country dynamic stochastic general equilibrium (DSGE) model with both capital inflows and outflows and credit market heterogeneity. The home economy (China) has comparatively less developed financial markets, whereas the foreign economy (the U.S.) has a higher level of financial market development.[1] The asymmetric model structure facilitates the adoption of an emerging market perspective for China, whilst credit market heterogeneity affords China's switch toward foreign credit markets post GFC.

We opt for the real business cycle (RBC) model and, as in Obstfeld and Rogoff (1995), trade between home and foreign economies occurs exclusively through financial markets.[2] In the model, home country entrepreneurs incur foreign liabilities and financial intermediaries (FIs) accumulate foreign assets. An increase in inflows is defined as an increase in home entrepreneurs' foreign liabilities, whilst an increase in outflows is defined as an increase in

[1]See Edwards (2007), Reinhardt et al. (2013), Eichengreen and Rose (2014), and De Nicolò and Juvenal (2014) for evidence on the comparatively higher level of financial development in advanced economies vis-a-vis emerging markets.

[2]The RBC two-country model framework with trade between home and foreign economies occurs exclusively through financial markets is inspired by Iacoviello and Minetti (2006), where the authors use the model to study international business cycles with domestic and foreign lenders. Similarly, RBC framework with trade between home and foreign economies occurs exclusively through financial markets in a small open economy setup can be found in Minetti and Peng (2013); Liu et al. (2021) .

home FIs' foreign assets. This is in line with the current situation of capital flows in China. FDI inflows are allowed and welcomed to a limit extent, whereas for outflows only selected domestic financial institutions are allowed to invest in foreign equity and bond markets since 2006 (Liu et al., 2021).

The distinction between capital inflows and outflows in the model affords the introduction of flow-specific capital controls by the home regulatory authority that can manage the fluctuations of the capital flows. This is in line with the Chinese authority's stance on capital controls. Since the demand for foreign credit by home borrowers lies at the heart of capital inflow behaviour, the inflow capital control takes the form of a quadratic adjustment cost restriction on foreign borrowing by home borrowers. Since the home regulator has no authority over foreign borrowers, and so cannot impose an outflow capital control on foreign borrowers. Instead, the outflow capital control takes the same form of a quadratic adjustment cost restriction on home FIs' purchases of foreign assets.

In addition to the technology shock as in a standard RBC model analysis, we subject the asymmetric model to negative interest rate shocks that serve to realize the shift toward foreign credit markets. This analysis is consistent with the empirical evidence on the influence of monetary policy on lender risk appetite as depicted in figures 4 and 6. The figures show that this switch toward foreign credit markets occurred during a period where interest rates were comparatively lower in the U.S. Easy monetary conditions in advanced economies facilitate emerging market access to foreign sources of credit. Bruno and Shin (2015) find that decreases in the U.S. Fed policy rate serve to dampen global risk perceptions and stimulate cross-border lending. Rey (2015) proffers further evidence on the influence that advanced economy monetary policy bears on emerging market access to foreign credit, where this influence is predicated on a global financial cycle driven by the stance of U.S. monetary policy.

This paper contributes to the literature on four fronts. First, the capital controls that we study are flow specific, which mimics the Chinese authority's stance on capital controls. They are not modelled as taxes on foreign debt, but rather as quantitative limits on foreign borrowing and lending. Most of previous studies deploy capital controls as a tax on net foreign borrowing. Because households are the only agents that borrow in these models, this approach cannot distinguish between tightening an inflow capital control and easing an outflow capital control. As a result, a tax on capital inflows is simultaneously a subsidy on capital outflows (and vice-versa, see e.g., Korinek, 2011; Bianchi and Mendoza, 2013; Farhi and Werning, 2014). The flow-specific nature of the capital controls studied here implies that each control is imposed on a different agent, affording an analysis of the agent-specific welfare effect of capital controls. This comprises the second contribution of this paper as studies cited above only focus on the social welfare implications of capital controls (see e.g., Jeanne and Korinek, 2010; Bianchi, 2011). Third, to best of our knowledge, this paper is the first of its kind using a theoretical asymmetric two-country DSGE approach to study China's capital control. The last contribution of this paper stems from the fact that, in this analysis, financial frictions fall on both borrowers and lenders. This contribution is synonymous with an investigation into flow-specific capital controls and affords a contrast between capital controls imposed on the real sector to those imposed on the financial sector. In previous studies, the use of a single financial friction prevents such a comparison (Kitano et al., 2016).

We examine the impact of the proposed flow-specific capital controls on inflows, outflows, and business cycle fluctuations by comparing the dynamics of a baseline model where these controls are absent, to one where either the inflow capital control or the outflow capital control is present. This allows us to find out whether a flow-specific capital control attenuates or amplifies the impact of external shocks on capital flows and business cycle fluctuations. Additionally, we evaluate the flow-specific capital controls in terms of welfare. Lastly, for robustness analysis, we compare the proposed flow-specific capital controls with traditional tax-based controls.

The results show that both flow-specific capital controls have a significant attenuation effect on the dynamics of their respective flows. The flow-specific capital controls, however, bear different implications for business cycle fluctuations. The inflow capital control places restrictions on the entrepreneur's balance sheet. In the model, entrepreneurs are able to allocate their collateral among home and foreign credit markets. This also provides a channel through which easier foreign credit market conditions can spill-over to home credit markets. Since the inflow control is imposed on the entrepreneur's balance sheet, it produces a significant attenuation effect on both home and foreign credits. The fact that the inflow control is imposed on the real sector, we see it produces a significant impact not only on the dynamics of home and foreign credits but also on the dynamics of the real economy. The outflow capital control, on the other hand, imposes a direct restriction on the FI's balance sheet, and produces minimal effects on the dynamics of other financial and real variables.

The robustness analysis results show that while the tax-based control on outflows achieves the same objective as the proposed flow-specific control does, it however has tremendous effects on other key financial and macroeconomic variables. Overall, the proposed inflow control outperforms the tax-based control in attenuating the effects of the shock on inflows. Additionally, our findings align with the literature that a tax on capital outflows is simultaneously a subsidy on capital inflows, and vice-versa. However, the proposed flow-specific capital controls don't suffer with this curse.

Based on the consumption equivalent welfare analysis, we find that the proposed inflow capital control enhances social welfare significantly, whereas imposing a tax on inflows has a significant negative impact on social welfare. Compared to the inflow capital control, the proposed outflow capital control only improves social welfare negligibly. This also holds for tax-based capital control, seeing an extremely marginal improvement in social welfare.

The rest of the paper is structured as follows. Section 2 provides the literature review. Sections 3 and 4 present the model framework and the calibration of the model. Section 5 reports the business cycle properties of the baseline model. Section 6 studies the impacts of flow-specific capital controls on business cycles and compares the results with those with tax-based capital controls. Section 7 examines the efficacy of the proposed flow-specific capital controls in mitigating the effects of excess capital flows caused by the easing of foreign credit markets. Section 8 concludes.

2 Literature review

There is a long-standing and inconclusive debate over capital control whether it should be used as a measure for financial and macroeconomic stability (Engle, 2011). For instance, a new strand of theoretical literature suggests that capital control has a positive impact on financial and macroeconomic stability (e.g., Schmitt-Grohe and Uribe, 2012; Farhi and Werning, 2014; Korinek, 2018), while the empirical literature suggests that capital control is not effective in limiting the size of flows (e.g., Forbes, 2007; Forbes et al., 2015; Klein and Shambaugh, 2015). The empirical literature is, however, suffering from a common problem that all empirical macroeconomic policy analyses are facing. That is, most policies are implemented in response to economic conditions, surge in capital flows in this case, and it is impossible to measure what would have happened in the absence of the policy implemented. This paper addresses this weakness of the empirical literature. We develop a structural model and assess the effectiveness of capital control by comparing a baseline model where capital control is absent to one where control is present.

A more recent strand of literature argues that volatile capital flows can create externality on aggregate demand (see e.g., Farhi and Werning, 2016; Korinek and Simsek, 2016; Korinek, 2020). If monetary policy, the instrument of first choice, cannot effectively offset this externality, and other instruments such as exchange rate is not feasible, i.e., exchange rate is fixed, capital control becomes the next desirable policy instrument to lean against overheating and reduce capital flows. Two points are worth noting here. First, on the one hand, when there is a surge in capital inflows, the regulatory authority needs to limit flows into an overheated economy. On the other hand, there needs to be certain measure in place to reduce future outflows which will generate negative demand effects. The flow-specific capital control proposed in this paper is in accordance with this strand of literature and inline with the Chinese authority's stance on capital controls – having tight measures on both inflows and outflows. Second, in July 2005 China's exchange rate regime changed from fixed to managed floating. Even though the trading band of China's currency gradually increased from as low as 0.3% in 2007 to 2% in 2014, and 10% in March 2022, China's exchange rate regime is still not feasible to effectively offset the externality caused by volatile capital flows like free floating exchange rate regime. Moreover, as pointed out by Engle (2011), an efficient foreign exchange market does not necessarily lead to efficient movements in international wages and prices and, hence, cannot completely offset the externality.

This paper is also related to the very limited literature on capital controls for China.[3] The most related one is Liu et al. (2021), where the authors develop a small open economy RBC model with overlapping generations and study optimal capital controls in China.[4] The study considers both inflow and outflow controls in the form of traditional tax-based capital

[3] Prasad and Wei (2007) provide a descriptive analysis of China's capital control on inflows. Similarly, Ma and McCauley (2008) show that China's capital control provided certain degree of short-term monetary autonomy during the fixed exchange rate regime prior to July 2005. Theoretical studies on China's capital control are extremely scarce. We only find two exemptions in the literature. Using a DSGE model Chang et al. (2015) show there is a tradeoff between price stability and the cost of sterilisation in China. The other one is Liu et al. (2021), which we discuss in details in the main text.

