Flow specific capital controls for emerging markets

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Abstract

This paper investigates the impact of capital controls on business cycle fluctuations and welfare. To perform this analysis, we deploy an asymmetric two country model that is subject to negative foreign interest rate shocks. The results show that both an inflow and outflow capital control are able to attenuate capital flow dynamics, but each control bears different implications for macroeconomic outcomes. Whilst the outflow capital control is associated with shock attenuation benefits, the inflow capital control is shown to amplify the impact of shocks. Easier capital control regimes enhance the attenuation and amplification properties associated with each capital control, whilst strict regimes do the opposite. Lastly, the analysis shows that the welfare effects of capital controls are agent dependent, and that society prefers the outflow capital control to the inflow capital control. Taken together, these results are indicative of the comparative desirability of capital controls imposed on the financial sector (outflows) as compared to the real sector (inflows).

1 Introduction

The post financial crisis period has been characterized by a rise in emerging economies' use of foreign capital markets to meet their demand for credit. Following Al-Saffar et al. (2013) and Catão and Milesi-Ferretti (2014), this reliance on foreign credit markets leaves emerging markets vulnerable to output losses, with support growing for the use of capital controls to deal with this external vulnerability (Fritz and Prates, 2014; Shin, 2014).[1] In this regard, the deployment of capital controls is usually motivated with reference to their effectiveness in curbing privately optimal behaviour that results in socially sub-optimal overborrowing (see e.g., Brunnermeier and Sannikov, 2015). Indeed, emerging markets have a history of capital control deployment to address concerns related to the dynamics of their foreign debt (see e.g., Eichengreen et al., 2007; Forbes et al., 2015). Through restricting participation in international credit markets, capital controls can increase emerging market reliance on domestic sources of credit, limiting their balance sheet vulnerability to foreign shocks (Burger and Warnock, 2006; Hale et al., 2016).

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[1] Al-Saffar et al. (2013) find that emerging market output is more adversely affected by increases in their gross external liabilities than advanced markets. Catão and Milesi-Ferretti (2014) find that the ratio of net foreign liabilities to GDP is a significant crisis predictor. For a discussion on the surge in global liquidity following the financial crisis, see Shin (2014). See Fritz and Prates (2014) for evidence on institutional support for active management of the capital account.

The influence of monetary policy on lender risk appetite indicates that easy monetary conditions in advanced economies facilitated emerging market access to foreign sources of credit. Bruno and Shin (2015) find that reductions in the Fed policy rate serve to dampen global risk perceptions which serves to stimulate cross-border lending. Ahmed and Zlate (2014) show that reductions in risk perception are associated with net capital inflows into emerging markets. Similarly, Forbes and Warnock (2012) find that global risk factors are associated with extreme capital flow episodes. 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.

By plotting the total amount of outstanding international debt securities for non-financial corporations in Brazil and China, figure 1 illustrates the emerging market shift toward foreign credit markets. Since 2008, there has been a marked increase in the foreign liabilities of both countries. The outstanding amount of U.S. dollar (USD) denominated foreign liabilities of Chinese non-financial corporations was more than 5 times bigger in 2016Q3 than in 2010Q1. In Brazil, the USD liabilities of non-financial corporations almost tripled between 2010Q1 and 2016Q3. Although we only report the data for China and Brazil, the same narrative holds for other emerging markets such as India, Russia, and South Africa. Indeed, Shin (2014) finds that the post crisis period has seen a marked increase in emerging market debt issuance on advanced country credit markets. Consistent with the empirical evidence on the influence of monetary policy on lender risk appetite, figure 2 shows that this switch toward foreign credit markets occurred during a period where interest rates were comparatively lower in the U.S. than in emerging markets.

This essay tests the efficacy of capital controls in curbing this shift toward foreign credit markets by comparing the dynamics and welfare implications of models where capital controls are present, to a baseline scenario where no such controls exist. To conduct this analysis, we design an asymmetric two-country framework with flow specific capital controls and credit market heterogeneity. This asymmetric model structure facilitates the adoption of an emerging market perspective whilst credit market heterogeneity affords the post 2008 emerging market switch toward foreign credit markets. In line with figures 1 and 2, this approach places focus on the home economy (emerging markets) whilst still affording endogenously determined foreign economy (advanced countries) dynamics.

We embed the asymmetric model structure by assuming that the home economy is a net international creditor, and that it is characterized by comparatively less developed financial markets. The higher levels of financial market development in advanced economies is well established in the literature, whilst the net international creditor position of the home economy is in accordance with the savings-glut hypothesis put forth by Bernanke (2005)[2]. 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

[2]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.

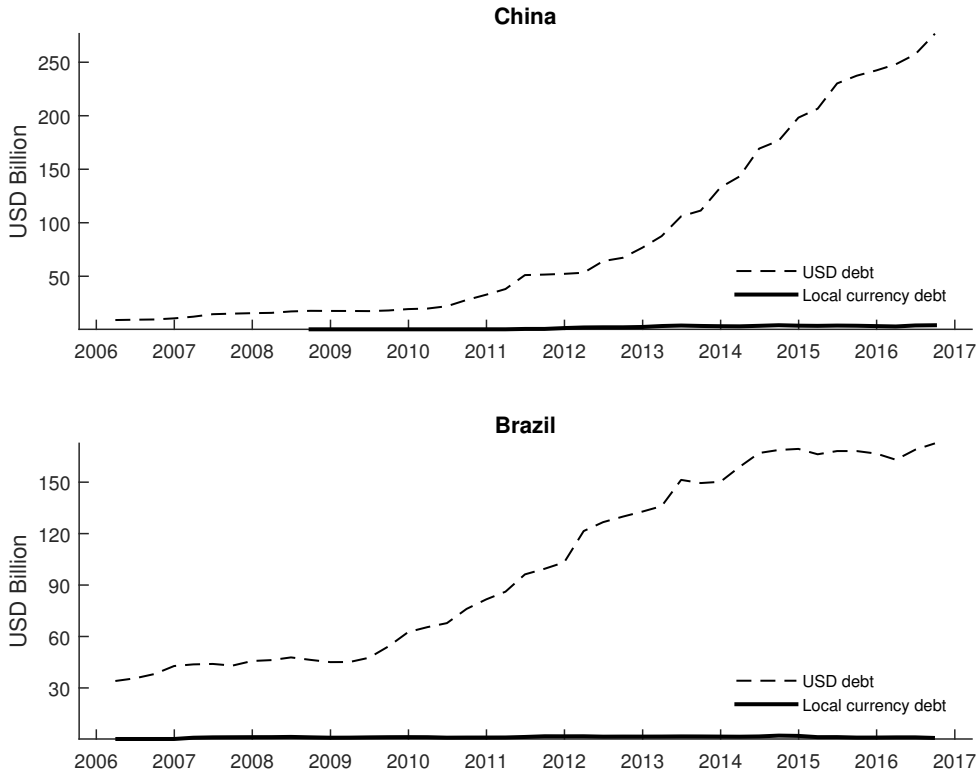

Figure 1: The outstanding international debt of non-financial corporations in USD (dotted line) and local currency (solid line). See appendix B for source details.

home economy[3].

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 emerging market authorities. The inflow capital control is introduced as a variant of the collateral constraints found in Iacoviello and Minetti (2006). This strategy sees the inflow capital control manifested as a restriction on the home entrepreneur's ability to allocate collateral to foreign credit markets. In this way, the inflow capital control exerts direct influence over capital inflows and can serve to increase the prominence of home credit markets on home entrepreneur balance sheets. The outflow capital control is in the spirit of Tobin (1978) and is manifested as a limit on the proportion of foreign assets on the home financial intermediary's (FI) balance sheet. Through this direct influence over capital outflows, the outflow capital control is able to increase the proportion of home credit on FI balance sheets.

This essay contributes to the literature on three fronts. Firstly, the capital controls that we study are flow specific. This implies that they are not modelled as taxes on foreign debt, but rather as quantitative limits on foreign borrowing and lending. Previous studies deployed capital controls as a tax on net foreign

[3]Eichengreen and Rose (2014) proffer further rationalization for this structural asymmetry by showing that advanced economies are significantly less likely to implement capital controls than developing countries. One can vindicate this belief with reference to the superior mobility of capital in advanced as compared to emerging economies and comparatively higher levels of financial development in advanced economies.

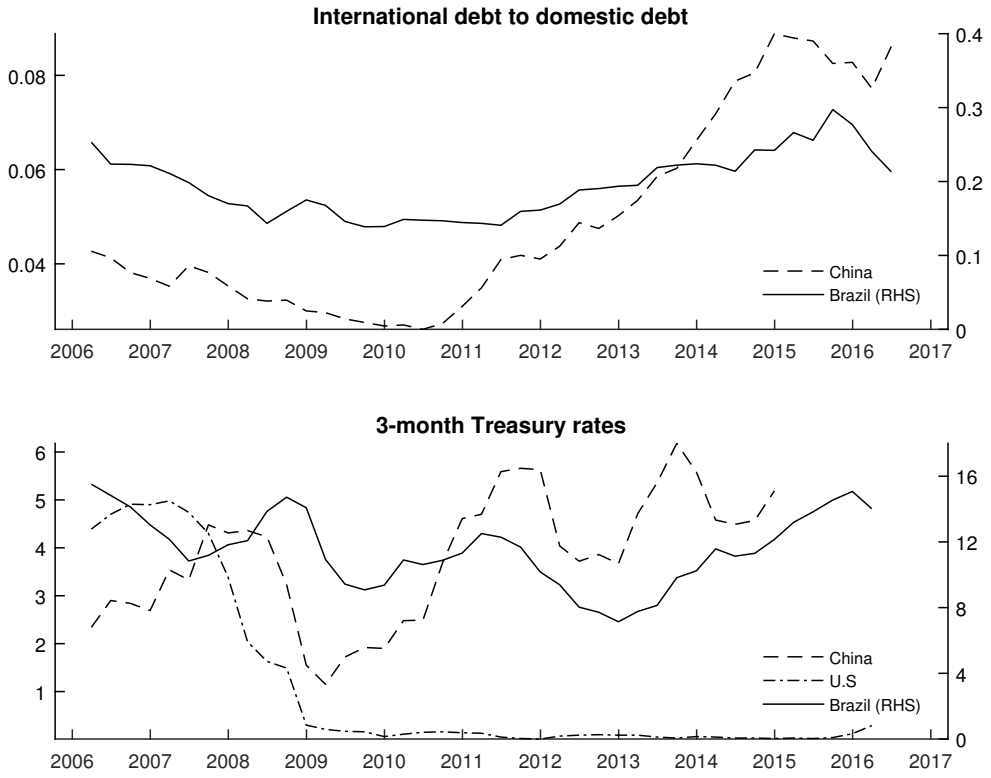

Figure 2: Emerging market international debt to domestic debt ratio and 3-month Treasury rates in advanced and emerging markets. See appendix B for source details.

borrowing, but 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 one is imposed on a different agent, affording an analysis of the agent specific welfare effects of capital controls. This comprises the second contribution of this essay as the studies cited above focus on the social welfare implications of capital controls (see e.g., Jeanne and Korinek, 2010; Bianchi, 2011)). The final 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).

The results show that both the inflow and outflow capital control are effective tools for managing capital flows.[4] However, the inflow capital control bears different implications for business cycle dynamics than the outflow capital control. In this regard, the inflow capital control amplifies the effect of foreign interest

[4]The baseline model (no capital controls) replicates the emerging market shift toward foreign credit markets following a negative foreign interest rate shock, and generates business cycle moments that match the data quite well. Upon introduction of each flow specific capital control, the shift toward foreign credit markets is constrained, resulting in the attenuation of inflows and outflows relative to the baseline.

rate shocks on the business cycle, whilst the outflow capital control attenuates the effect of foreign interest rate shocks. The attenuation property of the outflow capital control and the amplification property of the inflow capital control result from their influence over the entrepreneur's ability to exploit the comparative cheapness of foreign credit markets following the shock. In the framework deployed for this analysis, optimal collateral allocation generates benefits by affording the entrepreneur freedom in exploiting differences in the cost of credit between home and foreign markets. The inflow capital control precludes such behaviour by directly constraining the entrepreneur's ability to allocate collateral to foreign credit markets. As a result, its presence effectively removes the shock absorption properties associated with optimal collateral allocation, resulting in amplified business cycle dynamics relative to the baseline. The outflow capital control does not impart such a direct influence over optimal collateral allocation. Instead, it provides a channel through which easier foreign credit market conditions can spill-over to home credit markets. This spill-over reduces the entrepreneur's incentive to shift toward foreign credit markets, resulting in attenuated business cycle dynamics relative to the baseline.

We test the sensitivity of these findings to changes in the capital control regime, and find that the implications of such changes are capital control dependent. In the case of the inflow capital control, easier regimes serve to increase the entrepreneur's exposure to foreign credit markets, resulting in heightened inflow sensitivity to foreign interest rate shocks. As a result, easier inflow capital control regimes serve to enhance the business cycle amplification property associated with this flow specific capital control. For the outflow capital control, easier regimes serve to increase the FI's exposure to foreign assets, facilitating the spill-over of easier foreign credit market conditions to the home credit market. This implies that easier outflow capital control regimes serve to enhance the business cycle attenuation property of this flow specific capital control.

A comparison of social welfare dynamics under each capital control shows that, although both controls are effective at managing capital flows, society exhibits a strict preference for the outflow capital control over the inflow capital control. This preference results from the attenuation property associated with the outflow capital control, where its introduction improves on baseline social welfare dynamics. In contrast, shock amplification under the inflow capital control culminates in social welfare losses relative to the baseline. Lastly, this analysis indicates that capital controls have agent specific welfare consequences. An easing of foreign credit market conditions is welfare enhancing for entrepreneurs and welfare reducing for FIs. By removing their ability to exploit the cheaper cost of foreign credit, the inflow capital control sees the entrepreneur's welfare gain become a welfare loss. In contrast, the outflow capital control is able to mitigate the welfare loss that FIs associate with foreign interest rate shocks, leading to an improvement in FI welfare dynamics under the outflow capital control.

