Original sin redux: a model-based evaluation*

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Abstract

Using a two-country model, this paper shows that the shift from foreign currency to local currency external borrowing does not eliminate the vulnerability of EMs to foreign financial shocks but instead results in "original sin redux". A monetary tightening abroad is propagated to EM financial conditions through a tightening of foreign lenders' financial constraints, driven in part by currency mismatches on their balance sheets. Foreign exchange intervention and capital flow management measures can mitigate global financial spillovers to EMs in the short run and a larger domestic investor base can reduce the vulnerability in the longer run.

JEL Classification Codes: E3, E5, F3, F4, F6, G1

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1 Introduction

Emerging markets (EMs) have traditionally been unable to borrow abroad in their domestic currency, a phenomenon referred to as "original sin" (Eichengreen and Hausmann (1999)). Foreign currency borrowing and associated currency mismatches make borrower balance sheets vulnerable to exchange rate depreciation, an effect that has played a key role in many of the EM twin exchange rate and financial crises such as the 1997 Asian financial crisis. In the wake of these crises, many EMs have developed and deepened their local currency sovereign bond markets and can now routinely borrow from abroad in their own currency. This is reflected in a significant increase in the share of total external debt liabilities that is denominated in local currency in EMs to levels not far from that prevailing in small open AEs (Figure 1).

However, overcoming original sin has not led to a "redemption". EMs have remained vulnerable to capital flow and exchange rate swings because foreign investors often play an important role in their local currency bond markets (BIS (2019)). Carstens and Shin (2019) refer to the persistent vulnerability of EMs to external shocks as "original sin redux". They argue that EM local currency borrowing from abroad has just shifted currency mismatches to foreign lenders' balance sheets. Moreover, they suggest that the causes of EMs' vulnerability are rooted in the shallowness of their financial markets, making them dependent on external borrowing (irrespective of the currency of denomination) and making it difficult for international lenders to hedge currency risks. This notion of greater shallowness of financial markets in EMs compared to AEs is supported by the observation of significantly smaller sizes of their FX derivatives markets and of their domestic institutional investors, see Figure 1 and CGFS (2019).

This paper provides a model-based evaluation of the original sin redux hypothesis. We set up a quantitative two-country New Keynesian Dynamic Stochastic General Equilibrium (DSGE) model featuring an EM and an AE, deviating from the bulk of the literature which has typically studied spillovers in a small open economy setting.[1] In the model, EM firms borrow from domestic financial intermediaries to finance investment. EM intermediaries in turn obtain their funding from AE financial intermediaries and from domestic households. Both EM and AE financial intermediaries face a Gertler and Karadi (2011) type of funding constraint that is governed by their net worth. The EM government borrows from AE intermediaries in foreign or domestic currency to smooth government spending which impacts the domestic economy through aggregate demand.[2] We consider two scenarios: (i) EM borrowing from abroad in foreign currency (original sin, OS), (ii) EM borrowing from abroad in local currency (original sin redux, OSR).

Based on this quantitative framework, we obtain four main findings. First, in the absence of financial constraints of AE lenders, local currency borrowing eliminates much of the vulnerability to external shocks in the EM. In other words, local currency borrowing does lead to a "redemption" of OS.

Second, when financial frictions are present in both AE and EM financial sectors, an AE monetary tightening spills over to EM financial conditions even under OSR. This is because the shock which originates in the AE leads to a decline in the net worth of AE lenders, limiting their ability to lend to EMs. EM currency depreciation triggers further deterioration in AE financial intermediary balance sheet conditions, limiting their lending capacity even more. Local currency borrowing therefore *does not* eliminate EMs' vulnerability to foreign financial shocks. The effects are however smaller compared to the OS scenario, implying that OSR still yields a reduction in EM vulnerability.

Third, defensive policies such as foreign exchange (FX) intervention and capital flow management measures can mitigate spillovers of foreign financial shocks to EMs under both OS and OSR.