[4] The authors use a different term for capital control (in the academic literature) – capital account liberalization which refers to the IMF's institution view.

control, with a special focus on financial distortions due to financial repression in China. That is, compared to private-owned enterprises, state-owned enterprises have the privilege to obtain credit with lower interest rates, despite their relatively lower productivity. There are a few common grounds in our study and theirs. That is, both inflow and outflow controls are considered which is in line with the current capital control policy in China. Second, both studies opt for open economy RBC model. In addition to the key focus, our study differs from theirs from the following perspectives. First, we developed an asymmetric two-country DSGE model to capture that China is the second largest economy in the world. Second, the asymmetric two-country model facilitates that, compared to the U.S. and developed economies in general, China has comparatively less developed financial markets.[5] Last, and most importantly, the flow-specific capital controls proposed in our study mimic the Chinese authority's stance on capital controls.

3 The model

This asymmetric two-country approach places focus on the home economy (China), whilst still affording endogenously determined foreign economy (the U.S.) dynamics. Because foreign financial markets are more developed than their home counterparts, financial intermediation is only explicit in the home economy. This approach is coherent with Mendoza et al. (2009), where differences in financial market development are defined with reference to the enforceability of contracts. In line with Reinhart and Rogoff (2015), we further assume that financial repression is seen as unnecessary in advanced economies, and so, capital controls are only present in the home economy. Eichengreen and Rose (2014) proffer further rationalisation for this structural asymmetry by showing that advanced economies are significantly less likely to implement capital controls than developing countries.

The level of home economy's capital inflows (foreign liabilities) is dependent on the credit ceiling of home borrowers in foreign credit markets, as determined by their foreign credit market collateral constraint. In a similar fashion, the level of capital outflows (foreign assets) owned by the home economy is determined by the collateral constraint of foreign economy borrowers. This demand-side approach of modelling credit access is standard in the literature as it affords dynamic feedback between credit markets and borrowers' wealth (see e.g., Kiyotaki and Moore, 1997; Bernanke et al., 1999).[6]

The world economy is populated by citizens of the home country and citizens of the foreign country (variables with a star). Home country citizens consist of households, entrepreneurs, and FIs. In the foreign country, a comparatively higher level of financial development precludes the need for explicit financial intermediation, and so their citizenship is composed of households/entrepreneurs only. Thus, we liken the home country to the largest emerging market economy, China, and the foreign country to an advanced economy, the U.S. As mentioned previously, trade between home and foreign economies occurs exclusively through financial markets as in Obstfeld and Rogoff (1995).

[5] See section 3 for the detailed structure of the asymmetric two-country model.

[6] Since collateral constraints are imposed on borrowers, they operate on the demand-side of the credit market.

We follow the standard approach, assigning the role of saver to households and that of borrower to entrepreneurs. Home households provide FIs with deposits which are used for credit extension. In comparison, foreign households can extend credit to home entrepreneurs directly. This asymmetric model structure ensures that a spread between home and foreign interest rates exists in equilibrium. This concurs with previous studies that identify country specific factors as important determinants of sovereign interest rate spreads (see e.g., Uribe and Yue, 2006; Bellas and Papaioannou, 2010; Kennedy and Palerm, 2014).

Global risk sharing is imperfect in this asymmetric framework because financial markets are incomplete. Financial market incompleteness results from the presence of collateral constraints in both economies and a capital requirement for home FIs. As noted by Heaton and Lucas (1996) and Corsetti et al. (2008), when financial markets are incomplete, individuals are unable to adequately insure against country specific shocks. Thus, financial frictions in both home and foreign economies retard the efficient transfer of resources between countries such that global risk-sharing is imperfect.

The framework distinguishes between an inflow capital control that directly influences inflows and an outflow capital control that directly influences outflows. For tractability and comparison purposes, we adopt for a quadratic adjustment cost approach of capital control. That is, the regulatory authority imposes quadratic adjustment costs to home entrepreneurs when adjusting their foreign liabilities (capital inflows) and home FIs when adjusting their foreign assets (capital outflows). These adjustment costs are external to individual agents. Each flow-specific capital control can be interpreted as a balance sheet restriction that can feasibly be implemented by the regulatory authority. For comparison purposes, the model nests the tax-based capital controls on inflows and outflows.

3.1 Home households

The representative home household maximizes her lifetime utility

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_h^t \left\{ \log\left(C_t^h\right) + \tau \log\left(1 - N_t\right) \right\}, \tag{1}$$

where β_h gives the home household's discount factor, whilst $\tau > 0$ governs the utility generated by leisure $(1 - N_t)$. Household consumption is denoted by C_t^h.

The maximization of household's utility is restricted by her budget constraint:

$$C_t^h + D_t = W_t N_t + R_{t-1}^d D_{t-1}. \tag{2}$$

Households make use of interest income $(R_{t-1}^d D_{t-1})$ on their deposits (D_t) and labor income $(W_t N_t)$ to finance their consumption.

This setup sees optimal behavior in labor (N_t) and credit markets as given by

$$W_t = \tau \frac{C_t^h}{1 - N_t}, \tag{3}$$

$$1 = m_t^h R_t^d, \tag{4}$$

where $m_t^h \equiv \beta_h \mathbb{E}_t C_t^h / C_{t+1}^h$ gives the home household's stochastic discount factor. The first order condition for labor supply (3) shows that the optimal household wage rate (W_t) is given by the marginal rate of substitution between consumption and leisure. The first order condition for deposits (4) sees the interest rate on deposits to equate to the inverse of the household's stochastic discount factor.

3.2 Home entrepreneurs

The representative home entrepreneur seeks to maximize her lifetime utility as generated by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_e^t \{\log (C_t^e)\}, \tag{5}$$

where β_e denotes entrepreneurs' discount factor and C_t^e gives entrepreneurial consumption.

The budget constraint of entrepreneurs is given by

$$C_t^e + Q_t K_t + R_t^l L_{t-1} + (1+\tau_f) R_{t-1}^F B_{t-1}^F + W_t N_t = Y_t + B_t^F \left(1 - \psi_{f,t}\right) + L_t + Q_t (1-\delta) K_{t-1}. \tag{6}$$

L_t gives loan finance obtained from home FIs, which accrues a gross interest of R_t^l. B_t^F denotes foreign bonds (capital inflows) on which a gross interest of R_t^F is paid. The state-dependency of R_t^l implies that FIs take into the consideration of changing financial market conditions when deciding on bank loan rates, whereas the pre-determinate nature of R_t^F is consistent with the nature of underwritten of bond issuance.[7] Q_t denotes the price of physical capital.[8] Y_t and $W_t N_t$ denote their real income and wage bill from production, respectively.

We assume that the government can impose controls on capital inflows in the form of an adjustment cost $\psi_{f,t}$, where $\psi_{f,t} = \left(\omega_f/2\right)\left(B_t^F/B^F - 1\right)^2$, with $\omega_f \geq 0$.[9] That is, entrepreneurs have to pay an adjustment cost when adjusting the level of their foreign bond issuance. Alternatively, the government can impose taxes on inflows, where $0 \leq \tau_f \leq 1$ is the tax rate.

Domestic production takes a Cobb-Douglas form:

$$Y_t = A_t \left(K_{t-1}\right)^{\alpha} (N_t)^{1-\alpha},$$

where A_t is the home technology shock. α denotes the share of physical capital (K_t) in production and $1-\alpha$ gives that of household labor.

The model's transmission channel comprises the effect of changes in collateral values on home entrepreneurs' credit ceilings. This channel operates through dynamic feedback between credit ceilings and expected collateral values, and is standard in models with collateral constraints à la Kiyotaki and Moore (1997). Here, the home entrepreneur's access to two credit markets requires two collateral constraints:

[7]For the same reason, the return to foreign entrepreneur bonds is also pre-determinate. The same timing assumption can be found in Melnik and Nissim (2003); Iacoviello (2015).

[8]The optimization problem for capital producers is a standard one and can be found in appendix A.

[9]In the paper, a variable without subscript represents its corresponding steady state level.

$$\mathbb{E}_t R^l_{t+1} L_t \leq \mu_h \mathbb{E}_t Q_{t+1} K_t, \tag{7}$$
$$\mathbb{E}_t R^F_t B^F_t \leq \mu_f \mathbb{E}_t Q_{t+1} K_t, \tag{8}$$

where one can interpret $0 < \mu_h < 1$ as reflecting an effective loan-to-value (LTV) regulatory parameter for home borrowing, whereas the effective LTV ratio for foreign borrowing is given by μ_f.[10]

With $m^e_t \equiv \beta_e \mathbb{E}_t C^e_t / C^e_{t+1}$ giving entrepreneurs' stochastic discount factor, λ^H_t denoting the multiplier on constraint (7), and λ^F_t denoting the multiplier on constraint (8), the first order conditions for labor, physical capital, loans and foreign bonds are given by

$$W_t = (1-\alpha) \frac{Y_t}{N_t}, \tag{9}$$
$$Q_t = \mathbb{E}_t m^e_t \left[\alpha \frac{Y_{t+1}}{K_t} + (1-\delta) Q_{t+1} \right] + \mathbb{E}_t Q_{t+1} \left[\mu_h \lambda^H_t + \mu_f \lambda^F_t \right] C^e_t, \tag{10}$$
$$\mathbb{E}_t R^l_{t+1} \left(m^e_t + \lambda^H_t C^e_t \right) = 1, \tag{11}$$
$$R^F_t \left[(1+\tau_f) m^e_t + \lambda^F_t C^e_t \right] = 1 - \left(\psi_{f,t} + \psi^b_{f,t} B^F_t \right), \tag{12}$$

where $\psi^b_{f,t}$ is the derivative of $\psi_{f,t}$ with respect to B^F_t.