The rest of the paper is structured as follows. Before commencing with a description of the model setup, section 2 discusses the implications of the asymmetric modelling strategy, focussing on capital flows, capital controls, and negative foreign interest rate shocks. The model framework and calibration are presented in sections 3 and 4. Next, we assess the behaviour of the baseline model without capital controls in section 5. The impact of flow specific capital controls is analyzed in section 6, whilst the welfare effects associated therewith are investigated in section 7. Finally, section 8 concludes.

2 A primer on capital flows, capital controls, and foreign interest rate shocks

The asymmetric nature of the model takes the perspective of an emerging market economy, henceforth termed the home country. As a result of this perspective, capital inflows are reflected as changes to the foreign liabilities of the home country, whilst capital outflows affect its stock of foreign assets. In turn, the difference between the change in capital inflows and the change in capital outflows gives the change in net flows. Thus, net inflows imply that capital inflows were larger than capital outflows whilst the opposite applies for net outflows.

In the model presented here, home country entrepreneurs incur foreign liabilities whilst home country FIs accumulate foreign assets. Thus, an increase in inflows is defined as an increase in the home entrepreneur's foreign liabilities, whilst an increase in outflows is defined as an increase in the home financial intermediary's foreign assets. Analogously, a decrease in inflows is defined as a decrease in the home entrepreneur's foreign liabilities whilst a decrease in outflows is defined as a decrease in the home financial intermediary's foreign assets.

The home economy's level of 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 foreign assets owned by the home economy is determined by the collateral constraint of foreign economy borrowers. This demand-side approach to modelling credit access is standard in the literature as it affords dynamic feedback between credit markets and borrower wealth (see e.g., Kiyotaki and Moore, 1997; Bernanke et al., 1999).[5] As a result, capital inflows are driven by the home economy's demand for foreign credit whereas capital outflows are driven by the foreign economy's demand for credit.

Negative foreign interest rate shocks increase the present value of borrower collateral allocated to foreign credit markets, which leads to higher demand for foreign credit by both home and foreign borrowers. In turn, this increase in demand for foreign credit (by home and foreign borrowers) realizes a simultaneous increase in capital inflows and capital outflows. That is to say, both the foreign liabilities and foreign assets of the home economy increase following a negative foreign interest rate shock. The increase in foreign assets is counter-intuitive, as one would expect home economy accumulation of foreign assets to decline when the return that they offer decreases (see e.g., Cerutti et al., 2017).

Figures 2 and 3 provide some empirical backing for the increase in home economy foreign assets, indicating that emerging market supply of foreign direct investment to advanced countries is relatively insensitive to declines in foreign interest rates. Data limitations on bilateral capital flows restricts our focus to outward foreign direct investment and the 2006-2012 period. Thus, the period covered by figure 3 is shorter than that of figure 2; however it does span implementation of the quantitative easing programs of the Federal Reserve (Eichengreen, 2015; Feyen et al., 2015). Similarly, although focusing on outward foreign direct investment precludes any insights on whether emerging markets increased their purchases of advanced economy debt securities or equities, it can still serve as a proxy of emerging market demand for advanced economy assets

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

since such investments reflect a lasting interest and control in an enterprise resident in a foreign country (Buckley et al., 2007). Nevertheless, this model characteristic cautions against the applicability of this analysis across all emerging markets. Indeed, the empirical evidence indicates that the impact of advanced economy monetary policy varies greatly across emerging markets (see e.g., Eichengreen and Mody, 1998; Arora and Cerisola, 2001; Ferrucci, 2003; Ahmed et al., 2017) .

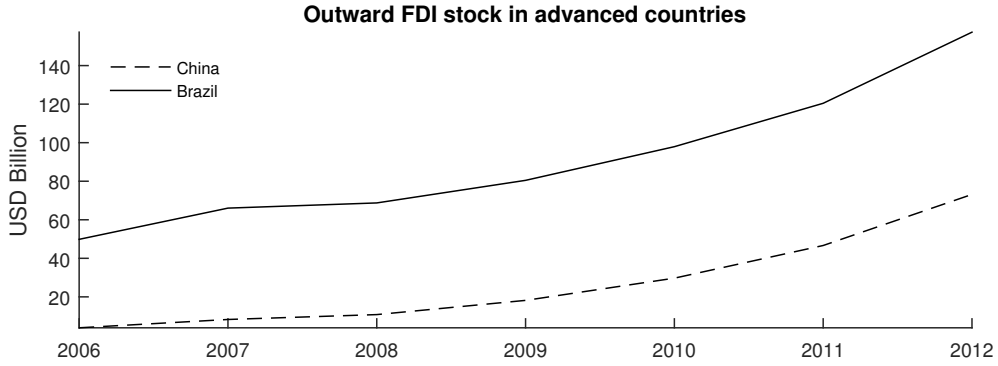

Figure 3: The stock of outward FDI held by emerging markets in developed economies. See appendix B for source details.

The distinction between capital inflows and outflows in the model affords the introduction of flow specific capital controls by home authorities that can reduce the increase in net inflows to the home country. Since demand for foreign credit by home borrowers lies at the heart of capital inflow behaviour, the inflow capital control takes the form of a quantitative restriction on foreign borrowing by these agents (home entrepreneurs). Home regulators have no authority over foreign borrowers, and so cannot impose an outflow capital control on foreign borrowers. Instead, the outflow capital control takes the form of a quantitative restriction on home agent (FI) purchases of foreign assets.

The impact of these flow specific capital controls on inflows, outflows, and the business cycle are assessed 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 are present. This approach is used to indicate whether the capital controls attenuate or amplify the impact of a negative foreign interest rate shock on capital flows and the business cycle.

We test the sensitivity of these findings to changes in capital control regulation when either of the two capital controls are present. Here, we distinguish between baseline, strict, and easy flow specific capital control regimes. For both capital controls, strict regimes reduce the economy's exposure to foreign credit markets – foreign liabilities in the case of the inflow control, foreign assets in the case of the outflow control – relative to the baseline regime, whilst the opposite occurs under the easy regime. This exercise indicates how changes to each capital control influence its attenuation or amplification effects on capital flows and the business cycle.

3 The model

The world economy is populated by citizens of the home country (H) and citizens of the foreign country (F). The home country's 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 and entrepreneurs only. Thus, we liken the home country to an emerging market economy, and the foreign country to an advanced economy.

As in Obstfeld and Rogoff (1995), trade between countries occurs exclusively through financial markets. We follow the standard approach, assigning the role of saver to households and that of borrower to entrepreneurs. Home entrepreneurs have access to the credit markets of both countries whilst foreign entrepreneurs make use of the foreign country's credit market only. Here, the model's asymmetrical structure sees that home households provide FIs with deposits which are used for credit extension. In comparison, foreign households can extend credit to home entrepreneurs directly. This asymmetrical model structure allows for an equilibrium spread between home and foreign interest rates and 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).[6]

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 the home and foreign economy retard the efficient transfer of resources between countries such that global risk-sharing is imperfect.

The model's transmission channel comprises the effect that changes in collateral values have on home entrepreneur credit ceilings. This channel works 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, home entrepreneur access to two credit markets requires two collateral constraints whereas restricting foreign entrepreneurs to foreign credit markets sees that they are only subject to one collateral constraint. The specification for the home entrepreneur's collateral constraints follows Iacoviello and Minetti (2006) and implies that home FIs face constant average liquidation costs whilst those of foreign households are increasing in the value of home entrepreneur collateral. This difference between the liquidation costs faced by home and foreign lenders implies that the dynamic feedback between home collateral values and inflows is less efficient than that between home collateral values and home loans. As a result, lower foreign interest rates are relatively inefficient in realizing virtuous feedback with home collateral values.

Departing from this baseline scenario, we assess the implications of flow specific capital controls that restrict home entrepreneur and FI participation in foreign credit markets. Here, the framework affords distinction between an inflow capital control that imparts direct influence over inflows, and an outflow capital control that directly influences outflows. The flow specific nature of these two instruments implies

[6] The model's asymmetrical structure sees that foreign entrepreneurs can only access credit from the home FI; however the results are insensitive to allowing the foreign household to also extend credit to the foreign entrepreneur.

that introduction of the inflow capital control requires an adjustment to the baseline home entrepreneur optimization problem, whilst the outflow capital control requires an adjustment to the optimization problem of the home FI.

We subject this asymmetric framework to negative foreign interest rate shocks that serve to realize the shift toward foreign credit markets as depicted in figures 1 and 2. These shocks reduce the relative inefficiency of the home entrepreneur's foreign collateral constraint, facilitating the switch toward foreign credit markets.

This framework is presented in the next section, where we differentiate between countries by denoting country F's variables with a star. We first consider a baseline version of the model where no capital controls are present (sections 3.1 – 3.4) and then describe the addition of flow specific capital controls in section 3.5. The full set of model equations can be found in appendix A.

3.1 Home households

The representative home household maximizes its lifetime utility function given by

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

where β_h gives the home household's discount factor, whilst $\tau > 0$ and $j > 0$ are coefficients that govern the utility generated by leisure $(1 - N_t)$ and real estate (H_t^h). Household consumption is denoted by C_t^h.

The maximization of household utility is restricted by their budget constraint as given by

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

The term $q_t(H_t^h - H_{t-1}^h)$ captures real estate purchases by the household where q_t denotes the domestic price of real estate. Households make use of interest income $(R_{t-1}^d D_{t-1})$ on their deposits (D_t) as well as labour income $(W_t N_t)$ to finance their purchases of real estate.

This setup sees optimal behaviour in labour, real estate, and credit markets as given by:

$$q_t = \frac{j C_t^h}{H_t^h} + m_t^h \mathbb{E}_t q_{t+1}, \tag{3}$$

$$W_t = \frac{\tau C_t^h}{1 - N_t}, \tag{4}$$

$$1 = m_t^h R_t^d. \tag{5}$$

where $m_t^h \equiv \frac{\beta_h C_t}{\mathbb{E}_t C_{t+1}^h}$ gives the home household's stochastic discount factor. The first order condition for labour supply (4) shows that the optimal household wage rate is given by the marginal rate of substitution between consumption and leisure. Equation 3 indicates that households require the present value of utility benefits associated with real estate accumulation to equate to the utility lost through postponed consumption.

Lastly, the first order condition for deposits sees the interest rate on deposits to equate to the inverse of the household's stochastic discount factor.

3.2 Home entrepreneurs

Home entrepreneurs seek to maximize their lifetime utility as generated by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_e^t \{\log(C_t^e)\}, \tag{6}$$

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

The budget constraint of entrepreneurs is given by

$$C_t^e + q_t(H_t^e - H_{t-1}^e) + R_t^l L_{t-1} + S_t R_t^H B_{t-1}^H + W_t N_t = Y_t + L_t + S_t B_t^H. \tag{7}$$

L_t gives loan finance obtained from home FIs that accrues state-dependent gross interest of R_t^l, whilst B_t^H denotes foreign capital inflows on which state-dependent gross interest of R_t^H is paid. The real exchange rate (home goods in terms of foreign goods) is given by S_t, and we assume that purchasing power parity holds (i.e. $S = 1$ at the steady state). H_t^e denotes entrepreneurs' stock of real estate whilst Y_t and $W_t N_t$ denote their real income and wage bill from production.

Domestic production takes a Cobb-Douglas form, where labour real estate serve as the factors of production:

$$Y_t = (H_{t-1}^e)^{\alpha} (N_t)^{1-\alpha}. \tag{8}$$

Here, α denotes the share of entrepreneur real estate in production and $1-\alpha$ gives that of household labour.

Entrepreneurs make use of inflows and home loans to finance their use of the factors of production. If entrepreneurs "walk away" from their debt burdens, debt holders have to incur information and transaction costs before being able to sell the pledged collateral. The presence of these costs reduce debt holders' expected return should the issuer "walk away", and create quantitative credit limits that depend on the expected proceeds of collateral sales, net of information and transaction costs (Korinek, 2011).

We assume that information asymmetries exist in these markets such that the collateral liquidation ability of home and foreign lenders differ. Following Iacoviello and Minetti (2006), foreign lenders may have a poorer understanding of home country bankruptcy practices than home lenders, such that they need to hire costly legal expertise in order to obtain ownership of the collateral pledged by home entrepreneurs. Alternatively, Hermalin and Rose (1999) argue that the information acquisition technology of foreign lenders exhibits decreasing returns to scale. Both cases indicate that the expected recovery value of foreign lenders will be lower than that of home lenders. These insights are embedded by making the home lender's transaction and

liquidation costs a linear function of pledged collateral whilst that of foreign lenders is quadratic in nature.[7] Formally, this setup sees the home entrepreneur's credit ceiling in each market as given by:

$$\mathbb{E}_t R^l_{t+1} L_t \leq \mu \Omega_t \mathbb{E}_t q_{t+1} H^e_t, \tag{9}$$

$$S_t \mathbb{E}_t R^H_{t+1} B^H_t \leq (1-\Omega_t)\mathbb{E}_t q_{t+1} H^e_t \left(1 - \frac{1-\mu}{qH^e}\mathbb{E}_t q_{t+1}(1-\Omega_t)H^e_t\right), \tag{10}$$

where one can interpret $0 < \mu < 1$ as reflecting a loan to value regulatory parameter whilst $0 < \Omega_t < 1$ is a choice variable that allows the home entrepreneur to optimally allocate their collateral in each credit market.