[1] See for instance Adrian et al. (2020), Basu et al. (2020), Engel and Park (2022) and Ottonello and Perez (2019).

[2] Our two-country framework is similar to Banerjee et al. (2016) but extended to include the government sector as well as additional macro-financial stability policy tools which are key extensions to analyse the issue at stake.

In particular, we show that sterilized FX intervention can help mitigate the negative impact of external financial shocks via a "debt limit" channel. A sterilized intervention that sells FX reserves and purchases domestic bonds from domestic financial institutions relaxes their leverage constraint and increases the available funds for lending, thereby mitigating the impact of the shock. On the other hand, FX intervention targeted at agents that are not financially constrained (such as households in our model) does not provide any benefits. As such, our results imply that it is not FX intervention *per se*, but rather liquidity provision by the central bank more generally that matters.

Fourth, in the longer run, financial development is key to reduce EMs' vulnerability to capital flow fluctuations. We find that a larger domestic investor base reduces the impact of external shocks on EM financial and economic conditions under both OS and OSR because greater availability of domestic funding sources reduces the dependence on borrowing from abroad.

The remainder of the paper is structured as follows. This section ends with a brief overview of the related literature. Section 2 presents the model. Section 3 discusses the main results of the model-based comparison of OS and OSR and analyzes policy implications. Section 4 provides empirical evidence on to key predictions of the model. Section 5 concludes.

Literature Review

This paper relates to the large literature on OS, pioneered by Eichengreen and Hausmann (1999) which has emphasized the inability of EMs to issue external debt in domestic currency, giving rise to balance sheet vulnerabilities from currency mismatches. As a result, in EMs, exchange rates may not play the stabilizing role through the standard trade channel that is at the core of the traditional Mundell-Fleming framework (e.g. Aghion et al. (2001), Céspedes et al. (2004) and Cook (2004)).

The subsequent literature has focused on the implications of currency mismatches in small open economy models with financial frictions in the spirit of Bernanke et al. (1999) and Gertler et al.

(2010). Prominent examples of this strand of the literature include e.g. Akinci and Queralto (2018), Aoki et al. (2016), Basu et al. (2020) and Adrian et al. (2020).

Inspired by the global financial cycle hypothesis of Rey (2013) and Kalemli-Özcan (2019), a number of recent papers have shifted the focus of analysis from borrowers' to lenders' balance sheet frictions (e.g. Bruno and Shin (2014), Morelli et al. (2021)). Our framework is related to Banerjee et al. (2016) and Devereux et al. (2020) who also use a two-country DSGE model building on the framework of banking frictions of Gertler and Karadi (2011). Banerjee et al. (2016) show that international monetary policy coordination does not yield welfare improvements compared to optimal self-oriented monetary policies. Devereux et al. (2020) assess how optimal practical rules for monetary policy trading off domestic inflation volatility with foreign factors and financial imbalances can be characterized in financially integrated economies.Our paper differs from these studies in important ways, both in the modeling approach and in the analytical focus. On the modeling side, our model features a fiscal sector which borrows from abroad and influences through adjustments in the fiscal stance private sector balance sheet conditions and hence financial constraints. The focus of our analysis is then on the effect of switching from foreign to local currency denominated external borrowing and the associated policy implications. For this analytical focus, a model featuring a fiscal sector is necessary given that in EMs local currency borrowing from abroad takes place primarily through governments (Du and Schreger (2021)). Another distinguishing analytical focus of our paper is on the role of complementary macro-financial stability tools, FX intervention and capital flow management measures, as well as of longer-term development in mitigating external financial spillover effects.

On the empirical front, there is a growing literature on the financial channel of capital flows and the exchange rate (e.g. Kearns and Patel (2016), Bertaut et al. (2020) Bruno and Shin (2019), Hofmann et al. (2020)). We provide, based on a DSGE model, conceptual support for this empirical evidence, highlighting the critical role of balance sheet constraints on the lenders' side.