The first order condition for labor demand (9) shows that labor is paid its marginal product. Equation (10) indicates that entrepreneurs require the current price of physical capital to reflect the discounted utility benefits that its purchase proffers through relaxing constraints (7) and (8). The optimal conditions for loans (11) and foreign bonds (12) show that utility benefits accrue through higher consumption that debt affords, whilst utility costs result from a tightening of entrepreneurs' collateral constraints (7) and (8).

The home entrepreneur's participation in foreign credit market is motivated by an interest rate differential between home and foreign credit markets. In keeping with the empirical evidence contained in section 1, we desire an equilibrium where foreign interest rates are lower than home interest rates. Through equations (11) and (12) we have that

$$\mathbb{E}_t R^l_{t+1} = \frac{\mathbb{E}_t R^F_{t+1} \left[(1+\tau_f) m^e_t + \lambda^F_t C^e_t \right]}{m^e_t + \lambda^H_t C^e_t} + \frac{\psi_{f,t} + \psi^b_{f,t} B^F_t}{m^e_t + \lambda^H_t C^e_t}. \tag{13}$$

Re-arranging (13), one can show that $R^l > R^F$ in equilibrium is optimal from the home entrepreneur's perspective.[11]

[10] We define $\mu_h = \theta\eta$, where θ is the LTV ratio for the home entrepreneur, and η is the fraction of home entrepreneur collateral allocated to the home credit market. Therefore, the home entrepreneur's effective LTV ratio for foreign borrowing $\mu_f = \theta(1-\eta)$. As long as $\mu_h \neq \mu_f$, an interest rate differential between the returns to home and foreign credits will exist in steady state.

[11] See appendix D for detailed proofs and derivations.

3.3 Home financial intermediaries

The FIs consume their profits and use bank capital and home household deposits to extend credit in home and foreign economies. Home credit extension is in the form of issuing loans to home entrepreneurs, whilst foreign credit extension occurs through purchases of bonds issued by foreign entrepreneurs.

The representative FI seeks to maximize the present value of her expected lifetime utility

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_f^t \left\{ \log \left(C_t^f \right) \right\}, \tag{14}$$

where β_f is the FI's discount factor and C_t^f gives FI consumption. The FI's budget constraint is given by

$$C_t^f + R_{t-1}^d D_{t-1} + L_t + B_t^H \left(1 + \psi_{h,t} \right) = D_t + R_t^l L_{t-1} + (1 - \tau_h) R_{t-1}^H B_{t-1}^H, \tag{15}$$

where B_t^H gives foreign entrepreneur bonds (capital outflows) that are remunerated at a gross interest rate of R_t^H.

Similar to the case of home entrepreneurs, home FIs can be subject to a control on capital outflows either in the form of taxes, where $0 \leq \tau_h \leq 1$ is the tax rate, or in the form of a quadratic adjustment cost on outflows when adjusting their holdings of foreign assets. That is, $\psi_{h,t} = (\omega_h/2) \left(B_t^H / B^H - 1 \right)^2$, where $\omega_h \geq 0$.

A non-trivial role for the FI is ensured by subjecting it to risk-weighted minimum capital requirements. Given FI's balance sheet $L_t + B_t^H = BK_t + D_t$, with BK_t denoting bank capital, formally this capital requirement constraint is given by

$$D_t \leq (1 - \vartheta \varphi_H) L_t + (1 - \vartheta \varphi_F) B_t^H. \tag{16}$$

In equation (16), $0 \leq \vartheta \leq 1$ gives the minimum capital requirement ratio, whilst $0 \leq \varphi_H \leq 1$ and $0 \leq \varphi_F \leq 1$ give risk weights on home and foreign entrepreneur debt, L_t and B_t^H respectively. As long as $\varphi_H \neq \varphi_F$, an interest rate differential between returns to domestic and foreign assets will exist in steady state.

With $m_t^f \equiv \beta_f \mathbb{E}_t C_t^f / C_{t+1}^f$ giving the FI's stochastic discount factor and λ_t^K representing the multiplier on constraint (16), optimal behavior by the FI generates first order conditions for deposits, home loans, and capital outflows:

$$m_t^f R_t^d = 1 - \lambda_t^K C_t^f, \tag{17}$$

$$m_t^f R_{t+1}^l = 1 - \kappa_H \lambda_t^K C_t^f, \tag{18}$$

$$(1 - \tau_h) m_t^f R_t^H = 1 - \kappa_F \lambda_t^K C_t^f + (\psi_{h,t} + \psi_{h,t}^b B_t^H), \tag{19}$$

where $\kappa_H = 1 - \vartheta \varphi_H$, $\kappa_F = 1 - \vartheta \varphi_F$ and $\psi_{h,t}^b$ is the partial derivative of $\psi_{h,t}$ with respect to B_t^H. The first order condition for deposits shows that the FI requires the present value of interest paid on deposits to equal the utility gains it proffers. In a similar fashion, the FI requires the interest rates received on home and foreign entrepreneur debt to equal the utility lost through forgone consumption. Here, equations (17), (18), and (19) show that minimum capital requirements reduce the utility cost associated with purchases of assets and increase the utility cost associated with liabilities.

Using equations (17), (18), and (19) the relevant interest rate spreads are derived as follows:

$$m_t^f(R_{t+1}^l - R_t^d) = (1-\kappa_H)\lambda_t^K C_t^f, \tag{20}$$

$$m_t^f\left[(1-\tau_h)R_t^H - R_t^d\right] = (1-\kappa_F)\lambda_t^K C_t^f + (\psi_{h,t} + \psi_{h,t}^b B_t^H), \tag{21}$$

$$m_t^f\left[\mathbb{E}_t R_{t+1}^l - (1-\tau_h)R_t^H\right] = (\kappa_F - \kappa_H)\lambda_t^K C_t^f - (\psi_{h,t} + \psi_{h,t}^b B_t^H). \tag{22}$$

Equations (20), (21), and (22) show that a precondition to $R^l > R^H > R^d$ is that the FI's capital requirement is binding in equilibrium.[12]

3.4 The foreign economy

As stated in the model preamble, the setup for the foreign economy is asymmetric to that of the home economy. We assume that foreign households/entrepreneurs only purchase home entrepreneur bond (B^F) issued in foreign credit markets and issue debt (B^H) to home FIs.[13] We embed these assumptions by imposing fewer financial frictions on the foreign economy. Specifically, the absence of FIs in the foreign economy precludes the need for a minimum capital requirement as per (16), whilst there is only one collateral constraint for foreign households/entrepreneurs as they only issue debt to home FIs. The asymmetric two-country model developed in this paper nests an assumption that financial development is decreasing in the amount of financial frictions (see e.g., Mendoza et al., 2009). Apart from these asymmetries, the setup for the foreign economy is identical to that of home economy. We, therefore, briefly present the foreign economy problem below.

The representative foreign household/entrepreneur utility function is given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_*^t \left\{\log\left(C_t^*\right)\right\}, \tag{23}$$

and the budget constraint is

$$C_t^* + B_t^F + Q_t^* K_t^* + R_{t-1}^H B_{t-1}^H = Y_t^* + B_t^H + (1-\delta)\, Q_t^* K_{t-1}^* + R_{t-1}^F B_{t-1}^F, \tag{24}$$

where β_* gives the foreign household/entrepreneur discount factor, and C_t^* gives foreign consumption. K_t^* and Q_t^* are the foreign physical capital and its price, respectively.[14]

[12] See appendix D for detailed proofs and derivations. A steady state where $R^l > R^H$ follows from figure (6). Although $R^H > R^d$ is not material to this analysis, it nests the idea that the FI will only be active on foreign credit markets if it is profitable to do so.

[13] For simplicity, as mentioned previously, this assumption is in keeping with a desire to focus on the home economy; however, the qualitative implications of the results remain when foreign households/entrepreneurs can also access credit from foreign credit markets.

[14] Capital producers in the foreign economy face the same optimization problem as that of its home economy counterpart (see appendix A).

In addition to the budget constraint, the foreign household/entrepreneur's maximization problem is subject to a collateral constraint

$$R_t^H B_t^H \le \mu^* \mathbb{E}_t Q_{t+1}^* K_t^*, \tag{25}$$

with μ^* denoting the foreign economy's effective LTV ratio.[15]

Foreign production takes a simplified version of Cobb-Douglas form

$$Y_t^* = A_t^* \left(K_{t-1}^*\right)^{\alpha^*}, \tag{26}$$

where A_t^* is the foreign technology shock.

Under this setup, the foreign household/entrepreneur's first order conditions are given by

$$1 = m_t^* R_t^F, \tag{27}$$

$$Q_t^* = \mathbb{E}_t m_t^* \left[\alpha \frac{Y_{t+1}^*}{K_t^*} + (1-\delta) Q_{t+1}^*\right] + \mu^* \mathbb{E}_t \lambda_t^* Q_{t+1} C_t^*, \tag{28}$$

$$1 = \mathbb{E}_t \left(m_t^* + \lambda_t^* C_t^*\right) R_t^H. \tag{29}$$

In equations (27) to (29), $m_t^* \equiv \beta_* \mathbb{E}_t C_t^* / C_{t+1}^*$ gives the foreign household/entrepreneur's stochastic discount factor, whilst λ_t^* gives the multiplier on constraint (25).