With $m^e_t \equiv \frac{\beta_e C^e_t}{\mathbb{E}_t C^e_{t+1}}$ giving entrepreneurs' stochastic discount factor, $\Lambda^H_t \equiv \frac{\lambda^H_t}{C^e_t}$ denoting the multiplier on constraint 9, and $\Lambda^F_t \equiv \frac{\lambda^F_t}{C^e_t}$ denoting the multiplier on constraint 10, the first order conditions for labour, real estate, home loans, and foreign bonds are given by

$$W_t = (1-\alpha)\frac{Y_t}{N_t}, \tag{11}$$

$$q_t = q_{t+1}(\mu\Omega_t\lambda^H_t + \mathbb{E}_t\tilde{\mu}_{t+1}(1-\Omega_t)\lambda^F_t) + m^e_t\left(\mathbb{E}_t q_{t+1} + \frac{\alpha\mathbb{E}_t Y_{t+1}}{H^e_t}\right), \tag{12}$$

$$1 = \mathbb{E}_t R^l_{t+1}(m^e_t + \lambda^H_t), \tag{13}$$

$$1 = \mathbb{E}_t R^H_{t+1}(m^e_t \frac{S_{t+1}}{S_t} + \lambda^F_t), \tag{14}$$

$$\mu\lambda^H_t = \mathbb{E}_t\tilde{\mu}_{t+1}\lambda^F_t. \tag{15}$$

Where $\mathbb{E}_t\tilde{\mu}_{t+1} \equiv 1 - \frac{2(1-\mu)}{qH^e}\mathbb{E}_t q_{t+1}(1-\Omega_t)H^e_t$ gives the marginal productivity of collateral in foreign bond markets.

The first order condition for labour demand (11) shows that labour is paid its marginal product. Equation 12 indicates that entrepreneurs require the current price of real estate to reflect the discounted utility benefits that its purchase proffers through relaxing constraints 9 and 10. Real estate accumulation also delivers utility benefits from the higher consumption that results from asset price growth and increased production. Entrepreneurs' first order conditions for home loans and foreign bonds shows that they require the interest on their debt to equate to the net utility gains associated with debt incursion. Utility benefits accrue through the higher consumption that debt affords whilst utility costs result from a tightening of entrepreneurs' collateral constraints 9 and 10. As per equation 15, optimal collateral allocation requires the multipliers on constraints 9 and 10 to equate the marginal productivity of collateral in each credit market.

The home entrepreneur's participation in foreign credit markets is motivated through 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. Thus, we require $R^l > R^H$ at the steady state. Through equations 13 and 14 we have that

[7] The quadratic specification of the foreign lender's liquidation costs is similar to the financial asset transaction costs used by Heaton and Lucas (1996) and Aiyagari and Gertler (1999).

$$\mathbb{E}_t R^l_{t+1} = \frac{\mathbb{E}_t R^H_{t+1}(m^e_t \frac{\mathbb{E}_t S_{t+1}}{S_t} + \lambda^F_t)}{m^e_t + \lambda^H_t}. \tag{16}$$

Equation 16 is the uncovered interest parity (UIP) condition for home entrepreneurs. Absent the entrepreneur's collateral constraints (i.e. $\lambda^H_t = \lambda^F_t = 0$), (16) reduces to the standard UIP condition where the spread between interest rates is determined by expected exchange rate dynamics.

Re-arranging (16), one can show that $R^l > R^H$ in equilibrium will be optimal from the home entrepreneur's perspective when he is relatively more constrained in foreign credit markets:

$$\lambda^F > \lambda^H. \tag{17}$$

A pre-condition for (17) is that the home entrepreneur's collateral constraints are binding in equilibrium, i.e. $\lambda^H > 0$ and $\lambda^F > 0$, as ensured by conditions 18 and 19:

$$\frac{1}{\beta_e} > \frac{1-\kappa_H}{\beta_f} + \frac{\kappa_H}{\beta_h}, \tag{18}$$

$$\beta_e < \beta_h. \tag{19}$$

Condition 18 is derived using equations 25 and 26, and requiring that $\beta_e R^H < 1$. In a similar fashion, condition 19 results from 41 with the requirement that $\beta_e R^F < 1$. When (17), (18), and (19) hold, it will be the case that the home entrepreneur is both credit constrained in equilibrium and faces lower borrowing costs in foreign credit markets, i.e. $R^l > R^H$.

Taking (15) at the steady state, the equilibrium share of collateral devoted to home credit markets is given as

$$\Omega = \frac{1}{2(1-\mu)}\left(\frac{\mu\lambda^H}{\lambda^F} + 2(1-\mu) - 1\right). \tag{20}$$

Re-arranging (20), it is possible to ensure that the home entrepreneur finds it optimal to be active in both home and foreign credit markets, i.e. $0 < \Omega < 1$, even though $R^l > R^H$:

$$2 - \frac{1}{\mu} < \frac{\lambda^H}{\lambda^F} < \frac{1}{\mu}. \tag{21}$$

When conditions 17, 18, 19, and 21 hold simultaneously, it will be the case that the model's equilibrium sees the home entrepreneur active in both home and foreign credit markets, $0 < \Omega < 1$, even though there is a positive spread between their home and foreign borrowing costs, $R^l > R^H$. These conditions ensure that

the home entrepreneur is borrowing constrained in equilibrium and, even though the interest rate on foreign bonds is lower than that on home loans, is active in the credit markets of both countries.

3.3 Home financial intermediaries

The FI consumes all of its profits and uses a combination of capital and home household deposits to extend credit in the home and foreign economy. Home economy credit extension by the FI consists of issuing loans to the home entrepreneur, whilst foreign economy credit extension occurs through purchases of bonds issued by the foreign entrepreneur.

The FI seeks to maximize the present value of its expected lifetime utility function as per

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_f^t \{log(C_t^f)\}, \tag{22}$$

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

$$C_t^f + L_t + S_t B_t^F + R_{t-1}^d D_{t-1} = D_t + R_t^l L_{t-1} + S_t R_t^F B_{t-1}^F, \tag{23}$$

with B_t^F giving capital outflows that are remunerated at a state dependent gross interest rate of R_t^F. As before, D_t denotes deposits received from the home household on which the FI pays pre-determined gross interest of R_t^d whilst L_t gives loans issued to the home entrepreneur on which state-dependent gross interest of R_t^l is earned.

A non-trivial role for the FI is ensured by subjecting it to risk-weighted minimum capital requirements. With $BK_t = L_t + B_t^F - D_t$ giving FI capital, this requirement can be formally represented as

$$D_t \leq (1 - \vartheta\varphi_H)L_t + (1 - \vartheta\varphi_F)S_t B_t^F. \tag{24}$$

In (24), $0 < \vartheta < 1$ gives the minimum capital requirement whilst $0 < \varphi_H < 1$ and $0 < \varphi_F < 1$ give risk weights on home and foreign entrepreneur debt, respectively.

With $m_t^f \equiv \frac{\beta_f C_t^f}{\mathbb{E}_t C_{t+1}^f}$ giving the FI's stochastic discount factor and $\Lambda_t^K \equiv \frac{\lambda_t^K}{C_t^f}$ representing the multiplier on constraint 24, optimal behavior by the FI generates first order conditions for deposits, home loans, and foreign bonds as per:

$$m_t^F R_t^d = 1 - \lambda_t^K, \tag{25}$$

$$m_t^F \mathbb{E}_t R_{t+1}^l = 1 - \kappa_H \lambda_t^K, \tag{26}$$

$$m_t^F \frac{\mathbb{E}_t S_{t+1}}{S_t} \mathbb{E}_t R_{t+1}^F = 1 - \kappa_F \lambda_t^K. \tag{27}$$

Where $\kappa_H = 1 - \vartheta\varphi_H$ whilst $\kappa_F = 1 - \vartheta\varphi_F$. 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, FIs require the interest rate received on home and foreign entrepreneur debt to equal the utility lost through forgone consumption. Here, equations 25, 26, and 27 show that minimum capital requirements reduce the utility cost associated with purchases of entrepreneur debt, and increase the utility cost associated with deposits.

As per the empirical evidence, the interests rates in home credit markets should be higher than those in foreign credit markets, i.e. $R^l > R^F > R^d$.[8] Using equations 25, 26, and 27 the relevant interest rate spreads are derived as:

$$m_t^f(R_{t+1}^l - R_t^d) = (1 - \kappa_H)\lambda_t^K, \tag{28}$$

$$m_t^f(\frac{\mathbb{E}_t S_{t+1}}{S_t}\mathbb{E}_t R_{t+1}^F - R_t^d) = (1 - \kappa_F)\lambda_t^K, \tag{29}$$

$$m_t^f(R_{t+1}^l - \frac{\mathbb{E}_t S_{t+1}}{S_t}\mathbb{E}_t R_{t+1}^F) = (\kappa_F - \kappa_H)\lambda_t^K. \tag{30}$$

In the absence of the FI's capital requirement ($\lambda_t^K = 0$), (29) and (30) reduce to the standard UIP condition.

Equations 28, 29, and 30 show that a precondition to $R^l > R^F > R^d$ is that the FI's capital requirement is binding in equilibrium, i.e. $\lambda^K > 0$. Taking equation 25 at the steady state, a binding capital requirement in equilibrium is generated by assuming that the FI is less patient than the home household:

$$\beta_f < \beta_h. \tag{31}$$

Provided (31) holds, it will be the case that $R^l > R^d$ and $R^F > R^d$. Then, equation 30 shows that a positive spread between R^l and R^F requires a higher risk weight on home entrepreneur debt as compared to foreign entrepreneur debt:

$$\varphi_H > \varphi_F. \tag{32}$$

Thus, provided conditions 31 and 32 hold, the model's equilibrium will see that $R^l > R^F > R^d$.

3.4 The foreign economy

As stated in the model pre-amble, the setup for the foreign economy is asymmetrical to that of the home economy. Since the focus of this analysis is on the home economy's (emerging market) dynamics, foreign agent participation in the model occurs within a simplified structure. We assume that the foreign household

[8] A steady state where $R^l > R^F$ follows from figure 2. Although $R^F > R^d$ 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.

only purchases home entrepreneur debt issued in foreign credit markets. This assumption implies that all of the debt issued by the foreign entrepreneur is bought by the home FI.[9]

We embed these assumptions by imposing fewer financial frictions on the foreign economy. Specifically, the absence of an FI in the foreign economy precludes the need for a minimum capital requirement as per (24), whilst sole reliance on foreign credit markets by the foreign entrepreneur is captured through a single collateral constraint. Given that these asymmetries are motivated as reflective of comparatively higher levels of financial development in advanced countries, the model 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 household and entrepreneur is identical to that of their home economy counterparts. We present the foreign economy problem (in foreign currency) below.

The utility function of the foreign household is given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_{h*}^t \{log(C_t^{h*}) + jlog(H_t^{h*}) + \tau log(1 - N_t^*)\}, \tag{33}$$

whilst their budget constraint is as per

$$C_t^{h*} + q_t^*(H_t^{h*} - H_{t-1}^{h*}) + B_t^H = W_t^* N_t^* + R_t^H B_{t-1}^H. \tag{34}$$

C_t^{h*} and β_{h*} gives the foreign household's consumption and discount factor, whilst H_t^{h*} and N_t^* gives their stock of real estate and supply of labour. In the foreign economy, labour fetches a real wage of W_t^* and the price of real estate is given by q_t^*. Equation 34 shows that the foreign household's only financial asset is given by B_t^H which earns state-dependent gross interest of R_t^H.

The foreign entrepreneur's utility function is given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_{e*}^t \{log(C_t^{e*})\}, \tag{35}$$

and their budget constraint is

$$C_t^{e*} + q_t^*(H_t^{e*} - H_{t-1}^{e*}) + R_t^F B_{t-1}^F + W_t^* N_t^* = Y_t^* + B_t^F \tag{36}$$

Where β_{e*} gives the foreign entrepreneur's discount factor, C_t^{e*} gives their consumption, and H_t^{e*} is their real estate holdings.

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

[9]For simplicity, we restrict the foreign entrepreneur's supply of credit to the home FI. This assumption is in keeping with a desire to focus on the home economy; however, the qualitative implications of the results remain when foreign entrepreneurs can also access credit from the foreign household.

Cobb-Douglas production function

$$Y_t^* = (H_{t-1}^{e*})^{\alpha}(N_t^*)^{1-\alpha}, \tag{37}$$

and collateral constraint

$$\mathbb{E}_t R_{t+1}^F B_t^F \leq \mu_* \mathbb{E}_t q_{t+1}^* H_t^{e*}, \tag{38}$$

with μ_* denoting the foreign economy's loan to value parameter.

Under this setup, the foreign household's first order conditions for labour, real estate, and credit are given by

$$W_t^* = \frac{\tau C_t^{h*}}{1 - N_t^*}, \tag{39}$$

$$q_t^* = \frac{jC_t^{h*}}{H_t^{h*}} + m_t^{h*}\mathbb{E}_t q_{t+1}^*, \tag{40}$$

$$1 = m_t^{h*}\mathbb{E}_t R_{t+1}^H, \tag{41}$$

whilst those of the foreign entrepreneur are

$$W_t^* = (1-\alpha)\frac{Y_t^*}{N_t^*}, \tag{42}$$

$$q_t^* = m_t^{e*}(\mathbb{E}_t q_{t+1}^*(1 + \mu_*\lambda_t^* + \alpha\frac{\mathbb{E}_t Y_{t+1}^*}{H_t^{e*}}) + \mu_*\mathbb{E}_t q_{t+1}^*\lambda_t^*, \tag{43}$$

$$1 = \mathbb{E}_t R_{t+1}^F(m_t^{e*} + \lambda_t^*). \tag{44}$$

In equations 39 to 44, $m_t^{h*} \equiv \frac{\beta_{h*}C_t^{h*}}{\mathbb{E}_t C_{t+1}^{h*}}$ and $m_t^{e*} \equiv \frac{\beta_{e*}C_t^{e*}}{\mathbb{E}_t C_{t+1}^{e*}}$, give foreign agents' stochastic discount factors whilst $\Lambda_t^* \equiv \frac{\lambda_t^*}{C_t^{e*}}$ gives the multiplier on constraint 38.