Lastly, our paper also links to the literature evaluating the effectiveness of FX intervention in the presence of financial frictions (see for instance Arce et al. (2019), Cavallino (2019), Davis et al. (2023), Devereux and Wu (2022) and Fanelli and Straub (2021)). We contribute to this literature by analyzing how FX intervention can address global financial spillovers also when EMs borrow from abroad in their local currency.

2 Model

The model is an asymmetric two-country New Keynesian model with Advanced Economy (AE) and Emerging Market (EM). The EM constitutes a mass $0 < n < 0.5$ of the world economy, and the AE, constitutes the remaining mass of $(1-n)$. Both economies feature households, capital producers, production firms, financial intermediaries (FIs),[3] and a monetary authority. We introduce a fiscal sector in the EM so the model features both EM sovereign and corporate debt, but we abstract from a sovereign in the case of the AE because it would not add any value given the EM focus of the analysis. The EM borrows from the AE in foreign or local currency (OS and OSR respectively). We provide a graphical representation of the model in Appendix A. The remainder of this section focuses on describing the modeling details and the calibration strategy .

[3] The FIs refer to the financial sector in general, comprising banks and non-bank financial intermediaries such as investment funds, institutional investors and asset managers.

2.1 The emerging market

Household. EM households take consumption and labor supply decisions and trade foreign and domestic financial assets with the objective of maximizing the following utility function:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{(C_t^e)^{1-\sigma}}{1-\sigma} - \chi \frac{(H_t^e)^{1+\psi}}{1+\psi} \right] \tag{1}$$

where C_t^e is a consumption basket and H_t^e is labor supply. σ is the constant relative risk aversion coefficient, χ is the disutility of labor, ψ is the inverse of Frish elasticity.

Denote $C_{e,t}^e$ and $C_{c,t}^e$ to be the EM households' consumption of EM goods and AE goods respectively. The consumption basket and CPI price index takes the following CES form:

$$C_t^e = [(\nu^e)^{\frac{1}{\eta}} (C_{e,t}^e)^{\frac{\eta-1}{\eta}} + (1-\nu^e)^{\frac{1}{\eta}} (C_{c,t}^e)^{\frac{\eta-1}{\eta}}]^{\frac{\eta}{\eta-1}},$$

$$P_t^e = [\nu^e (P_{e,t}^e)^{1-\eta} + (1-\nu^e)(P_{c,t}^e)^{1-\eta}]^{\frac{1}{1-\eta}} \tag{2}$$

where η is the cross-country elasticity of substitution between EM and AE goods, ν^e is the home bias. The EM household budget constraint in nominal local currency terms is:

$$\begin{aligned} P_t^e C_t^e + S_t P_t^c B_t^e + \gamma_B (B_t^e - B_{SS}^e)^2 + P_t^e D_t^e \\ = P_t^e W_t^e H_t^e + \Pi_t^e + R_{t-1}^c S_t P_{t-1}^c B_{t-1}^e + R_{t-1}^e P_{t-1}^e D_{t-1}^e - T_t^e \end{aligned} \tag{3}$$

where S_t is the nominal exchange rate, which is the price of the AE currency in terms of the EM currency so that an EM currency depreciation is an increase in S_t. B_t^e is the EM households' holding of the AE risk-free bond, which is denominated in AE currency and pays a nominal return of R_t^c. D_t^e is the domestic deposit in the EM financial system. W_t^e is the real wage rate. Π_t^e is the total nominal profit from EM firms and financial intermediaries. T_t^e is a lump sum transfer from the government (monetary authority). B_{SS}^e is the steady state EM households' holding of the AE risk-free bond and γ_B is a parameter that introduces a small convex transaction cost in international portfolio adjustment for stationarity as in Schmitt-Grohé and Uribe (2003).