A binding equilibrium collateral constraint in the foreign economy ($\lambda^* > 0$) is ensured by restricting the feasible values for their discount factors:[16]

$$\frac{(1-\tau_h)}{1-\kappa_F(1-\beta_f/\beta_h)} > \frac{\beta_*}{\beta_f}. \tag{30}$$

3.5 Market clearing and the current account

The home and foreign economy aggregate resource constraints are given by

$$\begin{aligned} Y_t &= C_t^h + C_t^e + C_t^f + \left[B_t^H - (1-\tau_h) R_{t-1}^H B_{t-1}^H + (1+\tau_f) R_{t-1}^F B_{t-1}^F - B_t^F\right] \\ &\quad + \psi_{f,t} B_t^F + \psi_{h,t} B_t^H + Q_t I_t \left[1 - \frac{\phi}{2}\left(\frac{I_t}{I} - 1\right)^2\right], \end{aligned} \tag{31}$$

$$\begin{aligned} Y_t^* &= C_t^* + B_t^F - R_{t-1}^F B_{t-1}^F + R_{t-1}^H B_{t-1}^H - B_t^H \\ &\quad + Q_t^* I_t^* \left[1 - \frac{\phi}{2}\left(\frac{I_t^*}{I^*} - 1\right)^2\right]. \end{aligned} \tag{32}$$

As in Obstfeld and Rogoff (1995), equation (31) sees that, in the absence of goods trade, any income in excess of home consumption is transferred abroad through financial trade.

[15] Analogous to the model setup for the home entrepreneur, $\mu^* = \theta^*(1-\eta^*)$, where θ^* is the foreign economy LTV ratio and $1-\eta^*$ is the fraction of foreign entrepreneur debt held by home FIs.

[16] See appendix D for detailed proofs and derivations.

Each country's current account can be defined as the change in its net foreign assets within a period:

$$CA_t = \left(\Delta B_t^H - \Delta B_t^F\right), \tag{33}$$

$$CA_t^* = \Delta B_t^F - \Delta B_t^H, \tag{34}$$

where $\Delta B_t^i = B_t^i - B_{t-1}^i$ for $i = F, H$. Here, the definition of current account is the same as the one in a standard two-country model. That is, $CA_t = -CA_t^*$. Defining the current account of each country as per (33) and (34) implies that, for the home economy, net inflows ($\Delta B_t^F > \Delta B_t^H$) are associated with current account deficits, whilst net outflows ($\Delta B_t^F < \Delta B_t^H$) generate a current account surplus. Current account deficits, therefore, represent a decline in the net foreign asset position of the home country, whilst the opposite occurs under current account surpluses.

4 Calibration

The model is calibrated at quarterly frequency, and table 1 reports the calibrated parameter values. The model is calibrated such that conditions in appendix D are satisfied, and in steady state all collateral constraints (7), (8), (25), and the minimum capital requirement constraint (16) are binding.

Parameters are calibrated so that in steady state interest rate relationships are given by $R^l > R^F > R^H > R^d$. We calibrate $\beta_* < \beta_h$ to generate a spread between the returns on inflows and outflows, so that $R^F > R^H$. In this regard, setting $\beta_* = 0.986$ sees in equilibrium the return on home entrepreneur bonds $R^F = 4.84\%$ per annum, whereas the annual return on outflows is given by $R^H = 4.44\%$. This implies that in foreign credit markets home entrepreneurs pay marginally more than foreign entrepreneurs. Setting $\beta_h = 0.99$ sees home households require a deposit rate of $R^d = 4.04\%$ per annum. With the home entrepreneur's cost of loan finance given by $R^l = 5.96\%$ per annum, this calibration implies that home entrepreneurs face a spread of $R^l - R^F = 1.12\%$ between home and foreign credit markets.

We assume symmetric LTV regulation between the two countries, and in line with Iacoviello and Minetti (2006), set $\theta = \theta^* = 0.8$. We calibrate $\eta = 0.625$ such that 62.5% of home entrepreneur collateral is allocated to home credit market. This is in line with the home bias observed in emerging market economies (see e.g., Burger and Warnock, 2006; Hale et al., 2016). We calibrate $1 - \eta^* = 0.18$ such that in steady state only 18% of foreign entrepreneur debt are held by home FIs. This implies that advanced economies do not borrow heavily from emerging markets like China.

The calibration for ϑ is taken from BIS (2010), whilst the values for $\varphi_H = 1$ and $\varphi_F = 0.2$ are as per the risk weights on AAA and BBB rated corporate debt given in BIS (2006). The resulting κ_H and κ_F are 0.9 and 0.98, respectively. The physical capital output share α is set at 0.33, whilst $\tau = 1.793$ sees households devote more or less a third of their time to labor activities, which is line with the RBC literature. The AR(1) shock persistence parameters in equation 35 are set at 0.9. Lastly, the scaling parameter ν that captures the correlation between home and foreign technology shocks (35) is set at 0.1 as in Backus et al. (1992).

Table 1: Calibration.

Parameter	*Symbol*	*Value*
Home household discount factor	β_h	0.99
Home entrepreneur discount factor	β_e	0.945
Home FI discount factor	β_f	0.945
Household utility to leisure	τ	1.793
Foreign household/entrepreneur discount factor	β_*	0.986
Physical capital output share	α	0.33
Home LTV ratio	θ	0.8
Foreign LTV ratio	θ^*	0.8
Fraction of home entrepreneur collateral allocated to home credit market	η	0.625
Fraction of foreign entrepreneur debt held by home FIs	$1-\eta^*$	0.18
Home FI minimum capital requirement	ϑ	0.1
Risk weight on home entrepreneur loans	φ_H	1
Risk weight on foreign entrepreneur debt (outflows)	φ_F	0.2
Weight on home entrepreneur loans	κ_H	0.9
Weight on foreign entrepreneur debt (outflows)	κ_F	0.98
AR(1) shock persistence parameters	ρ, ρ^*	0.9
Parameter for technology shock spillover	ν	0.1

Optimal policy parameters for both types of capital controls, ω_h, ω_f, τ_h, and τ_f, are derived by assuming the regulatory authority minimizes a loss function (see section 6).

5 Business cycle properties

Before analysing the impact of flow-specific capital controls, in this section we evaluate the business cycle properties of the model by comparing the second moments of the model to that of the data.[17]

The model moments are generated following a 1% positive productivity shock in the home country with technological spill-over as in Backus et al. (1992). Additionally, here we consider the baseline model in which both types of capital controls are shut down. As for the data we take natural logarithm of each series (with the exception of the interest rates and the ratio of current account to GDP (CA/GDP), and transform all aggregate variables into real per capita terms. All series are HP filtered.[18]

Exogenous technological processes in each country are as follows:

$$\begin{bmatrix} log(A_t) \\ log(A_t^*) \end{bmatrix} = \begin{bmatrix} \rho & \nu \times \rho_* \\ \nu \times \rho & \rho_* \end{bmatrix} \begin{bmatrix} log(A_{t-1}) \\ log(A_{t-1}^*) \end{bmatrix} + \begin{bmatrix} \varepsilon_t^A \\ \varepsilon_t^{A^*} \end{bmatrix}. \tag{35}$$

$\varepsilon_t^A \sim N(0, \sigma_A^2)$ gives the home technology shock whilst $\varepsilon_t^{A^*} \sim N(0, \sigma_{A^*}^2)$ gives that of the foreign country. This specification allows for technological spill-over between countries through

[17]We follow Schmitt-Grohé and Uribe (2007) and solve the model using second approximation.

[18]See appendix B for data source details.

the scaling parameter $\nu < 1$. We incorporate this feature to realize positive cross-country output correlations as per the international business cycle literature. We follow Backus et al. (1992) and Iacoviello and Minetti (2006) and set the value for this parameter at $\nu = 0.1$ such that, for example, $\nu \times \rho = 0.09$.

Table 2 reports the standard deviations of the key variables and their correlations with output. Standard deviations are expressed in terms of the ratio to that of output (except for output itself). Overall, the model does a fairly good job in reproducing the second moments that observed in the data. The standard deviation of output generated from the model, 1.61%, is close to that of the data, 2.08%. Moreover, the model is able to mimic most of key variables' standard deviations (relative to that of output). For instance, the standard deviation of consumption relative to that of output generated from the model is 1.21, which is close to that observed from the data (1.54). Using an 11-EME sample, Uribe and Schmitt-Grohe (2017) report the average ratio of 1.23 for the standard deviation of consumption relative to that of output.[19] Our model, however, does not reproduce the extremely volatile capital inflows that observed from the data.

The data reveals relative low correlation of consumption with output, 0.6, which is commonly found in EMEs. For instance, Uribe and Schmitt-Grohe (2017) find, on average, the correlation of consumption with output is 0.82 for developed countries, 0.68 for EMEs, and 0.53 for poor countries. Our model is able to mimic not only the observed low correlation of consumption with output, but also the correlations of bank loans, capital outflows, CA/GDP, and the return to capital outflows (R^H) with output. The model, however, overestimates the correlations of capital inflows and the return to capital inflows (R^F) with output. The positive correlation between output and capital inflows concurs with the notion that the dynamics of EME foreign debt are underpinned by economic fundamentals (Forbes and Warnock, 2012; Ahmed and Zlate, 2014). The positive co-movements among bank loans, capital inflows, capital outflows and output are in line with international credit cycle facts described in Rey (2015). The model's ability to match most of the second moments seen in the data implies that it provides a reasonably sound framework to assess the implications of the flow-specific capital controls.