As with the home entrepreneur, a binding equilibrium collateral constraint in the foreign economy ($\lambda^* > 0$) is ensured by restricting the feasible values for their discount factor:

$$\frac{1}{\beta_{e*}} > \frac{1-\kappa_F}{\beta_f} + \frac{\kappa_F}{\beta_h}. \tag{45}$$

3.5 Flow specific capital controls

The focus of this essay lies in capital controls that can be implemented by home country authorities.[10] To meet this requirement, we rely on capital controls that are manifest as quantitative limits on capital flows. This capital control structure constrains the ability of home agents to manage the composition of their balance sheets, with the objective being 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 FI, whilst the inflow control sees this restriction imposed on the home entrepreneur. Thus, in the context of this analysis, the outflow capital control is imposed on the financial sector, whilst the inflow capital control is imposed on the real sector.

The manifestation of these capital controls as quantitative limits on capital flows differs from the capital inflow tax approach that is usually deployed in the literature. In this regard, the quantitative nature of the capital controls assessed here implies that their transmission effect will work through quantitative financial variables, not interest rates.[11]

3.5.1 Outflow capital control

The outflow capital control (or outflow control) is inspired by Tobin (1978) and is manifest as a limit on the proportion of foreign entrepreneur debt on the FI's balance sheet[12]:

$$S_t B_t^F \leq \nu(L_t + S_t B_t^F). \tag{46}$$

Equation 46 shows that the outflow control restricts FI holdings of foreign entrepreneur bonds such that they cannot exceed a fraction, $0 < \nu < 1$, of total FI assets. (46) can be re-written to show that the outflow control imposes a linear relationship between the FI's assets, implying that L and B^F will exhibit similar dynamics when the outflow control binds:

$$S_t B_t^F \leq \frac{\nu}{1-\nu} L_t. \tag{47}$$

With this setup for the outflow control, $\nu \to 1$ implies easier outflow control regulatory regimes whilst $\nu \to 0$ implies stricter outflow control regulatory regimes.

When the outflow control is active, optimal behavior by the FI generates first order conditions for deposits, home loans, and foreign bonds as per:

[10] Sections 3.1 – 3.4 describe a model setup where no capital controls are present. Here, we extend this baseline setup such that home agents are subject to both inflow and outflow capital controls.

[11] A tax-based approach to capital controls is feasible when authorities seek to curb foreign participation on domestic credit markets (see e.g., Jeanne and Korinek, 2010; Bianchi, 2011; Forbes et al., 2016). In this analysis, capital flows are manifest in foreign credit markets, and so, the use of taxes imposed on foreign agents is not feasible for home authorities.

[12] Tobin (1978) argued for the use of capital controls that impair the efficient functioning of the financial sector.

$$m_t^F R_t^d = 1 - \lambda_t^K, \tag{48}$$

$$m_t^F \mathbb{E}_t R_{t+1}^l = 1 - \kappa_H \lambda_t^K - \nu \lambda_t^{OC}, \tag{49}$$

$$m_t^F \frac{\mathbb{E}_t S_{t+1}}{S_t} \mathbb{E}_t R_{t+1}^F = 1 - \kappa_F \lambda_t^K + (1-\nu)\lambda_t^{OC}. \tag{50}$$

Where $\Lambda_t^{OC} \equiv \frac{\lambda_t^{OC}}{C_t^f}$ gives the multiplier on constraint 46.

Given that (31) holds (i.e. $\lambda^K > 0$), we make use of (13), (15), (41), (48), and (49) to solve for the equilibrium value of λ^{OC} as

$$\lambda^{OC} = \frac{1}{\nu}\left(1 - \kappa_H\left(1 - \frac{\beta_f}{\beta_h}\right) - \frac{\beta_f}{\beta_e + \frac{\tilde{\mu}}{\mu}(\beta_{h*} - \beta_e)}\right). \tag{51}$$

Using (51), the necessary condition for a binding outflow control in equilibrium is given by:

$$\frac{1}{(1 - \frac{\tilde{\mu}}{\mu})\beta_e + \frac{\tilde{\mu}}{\mu}\beta_{h*}} < \frac{1 - \kappa_H}{\beta_f} + \frac{\kappa_H}{\beta_h}. \tag{52}$$

(52) and (18), the condition for a binding collateral constraint in the home economy ($\lambda^H > 0$), are quite similar. A comparison of these two conditions reveals that their co-existence requires $\tilde{\mu} > 0$ and $\beta_{h*} > \beta_e$, i.e. the marginal productivity of the home entrepreneur's collateral in foreign credit markets is positive, and the foreign household is more patient than the home entrepreneur.

The FI's first order conditions for loans and foreign bonds, (26) and (27), reveal that the outflow control reduces the utility cost of loan extension to home entrepreneurs and increases the utility cost associated with foreign entrepreneur bond purchases. In this way, the outflow control can serve to subsidize credit extension from the FI to the home entrepreneur. That is, when $\lambda^{OC} > 0$, the cost of loan finance to the home entrepreneur is strictly lower than when there is no outflow control. In contrast, a binding outflow constraint implies that foreign entrepreneurs face borrowing costs that are strictly higher than when there is no outflow control in the home economy.

As a result of the outflow control's influence over home loan and foreign bond rates, generating $R^l > R^F$ in equilibrium requires a restriction on the outflow control parameter, ν. Taking (49), (50), and (51) at the steady state, this condition is derived as:

$$\nu > \frac{1}{(\kappa_F - \kappa_H)\left(1 - \frac{\beta_f}{\beta_h}\right)}\left(1 - \kappa_H\left(1 - \frac{\beta_f}{\beta_h}\right) - \frac{\beta_f}{\beta_e + \frac{\tilde{\mu}}{\mu}(\beta_{h*} - \beta_e)}\right). \tag{53}$$

Thus, when conditions 52 and 53 hold, it will be the case that $R^l > R^F$ even though $\lambda^{OC} > 0$.

3.5.2 Inflow capital control

For the inflow capital control (or inflow control), we seek to restrict the home entrepreneur's ability to manage the composition of their debt. Thus, the inflow control is introduced by removing the home entrepreneur's ability to optimize the allocation of collateral between home and foreign credit markets. This implies that $\Omega_t \to \Omega$, such that the home entrepreneur's collateral constraints become

$$\mathbb{E}_t R^l_{t+1} L_t \leq \mu\Omega \mathbb{E}_t q_{t+1} H^e_t, \tag{54}$$

$$\mathbb{E}_t R^H_{t+1} S_t B^H_t \leq (1-\Omega)\mathbb{E}_t q_{t+1} H^e_t \left(1 - \frac{1-\mu}{qH^e}\mathbb{E}_t q_{t+1}(1-\Omega)H^e_t\right), \tag{55}$$

where Ω gives the inflow control parameter. With this setup, $\Omega \to 1$ implies stricter inflow capital control regulatory regimes as the home entrepreneur is forced to allocate more collateral to the home credit market. Conversely, $\Omega \to 0$ implies easier inflow capital control regimes as the home entrepreneur is able to allocate more collateral to the foreign credit market.

The inability of the home entrepreneur to optimally allocate his collateral between credit markets sees that the inflow control imposes a linear relationship between his debt limit in home and foreign credit markets. Thus, whilst the outflow control imposes a linear relationship between the FI's assets, the inflow control imposes this relationship between the home entrepreneur's liabilities. At the steady state, this relationship can be expressed as:

$$R^l L = \mu q H^e - \frac{\mu R^H B^H}{1-(1-\mu)(1-\Omega)}. \tag{56}$$

And so, the entrepreneur's debt ceiling in the home credit market is decreasing in his preference for foreign debt.

The use of Ω as an inflow control implies that the home entrepreneur's problem now consists of one fewer choice variable. As a result, optimal behaviour by the home entrepreneur is given by

$$W_t = (1-\alpha)\frac{Y_t}{N_t}, \tag{57}$$

$$q_t = q_{t+1}(\mu\Omega\lambda^H_t + \mathbb{E}_t\tilde{\mu}_{t+1}(1-\Omega)\lambda^F_t) + m^e_t\left(\mathbb{E}_t q_{t+1} + \frac{\alpha\mathbb{E}_t Y_{t+1}}{H^e_t}\right), \tag{58}$$

$$1 = \mathbb{E}_t R^l_{t+1}(m^e_t + \lambda^H_t), \tag{59}$$

$$1 = \mathbb{E}_t R^H_{t+1}(\frac{\mathbb{E}_t S_{t+1}}{S_t} m^e_t + \lambda^F_t). \tag{60}$$

With $\mathbb{E}_t\tilde{\mu}_{t+1} \equiv 1 - \frac{2(1-\mu)}{qH^e}\mathbb{E}_t q_{t+1}(1-\Omega)H^e_t$ giving the marginal productivity of collateral in foreign bond markets.[13]

[13] Note that apart from the removal of condition 15, the introduction of an inflow control in the form of Ω does not require any other changes to the baseline model structure.

3.6 Flow specific interest rate shocks

The bulk of the analysis relates to how the capital controls described above can influence the transmission of foreign interest rate shocks to the home economy. These shocks are designed to mimic the easy credit conditions that prevailed in advanced economies following the financial crisis. These shocks are defined below.

From the home country's perspective, R_t^F denotes the gross interest rate earned on capital outflows whilst R_t^H gives that paid on capital inflows. 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:

$$\log(R_t^F) = (1-\rho)\log(R^F) + \rho\log(R_{t-1}^F) + \varepsilon_t^F, \tag{61}$$

$$\log(R_t^H) = (1-\rho)\log(R^H) + \rho\log(R_{t-1}^H) + \varepsilon_t^H. \tag{62}$$

The specification of (61) and (62) assumes that each interest rate can be described as an AR(1) process where $\rho =$ governs the persistence of each process. $\varepsilon_t^F \sim N(0, \sigma^F)$ and $\varepsilon_t^H \sim N(0, \sigma^H)$ give flow specific white noise interest rate shocks. Letting $\mathbf{\Sigma}$ denote the variance-covariance matrix of the flow specific interest rate shocks, we incorporate correlated shocks through γ:

$$\mathbf{\Sigma} = \begin{bmatrix} \sigma^F & \gamma \times \sigma^F \sigma^H \\ \gamma \times \sigma^H \sigma^F & \sigma^H \end{bmatrix}, \tag{63}$$

where $0 < \gamma < 1$ sees that the flow specific interest rate shocks are positively correlated.

With this setup, one can view a flow specific interest rate shock as reflecting a foreign monetary policy shock that lowers foreign interest rates such that both home and foreign entrepreneurs face lower borrowing costs. Here, positive correlation between ε_t^F and ε_t^H implies that each flow specific interest rate shocks affects both foreign credit markets (B_t^H and B_t^F); however, because $0 < \gamma < 1$ the impact of each shock is stronger on its respective interest rate. Thus, a shock to ε_t^F sees a response in both R^F and R^H, but the response is stronger in R^F than in R^H. Conversely, a shock to ε_t^H sees a stronger response in R^H than in R^F.

The asymmetric response of R^F and R^H under each shock implies that flow specific interest rate shocks are unevenly distributed between the FI and the home entrepreneur. Both shocks serve to reduce the return on outflows and inflows. For the home entrepreneur, this reduction affords higher levels of consumption, whilst the FI associates each shock with consumption losses. In this regard, $0 < \gamma < 1$ sees that an outflow interest rate shock is associated with larger consumption losses for the FI than gains for the home entrepreneur, and as a result, outflow interest rate shocks realize net consumption losses in the home economy. The opposite applies under inflow interest rate shocks, where the gain in home entrepreneur consumption dominates the loss suffered by the FI such that inflow interest rate shocks realize net consumption gains in the home economy.

3.7 Market clearing and the current account

The quantity of real estate in each economy is normalized to one so that real estate market clearing is given by

$$1 = H_t^h + H_t^e, \tag{64}$$
$$1 = H_t^{h*} + H_t^{e*}. \tag{65}$$

The home, foreign, and world economy aggregate resource constraints are given by

$$Y_t = C_t^h + C_t^e + C_t^f + S_t(B_t^F - R_t^F B_{t-1}^F + R_t^H B_{t-1}^H - B_t^H), \tag{66}$$
$$Y_t^* = C_t^{h*} + C_t^{e*} + B_t^H - R_t^H B_{t-1}^H + R_t^F B_{t-1}^F - B_t^F, \tag{67}$$
$$Y_t^W = C_t^h + C_t^e + C_t^f + S_t(C_t^{h*} + C_t^{e*}), \tag{68}$$

where $Y_t^W = Y_t + S_t Y_t^*$. As in Obstfeld and Rogoff (1995) (66) sees that, in the absence of goods trade, any income in excess of home consumption is transferred abroad through financial trade:

$$Y_t - C_t^h - C_t^e - C_t^f = S_t(B_t^F - R_t^F B_{t-1}^F + R_t^H B_{t-1}^H - B_t^H). \tag{69}$$

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

$$CA_t = S_t(\Delta B_t^F - \Delta B_t^H), \tag{70}$$
$$CA_t^* = \Delta B_t^H - \Delta B_t^F. \tag{71}$$

where $\Delta B_t^i = B_t^i - B_{t-1}^i$ for $i = F, H$. This definition for the current account produces the standard two-country model outcome in that $CA_t = -S_t CA_t^*$.

Defining the current account of each country as per (70) and (71) implies that net inflows ($\Delta B_t^H > \Delta B_t^F$) are associated with current account deficits, whilst net outflows ($\Delta B_t^H < \Delta B_t^F$) 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.

Similar to Chang et al. (2015), (69) and (70) see that the home current account is defined as the sum of its financial trade surplus and net interest income received from foreign asset holdings, less the net interest paid on its foreign liabilities:

$$CA_t = Y_t - C_t^h - C_t^e - C_t^f + S_t(R_t^F - 1)B_{t-1}^F - S_t(R_t^H - 1)B_{t-1}^H. \tag{72}$$

Equation 72 shows that a balanced current account implies home consumption is matched perfectly by home production and the net income from financial trade.