The Euler equation resulting from the household's first order conditions for domestic deposits and foreign bonds in the vicinity of the steady state yields the familiar uncovered interest parity (UIP) condition which determines the evolution of the nominal exchange rate S_t:

$$E_t\left(\frac{S_{t+1}}{S_t}\right) = \frac{R_t^e}{R_t^c} \tag{4}$$

Capital goods producers. Capital producing firms in the EM buy back old capital from financial intermediaries at price Q_t^e (in units of the consumption aggregator) and produce new capital from the final good in the EM economy subject to the following adjustment cost function:

$$\Gamma(I_t^e, I_{t-1}^e) = \varsigma\left(\frac{I_t^e}{I_{t-1}^e} - 1\right)^2 I_t^e \tag{5}$$

where I_t^e is the EM investment in terms of the aggregate EM good.

The EM financial intermediaries then rent the capital to production firms. Denote K_t^e as the capital stock of the EM with the law of motion given by: $K_t^e = I_t^e + (1-\delta)K_{t-1}^e$

Financial intermediaries. The modeling of the financial sector follows Gertler and Karadi (2011). There is a mass n of competitive financial intermediaries. Each period, a fraction $1-\theta$ of the financial intermediaries exit and repatriate all their profits to households. The remaining fraction θ continues to operate and accumulate net worth. To replace the exiting financial intermediaries, the non-FI households are randomly assigned to be new financial intermediaries, with a start up capital of δ_T of existing financial intermediary capital injected by households, to keep the financial intermediary mass constant.[4] Financial intermediaries are subject to an incentive con-

[4] As in Gertler and Karadi (2011), this assumption of a turnover in the financial sector is needed to ensure that financial intermediaries do not accumulate a large enough net worth which would make the leverage constraint irrelevant.

straint described below. The net worth of bank i is denoted by $N^e_{i,t}$.

The banks raise their funds (liabilities) from two sources - loans from global banks and deposits in local currency from domestic household (D^e_t). We denote the loans in the contract currency in real terms (CPI of EM) as $V^e_{i,t}$. FI i's balance sheet in local currency real terms is then given by:

$$N^e_{i,t} + (RER_t)^{ld} V^e_{i,t} + D^e_t = Q^e_t K^e_{i,t} + TB^e_t \tag{6}$$

where $RER_t \equiv \frac{S_t P^c_t}{P^e_t}$ is the real exchange rate and ld (for liability dollarization) is an indicator which is equal to one if the loan is in foreign (AE) currency and zero if it is in local (EM) currency. The term TB^e_t represents a lump sum transfer from the government or the monetary authority.

Each period, the financial intermediary i's real net worth is the return generated from last period investment, minus the debt repayment to AE financial intermediaries and domestic depositors.

$$N^e_{i,t} = R^e_{k,t} Q^e_{t-1} K^e_{i,t-1} - (RER_t)^{ld} \frac{R_{b,t-1}}{(\pi^c_t)^{ld} (\pi^e_t)^{1-ld}} V^e_{i,t-1} - \frac{R^e_{t-1}}{\pi^e_t} D^e_{t-1} \tag{7}$$

where $R^e_{k,t}$ is the real capital rate of return, $R_{b,t-1}$ is the nominal interest rate charged by the AE financial intermediaries, $\pi^c_t \equiv \frac{P^c_t}{P^c_{t-1}}$ and $\pi^e_t \equiv \frac{P^e_t}{P^e_{t-1}}$ are the AE and EM inflation rates.

We model the financial friction following Gertler and Karadi (2011) as an incentive problem. Specifically, at the beginning of each period, the financial intermediary has the ability to abscond with a fraction κ^e_t of the assets. Therefore, lenders will not be willing to lend to the EM financial intermediaries unless the following incentive compatibility constraint is satisfied.

$$J^e_{i,t} \geq \kappa^e_t Q^e_t K^e_{i,t} \tag{8}$$

where $J^e_{i,t}$ is the value function of financial intermediary i at time t.