6 The impacts of flow-specific capital controls: The proposed vs. Tax-based

This section presents the main findings of the study. We assume the regulatory authority minimizes the loss function:

$$L = \lambda \sigma_Y^2 + (1-\lambda)\sigma_{CF}^2, \quad \lambda \in [0,1], \tag{36}$$

where σ_Y^2 and σ_{CF}^2 are the variance of output and capital flows, respectively.[20] λ measures the relative weight of the variance of output, whereas $1-\lambda$ measures the relative weight of

[19] See table 1.3 in Uribe and Schmitt-Grohe (2017).

[20] Given the focus of the study, we consider output and capital flows in the loss function. Capital flows are defined as the sum of outflows and inflows.

Table 2: Business cycle properties.

Variable	Standard deviations		Correlation with output	
	Data	Model	Data	Model
Output	2.0800	1.6124	1.0000	1.0000
Consumption	1.54	1.2116	0.6000	0.9069
Loans	1.2283	2.4463	0.1780	0.7605
Inflows	18.5948	0.6236	-0.2508	0.3007
Outflows	4.0085	2.2218	0.5963	0.5969
CA/GDP	0.8344	0.6098	0.0064	-0.5567
R^H	0.2572	0.2692	0.2229	0.523
R^F	0.3465	0.3951	-0.2413	0.7135

the variance of capital flows, respectively. Assuming an equal weight of output and capital flows in the loss function ($\lambda = 0.5$), we compute the set of optimal policy parameter values that yield the lowest loss function value following a specific shock. The resulting optimal policy parameter values are $\tau_f = 0.11$ for the tax rate on outflow, $\tau_h = 0.63$ for tax rate on inflow, $\omega_f = 19.90$ for the proposed outflow control, and $\omega_h = 20.20$ for the proposed inflow control, respectively. Results presented in this section are based on the obtained optimal policy parameter values. To evaluate the robustness of the proposed flow-specific controls, we compare the results with the same obtained from the model with tax-based capital controls.

6.1 Technology shock

Figure 1 presents the impulse response functions (IRFs) of the key macroeconomic variables following a positive technology shock. As shown in the figure, the shock has positive effects not only on macroeconomic aggregates, such as consumption and physical capital, but also on bank loans, capital inflows and outflows.

The technology shock has a significant positive effect on both inflows and outflows and both types of controls significantly mitigate this effect. Compared to tax-based control, the proposed inflow control shows a much stronger and significant attenuation effect. On the other hand, the attenuation effects of both proposed outflow control and taxes on outflow are more or less the same. While both the proposed inflow control and taxed on inflow almost have no impact on outflow, both types of outflow controls exacerbate the effects of the shock on inflows, with the proposed outflow control being more significant.

A positive technology shock does not only increase inflows as home entrepreneurs' demand for foreign liabilities increases following the shock, but also increases bank loans. That is, entrepreneurs use both foreign and domestic funding to finance the increased production. Although both types of outflow controls significantly reduce the increases in outflows, which spares more net liabilities for FIs to extend more loans, increases in FIs loans are negligible when outflow controls are in place. This sees a significant increase in bank consumption, especially with the proposed flow-specific control. In contrast, inflow controls seem to be able to significantly mitigate the positive effect of the shock on bank loans, with the proposed flow-specific control outperforming the tax-based control.

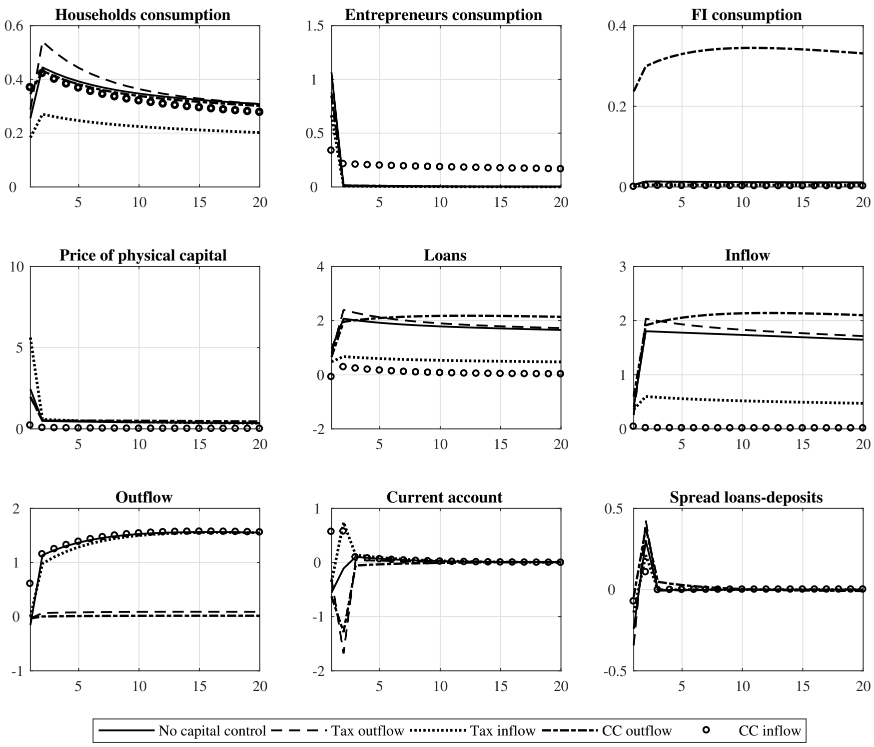

Figure 1: IRFs: Proposed vs. tax-based capital control, following a positive shock.

The proposed flow-specific controls have different effects on individual agent's consumption. For households, the proposed flow-specific controls have no significant effects on household consumption, following the technology shock. This is ideal since temporary controls on capital flows should have little effects on macroeconomic aggregates (Klein, 2012). However, taxes on inflows mitigate the positive effect of the shock on household consumption, whereas taxes on outflows exacerbate the effects of the shock. For entrepreneurs, only the proposed inflow control exacerbates the effect of the shock. For FIs, the shock has a minimal effect on FI consumption, whilst only the proposed outflow control exacerbates the effect of the shock.

Lastly, the technology shock decreases the current account, whereas both types of inflow controls offset the negative effect of the shock, and both types of outflow controls exacerbate the negative effect of the shock on the current account. The shock produces a contemporary positive effect on the spread between bank loans and deposits, while neither the proposed capital controls nor taxes on capital flows play a significant role in shaping the dynamics of the spread.

6.2 Welfare

As we have seen in section 6.1, while the technology shock has significant effects on the dynamics of individual agents' consumption, the flow-specific capital controls affect individual agents' consumption differently. In this section we investigate the welfare implication of the flow-specific capital controls.[21]

Following Rubio and Carrasco-Gallego (2014), we define household, entrepreneur, and FI welfare as follows:

$$W_{i,t}^{h} = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_h^t \left\{ \log\left(C_t^h\right) + \tau \log\left(1 - N_t\right) \right\}, \tag{37}$$

$$W_{i,t}^{e} = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_e^t \left\{ \log\left(C_t^e\right) \right\}, \tag{38}$$

$$W_{i,t}^{f} = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_f^t \left\{ \log\left(C_t^f\right) \right\}, \tag{39}$$

where i represents a specific capital control that is in place.

Accordingly, we define social welfare as a weighted sum of individual agents' welfare, where each agent's welfare is weighted by its own discount factor:

$$W_{i,t}^{sw} = \left(1 - \beta_h\right) W_{i,t}^{h} + \left(1 - \beta_e\right) W_{i,t}^{e} + \left(1 - \beta_f\right) W_{i,t}^{f}. \tag{40}$$

We then compute the welfare gain or loss in consumption equivalent measure (Lucas, 1987) when a specific capital control is implemented:

$$CE_{i,t}^{j} = \exp\left(\left(1 - \beta^j\right)\left(W_{i,t}^{j} - W_{*,t}^{j}\right)\right) - 1, \quad j \in \{h, e, f\}, \tag{41}$$

where $W_{*,t}$ is the welfare when there is no capital control in place. A positive (negative) value of $CE_{i,t}$ implies a welfare gain (loss) in consumption equivalent measure when implementing the flow-specific capital control relative to the scenario where there is no capital control.

Table 3 reports the consumption equivalent welfare gain (loss) from the proposed flow-specific capital controls and tax-based controls following a positive technology shock. The results show that both flow-specific capital controls are welfare-enhancing, with the inflow control being much more significant than the outflow control. This is mainly due to the improvement of home entrepreneurs' welfare when the proposed inflow control is implemented. As discussed in section 6.1, even though the inflow control has a negative impact on both household and FI consumption, this negative impact is, however, much smaller than the exacerbation of the increase in entrepreneur consumption. This results in a significant welfare gain for entrepreneurs. Compared to the inflow capital control, the outflow capital control only improves social welfare negligibly. This also holds for tax-based capital control, seeing an extremely marginal improvement in social welfare. Imposing a tax on inflows, however, has a significant negative impact on entrepreneur's welfare and, hence, the social welfare. This contrasts to the proposed inflow capital control.

[21] We compute welfare using the second-order approximation solution of the model, following the technology shock.

Lipinska and De Paoli (2013) develop a two-country RBC model and show that capital controls can be welfare improving for home economy, not necessarily for the global economy as a whole, as capital controls limit cross-border pooling of risk. In this paper, we focus on home economy, suggesting that the proposed inflow control outperforms tax-based inflow control in terms of welfare.

Table 3: Welfare gain/loss.