4 Calibration

The model's calibration is presented in table 1, where the model is calibrated for a quarterly frequency. In line with conditions 18, 19, 31, and 45, the calibration is consistent with a steady state where minimum capital requirements and collateral constraints are binding. The parameter values are also in line with (52), such that when it is active, the outflow capital control binds in equilibrium.

Table 1: Calibration of model parameters.

Parameter	*Symbol*	*Value*
Foreign household discount factor	β_{h*}	0.988
Home household discount factor	β_h	0.99
Foreign entrepreneur discount factor	β_{e*}	0.94
Home entrepreneur discount factor	β_e	0.94
Home FI discount factor	β_f	0.945
Household utility to leisure	τ	2
Household utility to real estate	j	0.075
Real estate share in production	α	0.05
Home LTV ratio	μ	0.8
Foreign LTV ratio	μ_*	0.8
Home FI minimum capital requirement	ϑ	0.1
Risk weight on home loans	φ_H	1
Risk weight on foreign entrepreneur bonds (outflows)	φ_F	0.2
AR parameter for shocks	ρ	0.9
Correlation between shocks	γ	0.5

The parameters are calibrated so that in the baseline scenario, the steady state interest rate relationships are given by $R^l > R^H > R^F > R^d$. As per Iacoviello (2015), the calibration for $j = 0.075$ and $\alpha = 0.05$ implies a home real estate wealth to output ratio of approximately 3 at the steady state, whilst $\tau = 2$ sees households devote a third of their time to labour activities. The discount factor values are standard in the literature. We calibrate $\beta_{h*} < \beta_h$ to generate a spread between entrepreneur borrowing rates in the foreign economy so that $R^H > R^F$. In this regard, setting $\beta_{h*} = 0.988$ sees the foreign household require a return of $R^H = 4.84\%$ per annum on home entrepreneur bonds in equilibrium whereas the return on foreign entrepreneur bonds is given by $R^F = 4.44\%$. Therefore, in the foreign credit market, home entrepreneurs pay marginally more than foreign entrepreneurs. $\beta_h = 0.99$ 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 $R^l = 5.96\%$, the baseline calibration sees a spread of $R^l - R^H = 1.12\%$ between home and foreign credit markets. The calibration for ϑ is taken from BIS (2010) whilst the values for φ_H and φ_F are as per the risk weights on AAA and BBB rated corporate debt given in BIS (2006). We assume symmetrical LTV regulation between the two

countries, and in line with IMF (2011) and Iacoviello and Minetti (2006), set $\mu = \mu_* = 0.8$. Finally, the AR(1) parameter on the flow specific interest rate shocks is set at 0.9 and we assume that these shocks are positively correlated with $\gamma = 0.5$.

When the outflow capital control is active, we calibrate $\nu = 0.3$ such that 70% of the FI's balance sheet is devoted to home loans. Similarly, when the inflow capital control is active, we calibrate $\Omega = 0.6$ such that 60% of home entrepreneur collateral is allocated to the home credit market. The calibration for each of these controls is in line with the home bias observed on emerging market balance sheets (see e.g., Burger and Warnock, 2006; Hale et al., 2016) and sees that in the absence of capital controls, foreign credit occupies a larger portion of both the FI and home entrepreneur's balance sheets.[14]

5 The baseline model performance

Before commencing with the analysis on the impact of flow specific capital controls, this section investigates the behaviour of the baseline model through two simulation exercises. The first exercise comprises an assessment of the business cycle performance of the baseline model whilst the second exercise comprises impulse response function analysis following negative flow specific foreign interest rate shocks.

5.1 Business cycle moments

To test the applicability of the framework, we compare the baseline model's moments to the data. The model moments are generated following a positive productivity shock in each country with technological spill-over as in Backus et al. (1992).[15] Table 2 reports the correlation of home output with consumption, real estate prices, and credit flows. Following the international business cycle literature, we also consider the cross-country correlations of these variables. Here, we make use of emerging market data for the home economy and advanced market data for the foreign economy.

The data shows that emerging market output is positively correlated with all of the home variables considered. The positive correlation between emerging market output (Y) and inflows (B^H) concurs with the notion that the foreign debt dynamics of emerging markets are underpinned by economic fundamentals (Forbes and Warnock, 2012; Ahmed and Zlate, 2014). In terms of cross-country correlations, the data shows a positive correlation between emerging and advanced market output. This international cycle is also present in consumption and real estate prices, but not across all credit flows. In particular, emerging credit markets are negatively correlated with advanced credit markets. Nevertheless, capital inflows (B^H) and outflows (B^F) are positively correlated. Capital inflows and emerging market domestic debt are also positively correlated. Combined with the co-movement of emerging market output and outflows (B^F), and the positive relationship between capital flows, B^F and B^H, the data is indicative of an international credit cycle as described in Rey (2015).

The baseline model is generally able to replicate the direction of both the domestic and international

[14] That is, without capital controls, the steady state levels of inflows and outflows are higher.

[15] The formal setup for this shock is provided in appendix A.7 whilst the data sources and transformations used are described in appendix B.

Table 2: Business cycle moments of the baseline model.

	Data	*Baseline*
Correlations with Y		
Y	1	1
C	0.76	0.96
q	0.39	0.96
L	0.27	0.34
B^H	0.83	0.16
B^F	0.60	0.66
Cross-country correlation		
Y, Y^*	0.30	0.67
C, C^*	0.19	0.94
q, q^*	0.20	0.95
L, B^H	0.42	-0.84
L, B^F	-0.23	-0.10
B^F, B^H	0.49	0.61

correlations seen in the data; however, it mostly overestimates the magnitude of the relationships. This amplification stems from the relatively simplistic nature of the model setup and is line with estimates produced by other papers that deploy the canonical real business cycle framework (Backus et al., 1992; King and Rebelo, 2000; Kehoe and Perri, 2002). Similarly, the negative correlation between L and B^H is driven by model design. This outcome results from the collateral constraints of Iacoviello and Minetti (2006), where optimal collateral allocation allows the home entrepreneur to exploit differences in the liquidation technology of home and foreign lenders. Nevertheless, the baseline model's ability to match most of the correlations seen in the data implies that it provides a reasonably sound foundation from which to assess the implications of flow specific capital controls.

5.2 Foreign interest rate shocks in the baseline model

We subject the baseline model to negative foreign interest rate shocks designed to mimic easing conditions in advanced credit markets. Because these shocks reduce foreign interest rates (R_t^H and R_t^F), they serve to increase the present value of the home and foreign entrepreneur collateral in foreign credit markets, and by extension their foreign credit ceiling (see equations 10 and 38). This easing of foreign credit market conditions raises demand for foreign debt by both the home and foreign entrepreneur such that both inflows and outflows increase following the shock. However, the increase in outflows is insufficient to offset the increase in inflows, and so, the home economy experiences net inflows such that a home current account deficit results from the shock.[16] The model's transmission channel comprises the effect that changes in collateral values have on home and foreign entrepreneur credit ceilings, where dynamic feedback between credit ceilings and expected collateral values culminates in shock amplification and persistence.

The asymmetrical two-country setup implies that the home economy is subject to two inter-related collateral value channels, whilst there is only one channel present in the foreign economy. Negative foreign interest rate shocks serve to reduce the relative inefficiency of the home economy's foreign collateral value

[16] Apart from figure 3, this increase in the FI's holdings of foreign entrepreneur bonds is consistent with the increase in emerging market purchases of foreign assets as mentioned by Turner (2013).

channel, resulting in the home entrepreneur's switch to foreign debt. Although this behaviour allows the entrepreneur to exploit the lower cost of foreign credit, it implies a net increase in foreign interest owed, and so, the shocks realize a redistribution of income between countries, such that negative foreign interest rate shocks realize contractionary effects in the home economy. These effects are coherent with a positive foreign money supply shock in Obstfeld and Rogoff (1995) and the positive foreign wealth shock deployed by Faia (2002). The contractionary effects on the home economy stem from the increased prominence of foreign credit markets following the shock. In this regard, the absence of goods trade in the model circumvents the expenditure switching channel present in Faia (2002). Instead, the focus on capital flows sees this channel manifested in the home entrepreneur's preference for foreign debt.[17]

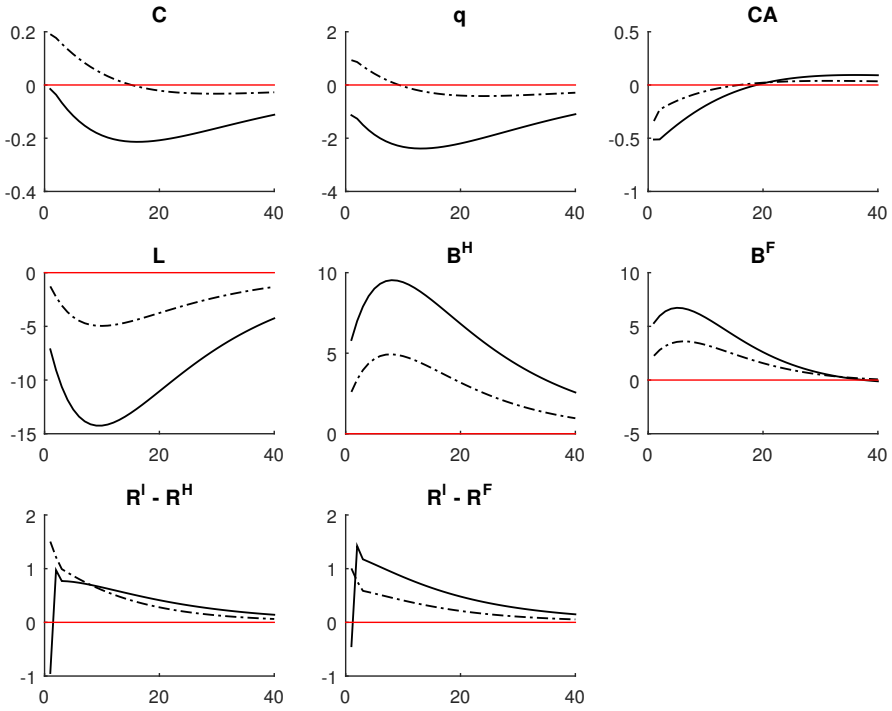

Figure 4: Negative foreign interest rate shocks in the baseline model (ε_t^F and ε_t^H). Outflow interest rate shock: solid line. Inflow interest rate shock: dash-dot line.

Figure 4 contains the impulse response functions for a selection of home variables in response to negative foreign interest rate shocks. Both shocks are associated with an increased spread between home and foreign credit markets ($R^l - R^H$ and $R^l - R^F$), a current account deficit in the home economy (CA), an increase in foreign credit extension (B^H and B^F), and an eventual contraction in consumption (C). In terms of credit flows, each shock increases the prominence of foreign capital flows (B^H and B^F) whilst the home credit market contracts (L).[18] The balance sheet reduction associated with this contraction aggravates FI

[17] The financial shock of Faia (2002) is manifest as an increase to foreign net wealth. Home output losses result from this shock as home agents exhibit a preference for foreign goods following the shock.

[18] Aggregate home consumption is defined as the sum of home agent consumptions: $C = C^h + C^e + C^f$. The focus of this essay is on the home economy, and as such, we do not report the foreign economy dynamics here. Nevertheless, the shocks are expansionary in the foreign economy, where each shock is associated with an increase in C^* and q^*.

consumption losses, tightening home credit market conditions further. Together with the relative inefficiency of the home economy's foreign collateral value channel, this tightening of home credit market conditions reduces the entrepreneur's demand for real estate, culminating in lower real estate prices (q).

Both the qualitative and the quantitative differences between each shock's dynamics can be attributed to their distribution across the entrepreneur and the FI.[19] The FI's consumption loss is greater under the outflow interest rate shock, which sees that the initial response of the spread between home and foreign interest rates differs between inflow and outflow interest rate shocks. Apart from this difference, the dynamics of an outflow interest rate shock are qualitatively similar to that of an inflow interest rate shock. Quantitatively, inflow interest rate shocks have a smaller impact than outflow interest rate shocks. In this case, the positive initial response of consumption and real estate prices reflect the net gain in home consumption associated with an inflow interest rate shock.

6 The impact of flow specific capital controls

The transmission of foreign interest rate shocks will differ when capital controls are introduced. For instance, the outflow control introduces linear dependence between the FI's assets that contrasts with the counter-cyclical relationship that they exhibit under the baseline model. This change in the relationship between FI assets bears implications for FI consumption, and by extension, the net consumption cost associated with outflow shocks. Similarly, the linear dependence introduced between entrepreneur debt types under the inflow control will influence the net consumption benefit associated with inflow shocks.[20] We subject the model to an outflow interest rate shock (ε_t^F) when looking at the impact of the outflow capital control, and to an inflow interest rate shock (ε_t^H) when looking at the inflow capital control. This approach focuses the effects of the shock on the agent most affected by the capital control.[21]

6.1 Outflow capital controls and outflow interest rate shocks

Figure 5 compares the impulse response functions obtained under the baseline and outflow control models following a negative outflow interest rate shock (ε_t^F). There are clear disparities between the dynamics of the baseline and those obtained when the outflow capital control is present. In terms of its influence on capital flows, the outflow control realizes a decline in both outflows (B^F) and inflows (B^H), culminating in a quicker return to equilibrium for the current account. Shock attenuation under the outflow control is reflected in the dynamics of home consumption, real estate prices, and credit quantities. That being said, the current account deficit is larger when the outflow capital control binds compared to the baseline. This outcome is to be expected, as the outflow control restricts the home FI's ability to lean against the current account deficit associated with the home entrepreneur's switch to foreign debt.