We limit the share of domestic deposits in the model as a simple way to capture financial sector under-development in EMs. Specifically, we assume that domestic deposits cannot be larger than

$\frac{\varphi_D - 1}{\varphi_D}$ of total liabilities, where $\varphi_D \geq 1$ is an exogenous parameter. In equilibrium, deposits therefore amount to:

$$D^e_{i,t} = (\varphi_D - 1) RER^{ld}_t V^e_{i,t} \tag{9}$$

The maximization problem of EM financial intermediaries is:

$$J^e_{i,t} = \max_{K^e_{i,t}, V^e_{i,t}, D^e_{i,t},} E_t \Lambda^e_{t+1|t} [(1-\theta) N^e_{i,t+1} + \theta J^e_{i,t+1}] \tag{10}$$

subject to eq(6), eq(7), eq(8) and eq(9). $\Lambda^e_{t+1|t} \equiv \beta (\frac{C^e_{t+1}}{C^e_t} \frac{P_t}{P_{t+1}})^{-\sigma}$ is the stochastic discount factor of the household.

The aggregate net worth at any time t is the sum of surviving FIs and newly injected capital ($N^e_t \equiv \int N^e_{i,t} di$) and is given by:

$$N^e_t \equiv \theta \left\{ R^e_{k,t} - \left(\frac{RER_t}{RER_{t-1}} \right)^{ld} \frac{\tilde{R}_{b,t-1}}{\varphi_D} \right\} Q^e_{t-1} K^e_{t-1} + \theta \left(\frac{RER_t}{RER_{t-1}} \right)^{ld} \frac{\tilde{R}_{b,t-1}}{\varphi_D} (N^e_{t-1} - TB^e_{t-1}) + \delta_T Q^e_t K^e_{t-1}$$

where $\tilde{R}_{b,t-1} = [\frac{R_{b,t-1}}{(\pi^c_t)^{ld} (\pi^e_t)^{1-ld}} + \frac{R_{e,t-1}}{\pi^e_t} (\varphi_D - 1)]$ is the average cost of funding for one unit of loan.

Production firms. The productions firms operate as in standard New Keynesian models. There are competitive intermediate firms and monopolistic final goods firms. A representative intermediate firm has the following production function:

$$Y^e_t = A^e_t (H^e_t)^{1-\alpha} (K^e_{t-1})^\alpha \tag{11}$$

For each period, the rate of return on investment for the EM FIs is:

$$R^e_{k,t} = \frac{R^e_{z,t} + (1-\delta) Q^e_t}{Q^e_{t-1}} \tag{12}$$

where $R^e_{z,t}$ is the rental rate on capital and δ is the rate of depreciation of capital.

The competitive assumption yields the following demand functions for capital and labor:

$$MC^e_t(1-\alpha)A^e_t(H^e_t)^{-\alpha}(K^e_{t-1})^{\alpha} = W^e_t \ , MC^e_t(\alpha)A^e_t(H^e_t)^{1-\alpha}(K^e_{t-1})^{\alpha-1} = R^e_{z,t} \tag{13}$$

where MC^e_t is the real marginal cost of production.

Monopolistic final goods firms buy goods from the intermediate firms, re-package them into differentiated goods, and sell them to domestic or foreign households in a monopolistically competitive setting. Several recent papers have emphasized the role of dollar invoicing in understanding the transmission of shocks across countries.[5] To capture this phenomenon, we allow the monopolistic firms to set two different prices, one for the domestic market in the EM currency and one for foreign markets in the foreign currency (DCP). Each of these prices are subject to the staggered setting in Calvo (1983), and the same random fraction $1-\varsigma$ of firms adjusts their prices each period for both currencies. This set up gives rise to two Phillips curves, one for domestic price inflation (($\pi^{PPI}_{e,t}$), and one for export price inflation ($\pi^{*e,c}_t$)).