	Tax outflow	CC outflow	Tax inflow	CC inflow
Households	0	0	-0.00053	-0.00043
Entrepreneurs	0.00924	0.00022	-0.10808	0.14190
Financial intermediaries	-0.00016	0	-0.00070	-0.00251
Social welfare	0.00901	0.00024	-0.10918	0.13854

7 Flow-specific interest rate shocks

Each flow-specific capital control can be interpreted as a balance sheet restriction that can feasibly be implemented by the home regulatory authority. The flow-specific capital controls constrain the ability of home agents to manage the composition of their balance sheets, aiming to minimize the home economy's exposure to foreign credit markets. In the case of the outflow control, the balance sheet restriction is imposed on the home FI, whilst the inflow control is imposed on the home entrepreneur's balance sheet.

We subject the model to negative foreign interest rate shocks to mimic easing conditions in advanced economy credit markets. This easing of foreign credit market conditions raises the demand for inflows and outflows following their respective shocks. Medina and Roldos (2018) conduct similar analysis, examining a negative foreign interest rate shock that mimics the easing of global credit markets since the GFC. From the home country's perspective, R_t^F represents the gross return to capital inflows, whilst R_t^H gives the gross interest rate earned on capital outflows. This association between interest rates and capital flows affords the introduction of flow-specific interest rate shocks as per ε_t^F and ε_t^H below:

$$\log(R_t^F) = (1-\rho)\log(R^F) + \rho\log(R_{t-1}^F) - \varepsilon_t^F, \tag{42}$$

$$\log(R_t^H) = (1-\rho)\log(R^H) + \rho\log(R_{t-1}^H) - \varepsilon_t^H. \tag{43}$$

The specification of (42) and (43) assumes that each interest rate can be described as an AR(1) process where ρ governs the persistence of each process. $\varepsilon_t^F \sim N(0, \sigma_{F,t}^2)$ and $\varepsilon_t^H \sim N(0, \sigma_{H,t}^2)$ give flow-specific interest rate shocks.[22]

[22]For simplicity, we shock the two interest rates directly in our empirical analysis. Formally, one can set up the interest rate shocks as follows: introduce a foreign monetary policy rate, the Fed fund rate, which is exogenous and following an AR(1) process; then assume there is a spread between the foreign monetary

We subject the model to an inflow interest rate shock (ε_t^F) when looking at the impact of the inflow capital control, and to an outflow interest rate shock (ε_t^H) when looking at the outflow capital control. This allows us to focus on the agent most affected by the flow-specific capital control.

7.1 Outflow interest rate shock

Figure 2 compares the IRFs of the key variables obtained under the baseline where there is no capital control (solid line), and cases with the proposed outflow capital control (dotted line) and the tax-based capital control on outflow (dashed line). It is clear that the shock produces a contractionary effect on the home economy through the FI's balance sheet channel and the borrower's collateral constraint. The decrease in the outflow interest rate makes capital outflows more attractive to foreign borrowers. Through the collateral constraint channel, the shock leads to higher demand for capital outflows. FI consumption decreases due to the increasing holdings of foreign assets. This, in turn, reduces the capacity of FI's home credit extension – seeing decreases in bank loans. The decrease in bank loans is also partially due to the initial decline in the spread between the bank loan rate and the deposit rate following the shock. On the demand side of bank loans, the decrease in the price of physical capital reduces the collateral value. Dynamic feedback through the collateral value channel realizes a contraction in home entrepreneur loans. Through the same channel, the shock reduces the demand for foreign credit – seeing decreases in capital inflows. Current account increases due to the increase in capital outflows and the decrease in capital inflows. The contractionary effect of the shock on the real economy is reflected by the decline in both household and entrepreneur consumption. Entrepreneurs can borrow less from both domestic and foreign credit markets, which causes production to decrease.

The implementation of the proposed outflow capital control attenuates the increase of capital outflows. The adjustment-cost approach of outflow control imposes a direct restriction on FI's balance sheet and foreign assets (outflows), whilst it produces minimal effects on other financial and real variables. With the proposed outflow control in place, the share of outflows on the FI's balance sheet is significantly smaller than that under the baseline case where outflows occupy a larger share of the balance sheet. Thus, a tighter outflow control reduces home economy's exposure to foreign assets. This, however, does not result in an increase in the supply of home credit – a tighter outflow control merely alter the impact of shock on bank loans. This indicates that, when capital control is imposed on the financial sector, the flow-specific control is ideal for the home country authority to mitigate the impact of foreign interest rate shock on the specific capital flows, and has minimal spillover effects on the rest of the economy. This, once again, aligns with Klein (2012)'s argument that capital controls should not have a significant effect on the dynamics of macroeconomic aggregates. The only visible impact of the outflow control on other variables is the exacerbation of the decline of household consumption.[23]

policy rate and the returns to inflows and outflows as in Uribe and Yue (2006); Uribe and Schmitt-Grohe (2017). Spreads can be calibrated using the relevant data; last, shock the foreign policy rate, which serves the same purpose as what we do in our study. Technically, the quality of the results will remain unchanged.

[23]This is due to the further decline in wage rate after implementing the outflow control. For the sake of

While the tax-based control on outflows achieves the same objective as the proposed flow-specific control does – significantly attenuating the increase of capital outflows, it however has tremendous effects on other key financial and macroeconomic variables. As shown in the figure, it nearly eliminates the effects of the negative outflow interest rate shock completely, resulting in no visible dynamic movements in the variables. It is also worth noting that while taxes on outflows significantly attenuate the increases in outflows, at the same time, this type of control also eliminates the decreases in inflow. This is consistent with the argument in the literature that a tax on capital outflows is simultaneously a subsidy on capital inflows (and vice-versa, see e.g., Korinek, 2011; Bianchi and Mendoza, 2013; Farhi and Werning, 2014).

This strong effect of taxes on outflows is largely due to the obtained significantly high optimal tax rate, $\tau_h = 0.63$, whereas the optimal tax rate on inflows is significantly lower, $\tau_f = 0.11$. As mentioned previously, for comparison purposes we assume the regulatory authority minimizes a loss function and obtain the optimal policy parameter values for both types of capital controls. In practice, it is unlikely a regulatory authority would impose such a high tax rate on capital flows. Nonetheless, the quality of the results with the tax-based control on outflows will remain the same, should a lower tax rate is imposed.

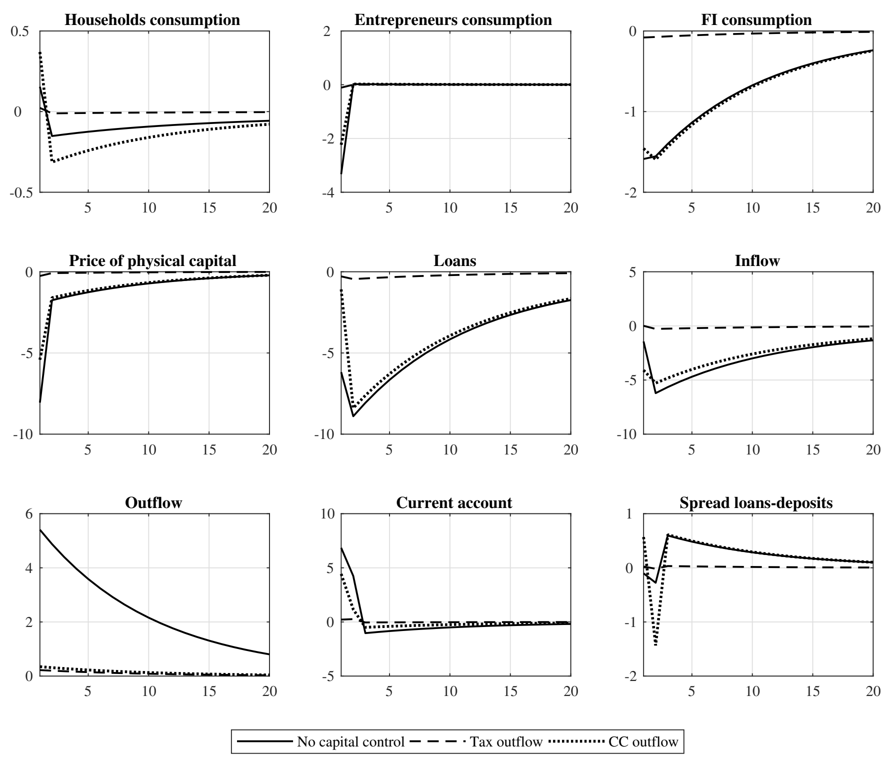

Figure 2: Outflow control: Proposed vs. tax-based capital control, following a negative outflow interest rate shock.

space we do not include the dynamics of wage rate in the figure.

7.2 Inflow interest rate shock

Whilst the outflow control places restrictions on the FI's balance sheet, the inflow capital control places focus on home entrepreneur's balance sheet. The inflow capital control reduces entrepreneur's exposure to external shocks by restricting its ability of exploiting easier foreign credit market conditions. Figure 3 shows the IRFs of the key variables following a negative inflow interest rate shock. Contrast to the outflow interest rate shock, a negative inflow interest rate shock produces an expansionary effect on the home economy (solid line). This expansionary effect also works through the FI's balance sheet channel and the borrower's collateral constraint channel. A decrease in the inflow interest rate makes foreign credit more attractive to home entrepreneur, seeing a significant increase in capital inflows. The shock also has a positive impact on the price of physical capital. This increases home entrepreneur's collateral value, and allows home entrepreneur to borrow more from the home credit market too. This produces a positive effect on production, and also increases all agents' consumption. The increase in bank loans is also due to increases in the spread between the loan rate and the deposit rate. The significant increase in bank loans also results in a decline in FI's foreign assets (outflows). Current account decreases due to the increase in capital inflows and the decrease in capital outflows. These findings are consistent with those in Medina and Roldos (2018), in which the authors examine the effects of a negative foreign interest rate shock on the domestic economy and capital flows.