The outflow control's effectiveness in reducing the sensitivity of home variables results from the linear dependence that it imposes between L and B^F. This relationship implies that home entrepreneur loans

[19] See section 3.6 for a discussion on the distribution of flow specific interest rate shocks across the FI and home entrepreneur.
[20] Equations 47 and 56 show how the capital controls impose this linear dependence between credit markets.
[21] Outflow shocks amplify the consumption losses of the FI whilst inflow shocks do the same for the home entrepreneur. As illustrated and discussed in section 7, the qualitative insights generated by this analysis are shock invariant.

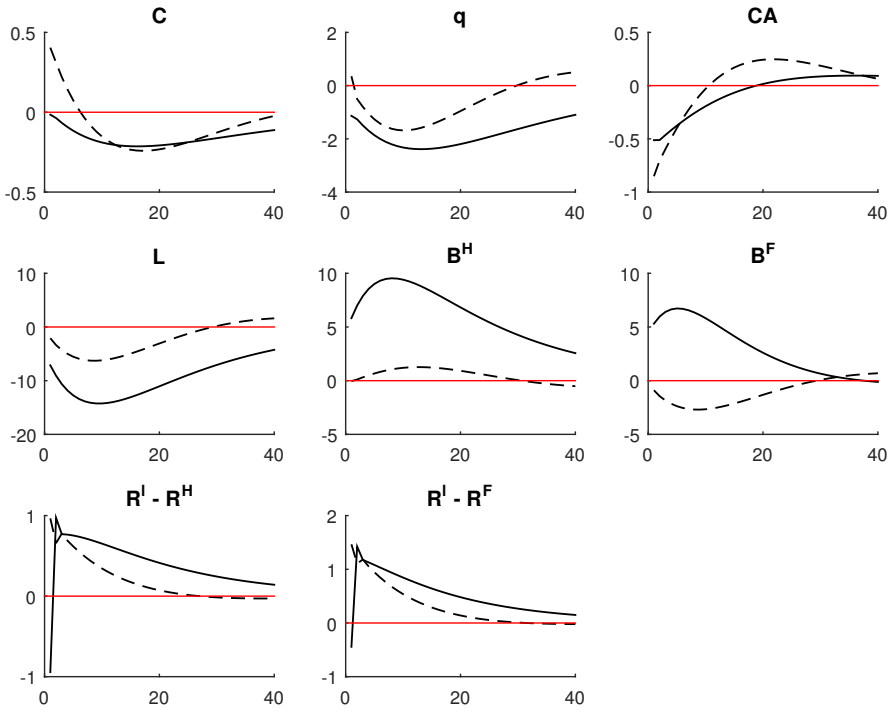

Figure 5: The impact of the outflow capital control following a negative foreign interest rate shock (ε_t^F). Baseline (no capital controls): solid line. Outflow capital control: dashed line.

and foreign entrepreneur bonds will exhibit the same dynamics. Because the control is imposed on the FI, linear dependence between L and B^F does not affect the home entrepreneur's tilt toward foreign sources of credit; however, it does provide a channel through which easier foreign credit market conditions can spill-over to the home credit market. Absent the outflow control, the collateral value channels of each country are independent of one another and move in opposite directions.[22] When the outflow control is imposed, linear dependence between L and B^F pits these two forces against one another and home loan extension is less adversely affected than under the baseline. This reduction in the sensitivity of home loans implies that the entrepreneur's preference for foreign debt is attenuated such that inflows are less sensitive to the shock when the outflow capital control binds.

6.2 Model sensitivity to outflow capital control regimes

In aggregate, figure 5 illustrates that the outflow control is able to attenuate the sensitivity of inflows, outflows, and the business cycle (real economy variables) to negative foreign interest rate shocks. To check the sensitivity of these attenuation benefits of the outflow control, we compare the impulse response functions generated under three different outflow capital control regimes (outflow regimes for short). As per their calibrations in table 3, movement across regimes change the FI's exposure to outflows. Under the strict outflow regime, the share of outflows on FI balance sheets is lower than that observed under the baseline

[22] This model characteristic is reflected in the decline of home entrepreneur loans and increase in foreign entrepreneur bonds following the shock.

regime. The opposite holds true for the easy outflow regime, where outflows occupy a larger share of FI balance sheets. Thus, relative to the baseline outflow regime, the strict regime reduces the home economy's exposure to foreign assets whilst the easy regime increases the home economy's exposure to foreign assets.

Table 3: Outflow capital control regimes.

		Regulatory regime		
Parameter	*Symbol*	*Baseline*	*Strict*	*Easy*
Outflow capital control	ν	0.3	0.15	0.45

Figure 6 plots the impulse response functions obtained under each outflow regime. In aggregate, figure 6 shows that the attenuation benefits associated with the outflow control increase as the outflow regime becomes easier. The easy regime attenuates the behaviour of all credit types relative to both the strict and baseline regimes. This does not hold for the contemporaneous response of outflows, where the shock's impact is largest under the easy outflow regime. Because home loans are less sensitive to the shock under the easy regime, the dynamics of home real estate prices are preferable to those obtained under the strict outflow regime. This outcome results from the higher marginal value of collateral with home lenders, where reduced sensitivity in home loans under the easy outflow regime feeds back into comparatively higher home real estate prices. In turn, higher real estate prices reduce the incentive for home entrepreneurs to borrow on foreign credit markets, implying a smaller increase in B^H under the easy regime. When the strict outflow regime is imposed, the narrative runs in the opposite direction, where the comparatively larger decline in home loans feeds back into lower home real estate prices and a more pronounced shift toward foreign credit markets.

The results show that the strict regulatory regime enhances the ability of the outflow control to attenuate home consumption dynamics. This finding contrasts with the superior real estate price dynamics under the easy outflow regime, and results from the consumption costs associated with negative outflow interest rate shocks. Recall that these shocks generate consumption gains for the home entrepreneur, but entail consumption losses for the FI. The easy outflow regime sees outflows occupy a larger share of FI balance sheets, amplifying this consumption loss. In contrast, the wealth effect of relatively higher real estate prices under the easy outflow regime increases both home household and home entrepreneur consumption. Figure 6 shows that this wealth effect is dominated by the consumption loss of the FI, and as such, the strict outflow regime is associated with the best dynamics for home consumption.

The insensitivity of interest rate spreads to changes in the outflow control regime shows that the outflow capital control's attenuation properties are manifest through quantitative financial variables, not interest rates. Thus, shock attenuation under the outflow capital control is founded upon the benefits that it proffers for the FI's balance sheet. Indeed, the fundamental purpose of the outflow capital control is to reduce the home FI's balance sheet exposure to foreign interest rate shocks. This property of the outflow capital control implies that it reduces the foreign interest rate shock sensitivity of the FI's balance sheet relative to the baseline model. Since credit market conditions are pivotal to the model's dynamics, the comparatively smaller reduction in the FI's balance sheet under the outflow control explains its ability to improve upon baseline dynamics.

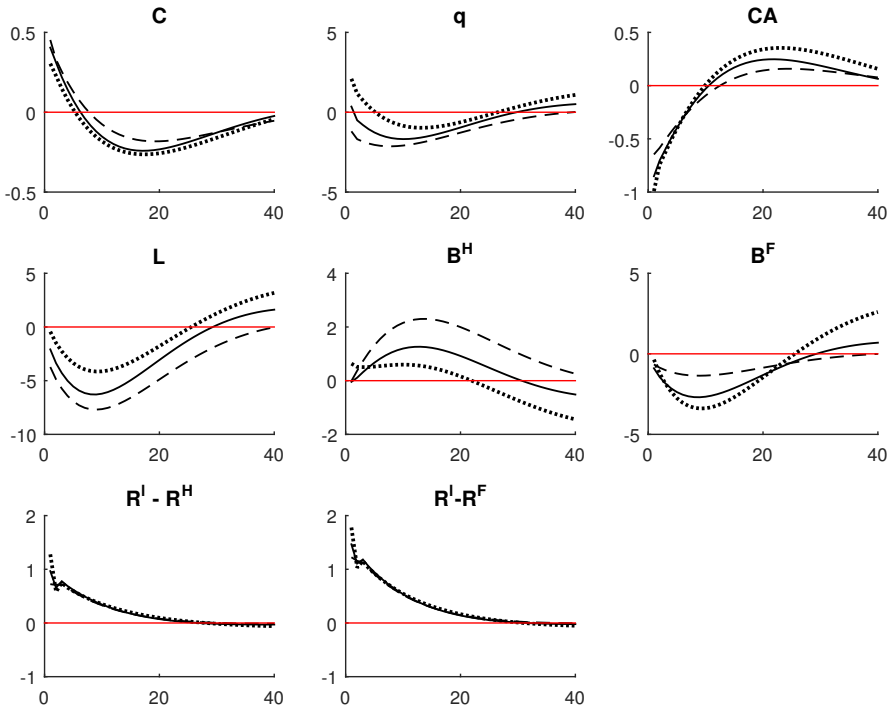

Figure 6: Model sensitivity to different outflow control regimes as per table 3 following a negative foreign interest rate shock (ε_t^F). Baseline outflow control regime: solid line. Strict outflow control regime: dashed line. Easy outflow control regime: dotted line.

6.3 Inflow capital controls and inflow interest rate shocks

Whilst the outflow control identifies the FI's balance sheet as a means to dealing with foreign interest rate shocks, the inflow capital control places focus on the home entrepreneur's balance sheet. Relative to the baseline model, the inflow capital control is able to reduce the home entrepreneur's exposure to inflows, but in doing so, precludes optimal collateral allocation. This implies that the home entrepreneur is unable to exploit easier foreign credit market conditions, constraining virtuous feedback through the home economy's foreign collateral value channel.

Figure 7 shows that the inflow capital control amplifies the effect of the shock relative to the baseline. Now, both types of entrepreneur debt decline and feed back into contemporaneously lower consumption and real estate prices. Dynamic feedback through the collateral value channel realizes a contraction in home loans that is more severe under the inflow control, leading to a smaller FI balance sheet and fewer outflows. As before, this balance sheet reduction amplifies the consumption losses that the FI associates with the shock. The household and entrepreneur also experience consumption losses. Here, the wealth reduction associated with lower real estate prices bears consequences for their consumption streams. Thus, whilst the inflow interest rate shock is net consumption enhancing in the baseline model, it realizes a net consumption loss when the inflow control is present.

The dynamics of capital outflows in figure 7 show that when the inflow control is present, the compara-

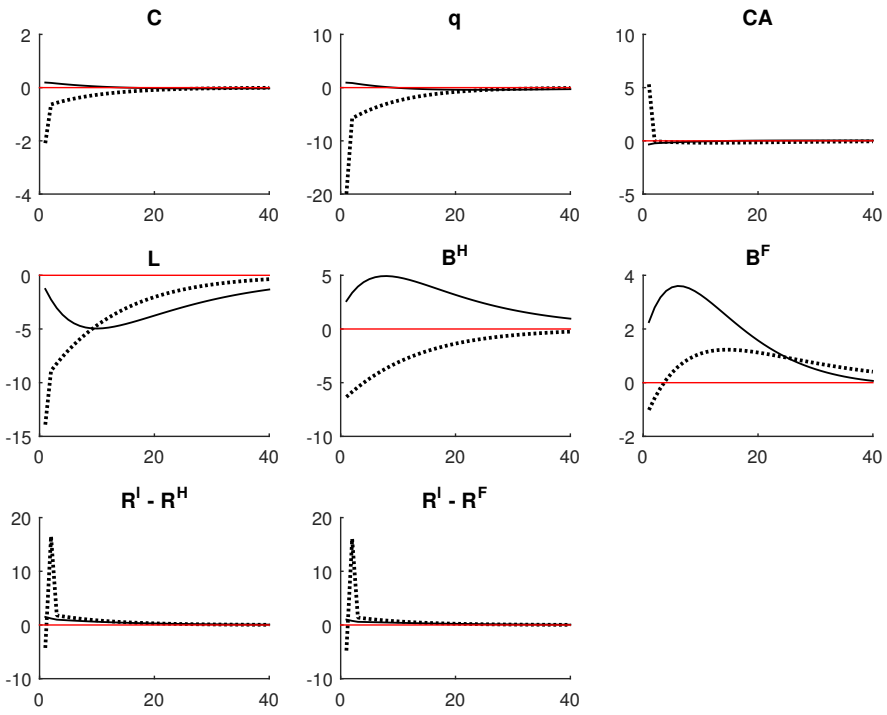

Figure 7: The impact of the inflow capital control following a negative foreign interest rate shock (ε_t^H). Baseline (no capital controls): solid line. Inflow control only: dotted line.

tively larger reduction in the FI's balance sheet has an adverse effect on foreign entrepreneur access to credit. The FI consumption losses associated with this shrunken balance sheet enhances the sensitivity of interest rate spreads such that the qualitative characteristics of their dynamics become similar to that of an outflow interest rate shock in the baseline model.[23] Nevertheless, the reduction in outflows is insufficient to dominate the current account surplus emanating from the decline in inflows, and as a result, the inflow control sees a large contemporaneous current account surplus in the home economy. Thus, the inflow control is able to initially reverse the income redistribution associated with the home economy's position as net international creditor. As reflected by the increase in shock persistence under the inflow control, this effect is transitory and introduction of the inflow control merely delays the income redistribution associated with the shock.

6.4 Model sensitivity to inflow capital control regimes

Figure 7 illustrates that the inflow control is effective in curbing both the home entrepreneur's shift to foreign credit markets as well as the increase in the FI's foreign assets. However, this control over capital flows comes at the cost of an increase in the sensitivity of the business cycle to negative foreign interest rate shocks. Thus, whilst the outflow control exhibits shock attenuation properties, the inflow control exhibits shock amplification properties. We test the sensitivity of these amplification properties to changes in the

[23] Recall that under the baseline model, outflow interest rate shocks initially bear net consumption losses whilst inflow interest rate shocks are initially net consumption enhancing. When the inflow control binds, inflow interest rate shocks bear net consumption losses and the interest rate dynamics are qualitatively similar to those of the baseline model following an outflow interest rate shock.

inflow capital control regime (inflow regime for short) by comparing the impulse response functions obtained under baseline, strict, and easy inflow regimes as defined in table 4.