As shown in figure 3, the proposed inflow capital control (dotted line) attenuates the impact of the shock, and effectively stabilising the financial sector and the real economy. The inflow capital control not only attenuates the increase in capital inflows but also limit the rise in bank loans. As a result, bank loans decrease following the implementation of the control. This aligns Ostry et al. (2012)'s fingdings that inflow controls reduce the financial instability associated with surges in inflows. The shrunken balance sheet significantly reduces the increase of FI consumption and, at the same time, has an adverse effect on foreign entrepreneur access to credit. This can be seen in the figure that the inflow capital control slightly exacerbates the decline in FI's foreign assets (capital outflows), and hence, current account. The attenuation effect of the control is also reflected by the narrowed spread between the bank loan rate and the deposit rate, and the mitigated increase in household consumption. This implies that the attenuation effect of the proposed inflow control comes at the costs of losses of household consumption. Additionally, what is different from outflow control is that when capital control is imposed on the real sector, the flow-specific control has significant spillover effects on both financial and real variables.

Overall, the proposed inflow control outperforms the tax-based control in attenuating the effects of the shock on inflows. This is also true for other variables, except for entrepreneur consumption, whereas taxes on inflows reduce the expansionary effect of the shock on all agents' consumption.

8 Conclusion

This paper investigates the effectiveness of capital controls as a means to curb the increase in capital flows that accompanied the post-2008 low interest rate environment in China.

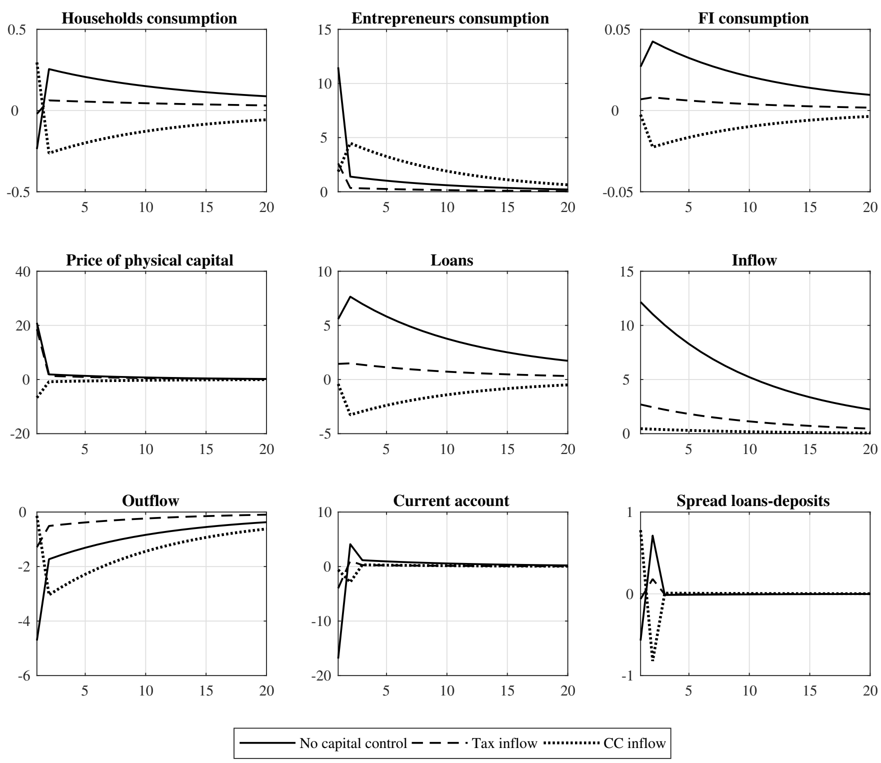

Figure 3: Inflow control: Proposed vs. tax-based capital control, following a negative inflow interest rate shock.

We develop an asymmetric two-country model with flow-specific capital controls and credit market heterogeneity. We contrast an inflow capital control, which is imposed on the real sector, to an outflow capital control which is imposed on the financial sector. Each flow-specific capital control can be interpreted as a balance sheet restriction that can feasibly be implemented by the regulatory authority. This model design mimics the Chinese regulatory authority's stance on capital controls.

We find that both inflow and outflow capital controls are able to attenuate the dynamics of their respective flows, but each control bears different implications for business cycle fluctuations. Whilst the inflow capital control produces a significant impact not only on the dynamics of home and foreign credits but also on the dynamics of the real economy, the outflow capital control produces minimal effects on the dynamics of other financial and real variables. The proposed inflow capital control enhances social welfare significantly, whereas imposing a tax on inflows has a significant negative impact on social welfare.

Given the focus of this paper is on the ability of capital controls to manage capital flows, the framework deployed in this analysis abstracts from nominal rigidities and the ability of monetary policy and foreign reserve accumulation to address such concerns. We leave the introduction of these features for future research.

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Appendix

A Capital producers in home and foreign economies

Physical capital production in both home and foreign economies is the same. The law of motion for physical capital accumulation is give by:

$$K_t = I_t \left[1 - \frac{\phi}{2} \left(\frac{I_t}{I} - 1 \right)^2 \right] + (1 - \delta) K_{t-1}, \tag{44}$$

where $\delta \in (0, 1)$ is the depreciation rate of physical capital, and $\phi \in (0, +\infty)$ is the adjustment cost parameter for investment I_t.

The representative capital producer maximizes her period profit

$$\max_{I_t} \quad Q_t I_t \left[1 - \frac{\phi}{2} \left(\frac{I_t}{I} - 1 \right)^2 \right] - I_t,$$

and the resulting first order condition is given by:

$$Q_t = \left[1 - \frac{\phi I_t}{I} \left(\frac{I_t}{I} - 1 \right) - \frac{\phi}{2} \left(\frac{I_t}{I} - 1 \right)^2 \right]^{-1}. \tag{45}$$

B Data sources

B.1 Empirical evidence

The data used in figures 4, 5 and 6 are gathered from the following sources:

- Figure 4
  - Debt securities of non-financial corporations issued in international markets in foreign and domestic currency, all maturities, quarterly data. Source: Bank for International Settlements (BIS) debt securities.
- Figure 5
  - China's outward foreign direct investment (FDI) flows: Outward FDI flows by partner country, annual data. Source: Organization for economic co-operation and development (OECD) data.
- Figure 6
  - Central bank policy rates for China, the United States (U.S.) and Brazil, monthly data. Source: BIS central bank policy rates.

B.2 Business Cycle Properties

The data below are used to generate the business cycle properties in table 2. We take natural logarithm of each series (with the exception of the interest rates and the ratio of current account to GDP), and transform all aggregate variables into real per capita terms. All series are HP filtered. The data sources for relevant model variables are as follows:

- **China (2006Q1 to 2020Q1):**
  - Gross Domestic product deflator: Implicit price deflator for GDP by value added. Name in the database: GDPDeflator. Source: Federal reserve bank of Atlanta, China's macroeconomy time series data.
  - Home country output: Gross domestic product expenditure approach (RMB billion). Name in the database: NominalGDP. Source: Federal reserve bank of Atlanta, China's macroeconomy time series data.
  - Home country aggregate consumption: Household consumption by expenditure (RMB billion). Name in the database: NominalHHC. Source: Federal reserve bank of Atlanta, China's macroeconomy time series data.
  - Home entrepreneurs loans: End-of-quarter financial institution loans outstanding. Name in the database: BankLoansTotal. Source: Federal reserve bank of Atlanta, China's macroeconomy time series data.

– Home entrepreneur foreign bonds (inflow): Non-financial corporations international market debt securities outstanding by nationality and residence in constant foreign currency. Source: BIS.

– Foreign entrepreneur bonds (outflow): Treasury securities in USD. Source: U.S. department of treasury "Major foreign holders of treasury securities".

– Current account to GDP: Current account balance as percentage of GDP. Source: OECD Statistics.

– Foreign interest rate: U.S. 3-Month treasury bill rate, percent, quarterly, not seasonally adjusted (DGS3MO). Source: Federal Reserve Economic Data.

C Observations from the data: China's inflows and outflows

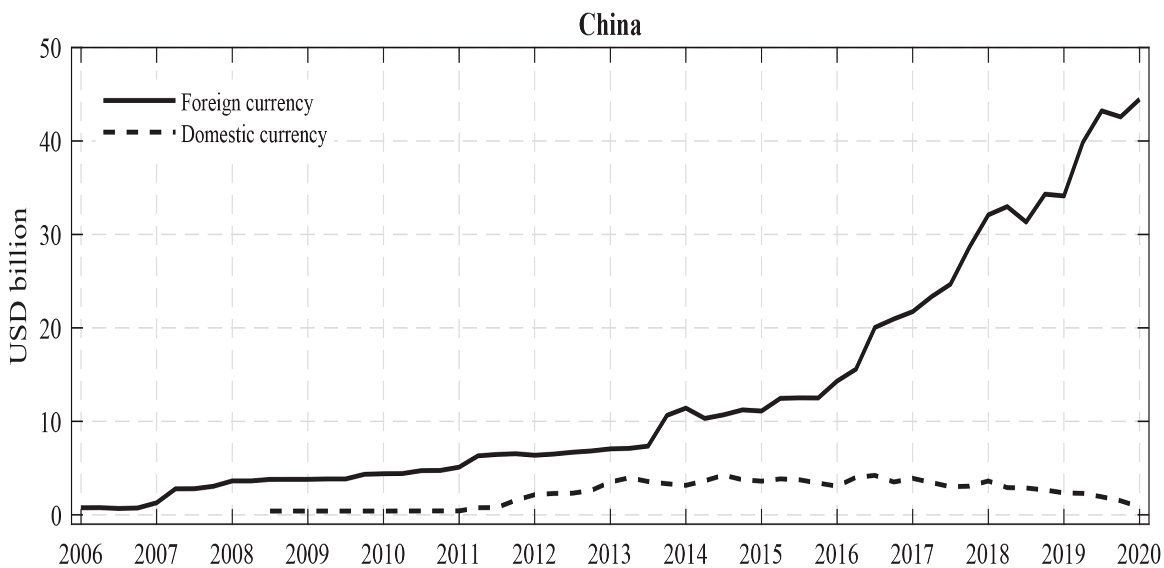

Figure 4: The outstanding international debt of non-financial corporations in foreign currency (solid line) and domestic currency (dotted line) for China. See appendix B for data source details.

D Proofs and derivations

This section provides detailed proofs and derivations of the conditions for constraints to be binding and relationships between the interest rates in equilibrium.

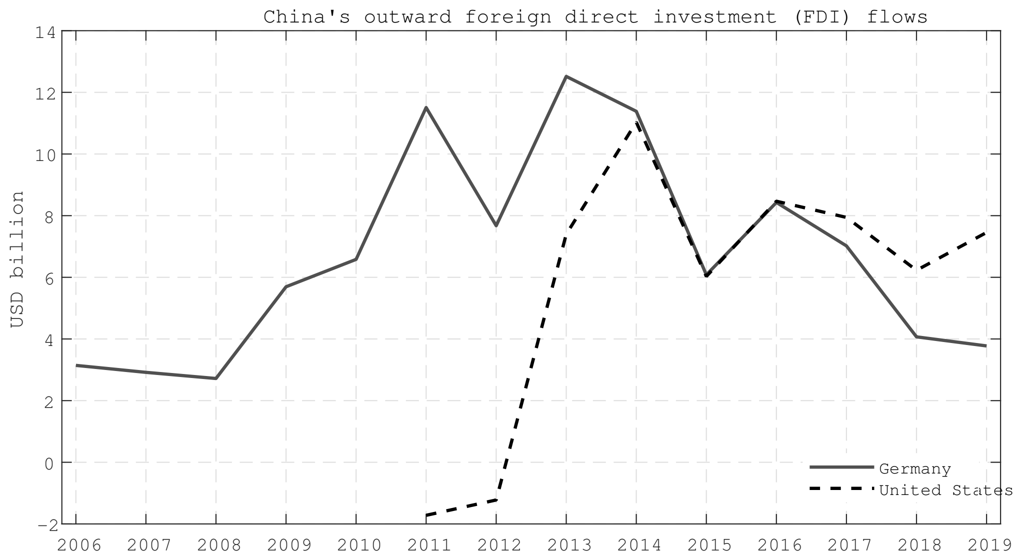

Figure 5: China's outward FDI flows by selected parter countries. See appendix B for data source details.

R^l:

In equilibrium, the gross rate on deposits can be derived from Equation (4):

$$R^d = \frac{1}{\beta_h}. \tag{46}$$

From Equations (17) and (18), we obtain the following conditions:

$$\lambda^K C^f = 1 - \beta_f R^d, \tag{47}$$

$$\beta_f R^l = 1 - \kappa_H \lambda^K C^f. \tag{48}$$

Thus, the gross rate on loans is:

$$R^l = \frac{1 - \kappa_H (1 - \beta_f / \beta_h)}{\beta_f}. \tag{49}$$

R^H:

When the **capital requirement constraint** (16) binds in equilibrium (i.e., $\lambda^K > 0$), we have:

$$\lambda^K C^f = 1 - \beta_f R^d > 0. \tag{50}$$

This holds requires $\beta_h = 1/R^d > \beta_f$, that is FIs is less patient than households. We, therefore, calibrate these two discount factors such that $\beta_h > \beta_f$, along the lines of Iacoviello (2015).

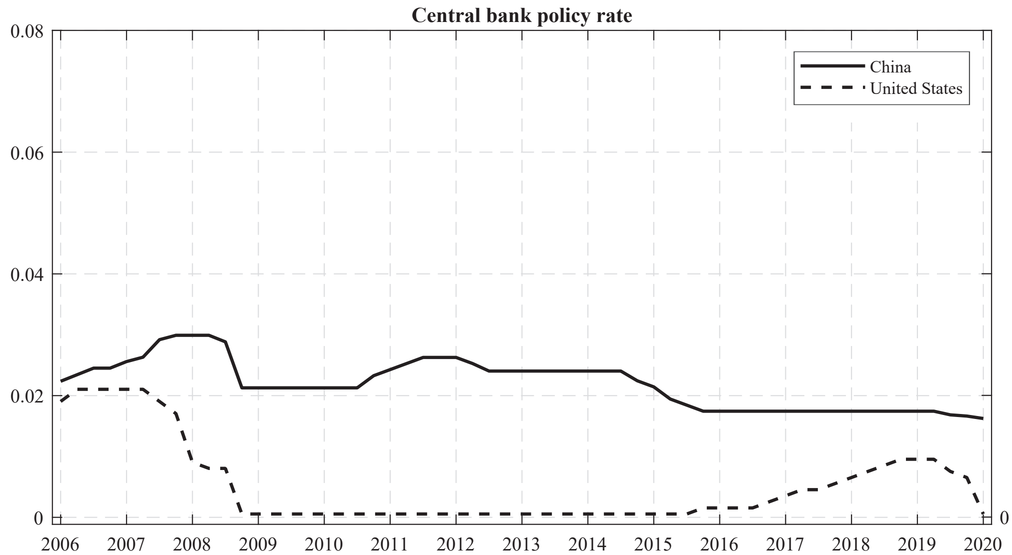

Figure 6: Monetary policy rates in the U.S. and China. See appendix B for data source details.

Similarly, the **collateral constraint** (7) binds in equilibrium ($\lambda^H > 0$) when:

$$\lambda^H C^e = \frac{1}{R^l} - \beta_e > 0. \tag{51}$$

This implies the condition:

$$\frac{\beta_f}{\beta_e} > 1 - \kappa_H(1 - \beta_f/\beta_h), \tag{52}$$

where the right-hand side is positive and less than one. Therefore, there is no strict on β_f and β_e, as long as Equation (52) holds.

Solving for R^H from equation 19, we obtain:

$$R^H = \frac{1 - \kappa_F(1 - \beta_f/\beta_h)}{(1 - \tau_h)\beta_f}. \tag{53}$$

Interest rate spreads:

We can use the equilibrium expressions for R^d, R^l and R^H to determine the structure of the interest rate spreads.

Using Equation (21), we obtain:

$$R^H - R^d = \frac{(1 - \kappa_F)(1 - \beta_f/\beta_h)}{\beta_f} + \tau_h \frac{1 - \kappa_F(1 - \beta_f/\beta_h)}{(1 - \tau_h)\beta_f}. \tag{54}$$

Thus, $R^H > R^d$ when $0 \leq \kappa_F < 1$ and $\beta_f \leq \beta_h$.

The relationship between R^l and R^H from Equation (22) turns

$$R^l - R^H = \frac{(\kappa_F - \kappa_H)\lambda^K C^f}{\beta_f} - \tau_h R^H. \tag{55}$$

Hence, $R^l > R^H$ when $\kappa_F > \kappa_H$ and the following inequality holds:

$$(\kappa_F - \kappa_H)(1 - \beta_f/\beta_h) > \tau_h \frac{1 - \kappa_F(1 - \beta_f/\beta_h)}{(1 - \tau_h)}. \tag{56}$$

To derive the relationship between R^l and R^d, we use Equation (20):

$$R^l - R^d = \frac{(1 - \kappa_H)(1 - \beta_f/\beta_h)}{\beta_f}, \tag{57}$$

from which we see that $R^l > R^d$, when $0 \leq \kappa_H < 1$ and $\beta_h > \beta_f$ (which is the case as explained previously).

From entrepreneurs first order conditions, we obtain a relationship between R^l and R^F. In equilibrium, Equation (13) yields:

$$R^l = \frac{R^F\left[(1+\tau_f)m^e + \lambda^F C^e\right]}{m^e + \lambda^H C^e}. \tag{58}$$

Hence, $R^l > R^F$ holds when: (i) $\lambda^F > \lambda^H$ and $\tau_f \geq 0$, and (ii) when $\lambda^F = \lambda^H$ and $\tau_f > 0$.

In equilibrium, R^F can be obtained from Equation (27):

$$R^F = 1/\beta_*, \tag{59}$$

From the foreign entrepreneurs' first order conditions, we have:

$$R^H = 1/\left(\beta_* + \lambda^* C^*\right). \tag{60}$$

Hence, $R^F > R^H$ when the **foreign collateral constraint** (25) binds (i.e., $\lambda^* > 0$). The binding condition (25) requires:

$$\frac{(1 - \tau_h)}{1 - \kappa_F(1 - \beta_f/\beta_h)} > \frac{\beta_*}{\beta_f}. \tag{61}$$

Since $R^d = 1/\beta_h$ and $R^F = 1/\beta_*$, hence, $R^F > R^d$ when $\beta_h > \beta_*$.

The condition (12) from domestic entrepreneurs holds when $1/R^F > (1 - \tau_f)\beta_e$. Given $R^F = 1/\beta_*$, we have:

$$\beta_*/\beta_e > (1 - \tau_f). \tag{62}$$

Based on the detailed proofs and derivations above, we show that the interest rates in the model satisfy the following ranking: $R^l > R^F > R^H > R^d$.