Table 4: Inflow capital control regimes.

		Regulatory regime		
Parameter	*Symbol*	*Baseline*	*Strict*	*Easy*
Inflow capital control	Ω	0.6	0.75	0.45

Figure 8 plots the impulse response functions generated under each inflow regime. The strict regime sees that the share of collateral devoted to home credit markets is larger than that under the baseline whilst the opposite holds true under the easy regime. Thus, the home entrepreneur's exposure to the consumption gain associated with inflow shocks is enhanced under the easy regime and impaired under the strict regime.

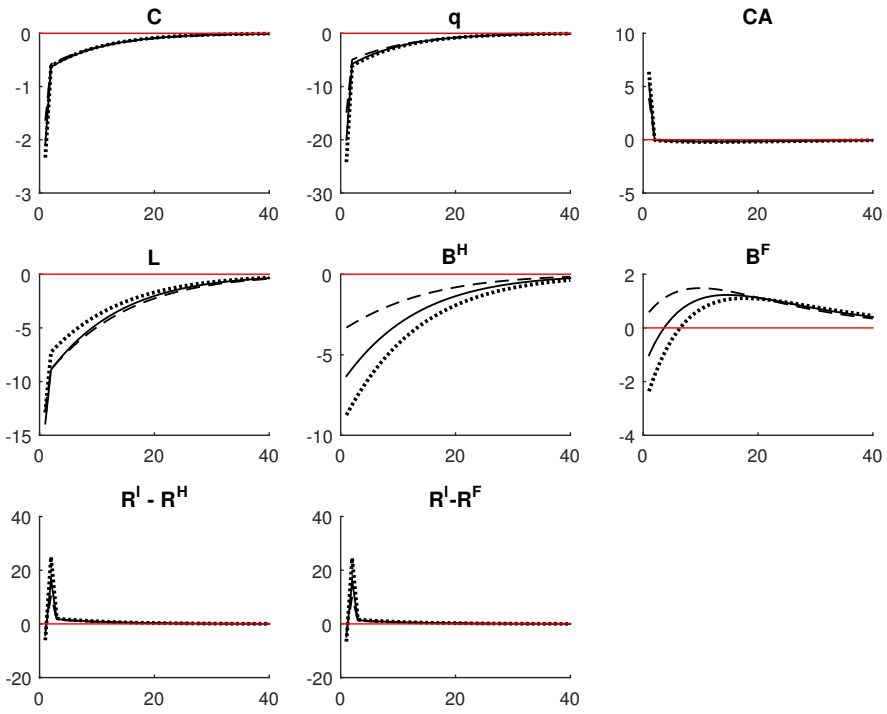

Figure 8: Model sensitivity to changes in the inflow capital control regime as per table 4 following a negative foreign interest rate shock (ε_t^H). Baseline inflow control regime: solid line. Strict inflow control regime: dashed line. Easy inflow control regime: dotted line.

Although only evident from the dynamics of B^H and B^F, the strict inflow regime reduces the impact of the shock across all of the variables plotted in figure 8, barring home loans. Thus, the amplification properties of the inflow control are reduced as the inflow regime becomes stricter.

The strict regime reduces the role of the foreign collateral constraint, limiting adverse feedback between inflows and real estate prices which attenuates the impact of the shock. The opposite holds true under the easy inflow regime, where an increased role for the foreign collateral constraint is associated with enhanced shock amplification relative to the baseline inflow regime. Here, the easy regime's relatively better dynamics

for home loans is a product of the larger decline in foreign debt associated with the shock.[24] Regardless of the relative amplification of inflow interest rate shocks under the easy regime, figure 8 indicates that all three regimes return to equilibrium at a similar pace. Thus, changes to the inflow regime have a temporary impact. As with the outflow control, the insensitivity of interest rate spreads to changes in the inflow regime reflects the manifestation of the inflow capital control as a quantitative limit on inflows.

Taken together, the impulse response function analyses of the outflow and inflow capital controls are illustrative of the shock absorption properties of optimal collateral allocation. The model's dynamics under the inflow control indicate that when capital controls are manifest as quantitative limits that impair optimal collateral allocation, effective management of capital flows comes at the cost of shock amplification. In contrast, the outflow control analysis shows that quantitative limits which reduce the home economy's exposure to foreign credit markets without affecting optimal collateral allocation afford both effective capital flow management and shock attenuation. Thus, the outflow control's attenuation effects are driven by the fact that it does not directly influence the home entrepreneur's shift toward foreign credit markets. Instead, the co-existence of optimal collateral allocation and the outflow capital control affords virtuous feedback through the home economy's foreign collateral value channel, culminating in the outflow control's ability to improve upon the baseline model's dynamics.

7 The welfare effects of flow specific capital controls

Both capital controls restrict the behaviour of home agents relative to the baseline model. In the case of the outflow capital control, the share of foreign assets on the FI's balance sheet is reduced and their ability to purchase these instruments is restricted. Alternatively, the inflow capital control precludes optimal collateral allocation and increases the home entrepreneur's dependence on home credit markets. The impulse response analysis conducted above showed that the introduction of these rigidities influence consumption dynamics, and as a result, flow specific capital controls carry consequences for welfare.

Following Rubio and Carrasco-Gallego (2014), we assess the welfare implications of these capital controls by numerically evaluating the welfare derived under each shock. This approach affords a distinction between the welfare of the home household (ω_t^h), entrepreneur (ω_t^e), and FI (ω_t^f) as defined by

$$\omega_t^h = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_h^t \left[\log(C_t^h) + j \log(H_t^h) + \tau \log(1 - N_t)\right], \tag{73}$$

$$\omega_t^e = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_e^t \left[\log(C_t^e)\right], \tag{74}$$

$$\omega_t^f = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_f^t \left[\log(C_t^f)\right], \tag{75}$$

with social welfare given by the weighted sum of individual welfares:

[24] As shown by equation 56, the inflow control sees that declines in B^H raise L. Thus, the attenuation of home loan dynamics under the easy inflow regime are a product of the comparatively larger decline in B^H under this regime.

$$\omega_t = (1-\beta_h)\omega_t^h + (1-\beta_e)\omega_t^e + (1-\beta_b)\omega_t^b. \tag{76}$$

Here, weighting each agent's welfare by their respective discount factor ensures that the household, entrepreneur, and FI all receive the same level of utility from a constant consumption stream. These specifications for the measurement of welfare implies that impulse response function analysis can be used to illustrate the welfare effects of the capital controls.

7.1 Flow specific capital controls and social welfare

The preceding analysis made use of outflow interest rate shocks to assess the impact of the outflow control and inflow interest rate shocks to assess that of the inflow control. Notwithstanding the qualitative similarities between these shocks (see figure 4), it may be beneficial to determine whether the results are driven by this approach. To address these concerns, we compare the welfare implications of each control under both shocks, and plot the social welfare dynamics that result from this exercise in figure 9.

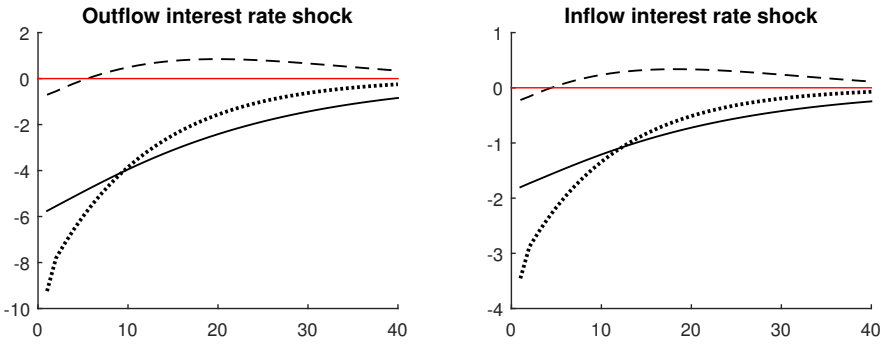

Figure 9: The implications of flow specific capital controls for social welfare following a negative foreign interest rate shock (ε_t^F and ε_t^H). Baseline (no capital controls): solid line. Outflow control only: dashed line. Inflow control only: dotted line.

Figure 9 shows that inflow and outflow interest rate shocks bear qualitatively similar consequences for the dynamics of social welfare, but differ quantitatively. Both shocks realize a reduction in social welfare under the baseline model. The outflow control unequivocally reduces this welfare loss whilst the inflow control is associated with a larger contemporaneous welfare loss. For both shocks, the attenuation of social welfare dynamics under the outflow control is coherent with the analysis in section 6.1. Similarly, the discussion in section 6.3 agrees with the amplified response of social welfare under the inflow control. Therefore, figure 9 indicates that the narratives presented in these sections are not shock dependent.

7.2 Flow specific capital controls and agent welfare

This similarity between inflow and outflow shocks is exploited in figure 10, where we compare the implications of each capital control for agent welfare following an outflow interest rate shock.[25] In the case of the

[25] As in figure 9, making use of an inflow shock does not alter the qualitative implications of these results.

entrepreneur and FI, welfare depends solely on consumption. For the household, welfare depends on a composite of consumption, real estate balances, and leisure time.

The welfare consequences of foreign interest rate shocks are agent dependent. Due to its effect on their wealth, the lower real estate prices that follow the shock negatively affects the household and entrepreneur's consumption streams. In the case of the household, the ensuing reduction in welfare is mitigated through increased leisure time and higher real estate balances.[26] For the entrepreneur, a concomitant increase in their foreign debt negates the consumption cost associated with this decline in their wealth. The FI's consumption depends solely on the size of their balance sheet and the spread between the interest rates on their assets and liabilities. Foreign interest rate shocks shrink their balance sheet and reduce the return on their foreign assets. Thus, whilst the household and entrepreneur are exposed to forces that mitigate their consumption losses, the FI is not. Together with the baseline dynamics of figure 10, this characteristic implies that the baseline social welfare losses depicted in figure 9 are driven by the FI.

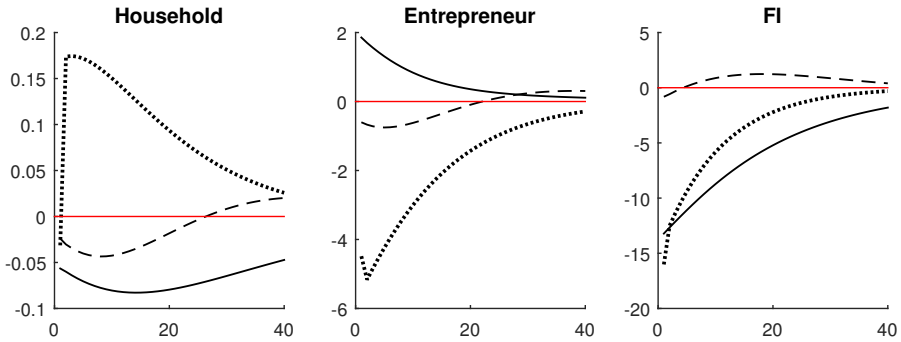

Figure 10: The implications of flow specific capital controls for agent welfare following a negative foreign interest rate shock (ε_t^F). Baseline (no capital controls): solid line. Outflow control: dashed line. Inflow control: dotted line.

The agent specific welfare dynamics of figure 10 illustrate that by preventing optimal collateral allocation, the inflow capital control generates social welfare losses that are driven by the entrepreneur. In this case, reduced access to inflows implies that the inflow control carries a consumption cost for the entrepreneur, and as such, the entrepreneur associates the inflow capital control with welfare losses.[27] In contrast, shock amplification under the inflow control implies that, from the household's perspective, the inflow capital control is associated with welfare gains. These welfare gains stem from amplification of household leisure and real estate dynamics under the inflow control. The FI's welfare dynamics are similar between the baseline model and when the inflow control is present. Here, the quicker recovery of FI balance sheets under the inflow control is negated by the larger initial balance sheet reduction that results from shock attenuation.

The outflow control bears no direct consequences for optimized collateral allocation by the entrepreneur, and affords virtuous spill-over of the foreign collateral value channel to the home economy. This property realizes an improvement on the baseline's dynamics as illustrated by the smaller welfare losses of the household and FI in figure 10. As with the inflow control, the home entrepreneur experiences a welfare loss when

[26] Since the shock is contractionary for the home economy, the demand for labour services declines and real estate shifts from the entrepreneur to the household.

[27] The baseline entrepreneur consumes the increase in foreign debt because of the negative effect that the shock has on home output.

the outflow control binds. Therefore, the outflow control's attenuation of foreign debt dynamics sees that the wealth reduction associated with the shock dominates the entrepreneur's consumption dynamics. Because the outflow control bears no direct influence over collateral allocation, the entrepreneur's welfare loss is smaller than that associated with the inflow control, and so in terms of welfare, each agent strictly prefers the outflow control to the inflow control.

The preferability of the outflow control is consistent with the existing literature and, as per the analysis of section 6, this preference stems from the fact that the outflow control does not directly influence optimal collateral allocation. In previous studies, the welfare benefits of capital controls are predicated on these controls imparting an indirect influence over the borrowing behaviour that they seeks to address. Since this behaviour is optimal in the absence of such a control, capital controls that impart a direct effect on borrowing can reduce welfare by more than the gains stemming from a decrease in the external vulnerability of the economy (see e.g., Arnott et al., 1994; Korinek, 2011). In contrast, capital controls that bear no direct consequences for this borrowing behaviour, but still reduce external vulnerabilities will be welfare enhancing.

Thus, because the outflow capital control is imposed on the financial sector, and not the real sector, it has an indirect effect on the borrowing behaviour exhibited by the real sector (home entrepreneur), and as such, is associated with improvements to the baseline's social welfare dynamics.[28] In contrast, the inflow capital control's manifestation in the real sector implies that it directly affects the borrowing behaviour exhibited by the real sector, culminating in social welfare losses relative to the baseline.

8 Conclusion

This paper investigates the effectiveness of flow specific capital controls as a means to curb the increase in emerging market foreign debt that accompanied the post 2008 low interest rate environment. We contrast the impact of an outflow capital control imposed on the financial sector to an inflow capital control imposed on the real sector.

Both controls are shown to be effective at managing capital flows and can feasibly be implemented by emerging market authorities. The outflow control analysis shows that, in addition to its influence over capital flows, the outflow capital control is an effective insulator from negative foreign interest rate shocks. In contrast, the analysis of the inflow control suggests that its effectiveness at managing capital flows comes at the cost of shock amplification.

The findings indicate that the outflow capital control confers social welfare benefits whilst the inflow capital control is associated with social welfare losses. Social welfare gains under the outflow control stem from the ability of this control to co-exist with optimal collateral allocation. The welfare analysis also shows that each capital control bears different implications for agent welfare. Taken together, this paper points to the comparative desirability of capital controls imposed on the financial sector as opposed to the real sector.

Given the focus of this paper on the ability of capital controls to manage capital flows, the framework deployed in this analysis abstracted from nominal rigidities and the ability of monetary policy and foreign

[28] Although the outflow control does reduce entrepreneur welfare, figure 9 shows that the indirect nature of this influence implies a net welfare gain for the home economy.

reserve accumulation to address such concerns. We leave the introduction of these features for future research.

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A Model equations

Below, we present the full set of model equations for the baseline scenario, i.e. when no capital controls are active. When capital controls are active, section 3.5 shows the changes to the model setup.

A.1 Home households

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_h^t \{log(C_t^h) + jlog(H_t^h) + \tau log(1 - N_t)\} \tag{77}$$

$$C_t^h + q_t(H_t^h - H_{t-1}^h) + D_t = W_t N_t + R_{t-1}^d D_{t-1} \tag{78}$$

$$q_t = \frac{jC_t^h}{H_t^h} + m_t^h \mathbb{E}_t q_{t+1} \tag{79}$$

$$W_t = \frac{\tau C_t^h}{1 - N_t} \tag{80}$$

$$1 = m_t^h R_t^d \tag{81}$$

A.2 Home entrepreneurs

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_e^t \{log(C_t^e)\} \tag{82}$$

$$C_t^e + q_t(H_t^e - H_{t-1}^e) + R_t^l L_{t-1} + S_t R_t^H B_{t-1}^H + W_t N_t = Y_t + L_t + S_t B_t^H \tag{83}$$

$$Y_t = A_t (H_{t-1}^e)^{\alpha} (N_t)^{1-\alpha} \tag{84}$$

$$\mathbb{E}_t R_{t+1}^l L_t \leq \mu \Omega_t \mathbb{E}_t q_{t+1} H_t^e \tag{85}$$

$$S_t \mathbb{E}_t R_{t+1}^H B_t^H \leq (1 - \Omega_t) \mathbb{E}_t q_{t+1} H_t^e \left(1 - \frac{1-\mu}{qH^e} \mathbb{E}_t q_{t+1} (1 - \Omega_t) H_t^e\right) \tag{86}$$

$$W_t = (1 - \alpha) \frac{Y_t}{N_t} \tag{87}$$

$$q_t = \mathbb{E}_t q_{t+1} (\mu \Omega_t \lambda_t^H + \mathbb{E}_t \tilde{\mu}_{t+1} (1 - \Omega_t) \lambda_t^F) + m_t^e \left(\mathbb{E}_t q_{t+1} + \frac{\alpha \mathbb{E}_t Y_{t+1}}{H_t^e}\right) \tag{88}$$

$$1 = \mathbb{E}_t R_{t+1}^l (m_t^e + \lambda_t^H) \tag{89}$$

$$1 = \mathbb{E}_t R_{t+1}^H (\frac{\mathbb{E}_t S_{t+1}}{S_t} m_t^e + \lambda_t^F) \tag{90}$$

$$\mu \lambda_t^H = \mathbb{E}_t \tilde{\mu}_{t+1} \lambda_t^F \tag{91}$$

A.3 Home financial intermediaries

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_f^t \{log(C_t^f)\} \tag{92}$$

$$C_t^f + L_t + S_t B_t^F + R_{t-1}^d D_{t-1} = D_t + R_t^l L_{t-1} + S_t R_t^F B_{t-1}^F \tag{93}$$

$$D_t \leq (1 - \vartheta\varphi_H) L_t + (1 - \vartheta\varphi_F) S_t B_t^F \tag{94}$$

$$m_t^f R_t^d = 1 - \lambda_t^K \tag{95}$$

$$m_t^f \mathbb{E}_t R_{t+1}^l = 1 - \kappa_H \lambda_t^K \tag{96}$$

$$m_t^f \frac{\mathbb{E}_t S_{t+1}}{S_t} \mathbb{E}_t R_{t+1}^F = 1 - \kappa_F \lambda_t^K \tag{97}$$

A.4 Foreign households

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_h^t \{log(C_t^{h*}) + jlog(H_t^{h*}) + \tau log(1 - N_t^*)\} \tag{98}$$

$$C_t^{h*} + q_t^* (H_t^{h*} - H_{t-1}^{h*}) + B_t^H = W_t^* N_t^* + R_t^H B_{t-1}^H \tag{99}$$

$$W_t^* = \frac{\tau C_t^{h*}}{1 - N_t^*} \tag{100}$$

$$q_t^* = \frac{j C_t^{h*}}{H_t^{h*}} + m_t^{h*} \mathbb{E}_t q_{t+1}^* \tag{101}$$

$$1 = m_t^{h*} R_{t+1}^H \tag{102}$$

A.5 Foreign entrepreneurs

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_{e*}^t \{log(C_t^{e*})\} \tag{103}$$

$$C_t^{e*} + q_t^* (H_t^{e*} - H_{t-1}^{e*}) + R_t^F B_{t-1}^F + W_t^* N_t^* = Y_t^* + B_t^F \tag{104}$$

$$Y_t^* = A_t^* (H_{t-1}^{e*})^{\alpha} (N_t^*)^{1-\alpha} \tag{105}$$

$$\mathbb{E}_t R_{t+1}^F B_t^F \leq \mu_* \mathbb{E}_t q_{t+1}^* H_t^{e*} \tag{106}$$

$$W_t^* = (1 - \alpha) \frac{Y_t^*}{N_t^*} \tag{107}$$

$$q_t^* = m_t^{e*} (\mathbb{E}_t q_{t+1}^* (1 + \mu_* \lambda_t^* + \alpha \frac{\mathbb{E}_t Y_{t+1}^*}{H_t^{e*}}) + \mu_* \mathbb{E}_t q_{t+1}^* \lambda_t^* \tag{108}$$

$$1 = \mathbb{E}_t R_{t+1}^F (m_t^{e*} + \lambda_t^*) \tag{109}$$

A.6 Market clearing

$$1 = H_t^h + H_t^e \tag{110}$$

$$1 = H_t^{h*} + H_t^{e*} \tag{111}$$

$$Y_t = C_t^h + C_t^e + C_t^f + S_t(B_t^F - R_t^F B_{t-1}^F + R_t^H B_{t-1}^H - B_t^H) \tag{112}$$

$$Y_t^* = C_t^{h*} + C_t^{e*} + B_t^H - R_t^H B_{t-1}^H + R_t^F B_{t-1}^F - B_t^F \tag{113}$$

$$Y_t^W = Y_t + S_t Y_t^* \tag{114}$$

$$CA_t = S_t(\Delta B_t^F - \Delta B_t^H) \tag{115}$$

$$CA_t^* = \Delta B_t^H - \Delta B_t^F \tag{116}$$

A.7 Technology shocks

The model moments in table 2 are generated following a positive productivity shock in the home country. Supposing that home and foreign technologies are given by A_t and A_t^*, the model setup assumes exogenous technological processes in each country as described by

$$\begin{bmatrix} log(A_t) \\ log(A_t^*) \end{bmatrix} = \begin{bmatrix} \rho & \eta \times \rho \\ \eta \times \rho & \rho \end{bmatrix} \begin{bmatrix} log(A_{t-1}) \\ log(A_{t-1}^*) \end{bmatrix} + \begin{bmatrix} \iota_t \\ \iota_t^* \end{bmatrix} \tag{117}$$

Where $\iota_t \sim N(0, \sigma)$ gives the home technology shock whilst $\iota_t^* \sim N(0, \sigma^*)$ gives that of the foreign country. This specification allows for technological spill-over between countries through the scaling parameter $\eta < 1$. 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 $\eta = 0.1$ such that $\eta \times \rho = 0.09$.

B Data

B.1 Empirical evidence

To generate figure 1, we sum the amount of USD international debt securities outstanding for Chinese and Brazilian non-financial corporations according to the resident definition with that according to the nationality definition. As noted by Shin (2014), this affords inclusion of debt issuances that occur through the foreign branches of these corporations. The data used in figures 1, 2, and 3 were gathered from the following sources:

- Figure 1
  - Brazil USD: Total international debt securities issued by non-financial Brazilian residents + total international debt securities issued by non-financial Brazilian nationals in USD. Source: BIS table C3.

- Brazil local currency: Total international debt securities issued by non-financial Brazilian residents in local currency. Source: BIS table C3.
- China USD: Total international debt securities issued by non-financial Chinese residents + total international debt securities issued by non-financial Chinese nationals in USD. Source: BIS table C3.
- China local currency: Total international debt securities issued by non-financial Chinese residents in local currency. Source: BIS table C3.

- Figure 2
  - Brazil international debt to domestic debt ratio: Total amount of non-financial international debt securities of Brazilian nationals and residents outstanding divided by total amount of non-financial domestic debt securities of residents outstanding. Source: BIS table C3.
  - China international debt to domestic debt ratio: Total amount of non-financial international debt securities of Chinese nationals and residents outstanding divided by total amount of non-financial domestic debt securities of residents outstanding. Source: BIS table C3.
  - Brazil treasury rate: 3-month treasury bill rate. Source: Federal Reserve Bank of St. Louis.
  - China treasury rate: 3-month treasury bill rate. Source: Federal Reserve Bank of St. Louis.
  - U.S. treasury rate: 3-month treasury bill rate. Source: Federal Reserve Bank of St. Louis.

- Figure 3
  - Brazil: Outward FDI stock in advanced countries. Source: UNCTAD Bilateral FDI Statistics 2014.
  - China: Outward FDI stock in advanced countries. Source: UNCTAD Bilateral FDI Statistics 2014.

B.2 Business cycle moments

The data below are used to generate the cross country correlations in table 2. All of the data are denominated in constant 2010 U.S. dollars. We take the natural logarithm of each series and de-trend the data with a quadratic time trend. An emerging market sample is constructed for comparison to country H variables whilst country F moments are compared to a sample of advanced countries. To create the data series for each sample, we sum across countries. Thus, emerging market GDP is given by the sum of Chinese, Brazilian, Russian, South African, Mexican, Turkish, and South Korean GDP in constant 2010 USD. The relevant model variables and data sources are as follows:

- GDP implicit price deflator. Re-based so that 2010=100. Source: U.S. Bureau of Economic Analysis.
- Home country output: Y_t. Current price GDP in national currency converted into USD at spot rate and deflated into 2010 constant USD using the U.S. GDP implicit price deflator. Sample: China, Brazil,

Russia, South Africa, Mexico, Turkey, and South Korea. Time period: 2000Q1–2016Q3. Source: OECD, Board of Governors of the Federal Reserve System.

- Foreign country output: Y_t^*. Current price GDP in national currency converted into USD at spot rate and deflated into 2010 constant USD using the U.S. GDP implicit price deflator. Sample: United States, Japan, United Kingdom, and the Eurozone. Time period: 2000Q1–2016Q3. Source: Eurostat, Japan Cabinet Office, Great Britain Office for National Statistics, Board of Governors of the Federal Reserve System.

- Home country aggregate consumption: C_t. Private final consumption expenditure in national currency converted into USD at spot rate and deflated into 2010 constant USD using the U.S. GDP implicit price deflator. Sample: China, Brazil, Russia, South Africa, Mexico, Turkey, and South Korea. Time period: 2000Q1–2016Q3. Source: OECD, Board of Governors of the Federal Reserve System.

- Foreign country aggregate consumption: C_t^*. Private final consumption expenditure in national currency converted into USD at spot rate and deflated into 2010 constant USD using the U.S. GDP implicit price deflator. Sample: United States, Japan, United Kingdom, Germany, France, Italy, Spain, Netherlands. Time period: 2000Q1–2016Q3. Source: OECD, Board of Governors of the Federal Reserve System.

- Home country real estate price: q_t. Residential price index (2010=100) in national currency converted into constant 2010 USD. Sample: China, Brazil, Russia, South Africa, Mexico, Turkey, and South Korea. Time period: 2001Q1–2016Q3. We aggregate these indices into a single emrging market index by assigning time-varying GDP weights to each country's residential price index.

- Foreign country real estate price: q_t^*. All transactions house price index for the United States, 2010=100. Sample: United States. Time period: 2000Q1–2016Q3. Source: U.S. Federal Housing Finance Agency.

- Home entrepreneur home loans: L_t. Non-financial corporations domestic market debt securities outstanding in constant 2010 USD. Sample: China, Brazil, Russia, South Africa, Mexico, Turkey, and South Korea. Time period: 2000Q1–2016Q3. Source: BIS.

- Home entrepreneur foreign bonds: B_t^H. Non-financial corporations international market debt securities outstanding by nationality and residence in constant 2010 USD. Sample: BIS developing countries. Time period: 2000Q1–2016Q3. Source: BIS.

- Foreign entrepreneur bonds: B_t^F. Total credit to non-financial corporations in constant 2010 USD. Sample: Japan, Euro Area, United Kingdom, United States. Time period: 2000Q1–2016Q3. Source: BIS and Federal Reserve Bank of St. Louis.