$$(\pi^{PPI}_{e,t})^{1-\eta} = \varsigma + (1-\varsigma)(\pi^*_{e,t})^{1-\eta}, (\pi^{ec}_{,t})^{1-\eta} = \varsigma + (1-\varsigma)(\pi^{*ec}_{,t})^{1-\eta}$$

$$\pi^*_{e,t} = \frac{\sigma_p}{\sigma_p - 1}\frac{F_{e,t}}{G_{e,t}}\pi^{PPI}_{e,t} \ , \pi^{*e,c}_t = \frac{\sigma_p}{\sigma_p - 1}\frac{F^{e,c}_t}{G^{e,c}_t} \tag{14}$$

$$F_{e,t} = Y_{e,t}MC_{e,t} + E_t[\beta\varsigma\Lambda^e_{t,t+1}(\pi^{PPI}_{e,t+1})^{\eta}F_{e,t+1}], G_{e,t} = Y^{ee}_{,t}P^{ee}_{,t} + E_t[\beta\varsigma\Lambda^e_{t,t+1}(\pi^{PPI}_{e,t+1})^{-1+\eta}G_{e,t+1}] \tag{15}$$

$$F^{e,c}_t = Y^{ec}_t MC^e_t + E_t\left[\zeta\Lambda^e_{t+1}\pi^{ec}_{t+1}F^{ec}_{t+1}\right], G^{ec}_t = Y^{ec}_t P^{ec}_t RER_t + E_t\left[\zeta\Lambda^e_{t+1}{\pi^{ec}_{t+1}}^{(\sigma_p-1)}G^{ec}_{t+1}\right] \tag{16}$$

where σ_p is the cross-good elasticity within the country. $\pi^{PPI}_{e,t}$ is the PPI inflation rate.

Monetary authority. The central bank sets the domestic currency risk-free rate following a

[5] See for instance Akinci and Queralto (2018), Gopinath et al. (2020) and Cook and Patel (2020).

simple inertial Taylor rule of the form:

$$R_t^e = \lambda_r^e R_{t-1}^e + (1-\lambda_r^e)[\lambda_\pi^e(\pi_t^e - \pi_{ss}^e) + \lambda_y^e(Y_t^e - Y_{ss}^e)] + \varepsilon_t^e \tag{17}$$

The central bank is thus assumed to respond to deviations of inflation and output from their steady state levels in an inertial way, captured by the presence of the lagged policy rate in the reaction function.

Fiscal sector. The government borrows directly from the AE financial sector. We model the fiscal entity as an economic agent that maximizes the discounted sum of government spending:

$$\max_{G_t, B_t^{Ge}} E_0 \sum_{t=0}^{\infty} \beta^t \frac{(G_t)^{1-\sigma} - 1}{1-\sigma}$$

The fiscal surplus each period is:

$$surplus_t = \underbrace{\tau \times (\text{firm profit}_t)}_{\text{tax income}} + \underbrace{B_t^{Ge}(RER_t)^{ldg}}_{\text{new debt}} - \underbrace{B_{t-1}^{Ge}(RER_t)^{ldg} \frac{R_{t-1}^G}{(\pi^c)^{ldg}(\pi^e)^{1-ldg}} (\frac{RER_t}{RER_{t-1}})^{ldg}}_{\text{debt repayment}} - \underbrace{G_t}_{\text{spending}} \tag{18}$$

where τ is the tax rate on firm profits, B_t^{Ge} is the amount of government debt in period t and ldg is an indicator to indicate whether the government contract is denominated in foreign currency ($ldg = 1$) or local currency ($ldg = 0$). The government taxes firm profits for the repayment of the debt. Its fiscalpolicy is assumed to follow a simple rule as in Kumhof and Laxton (2013):

$$surplus_t = \alpha_1 + \alpha_2 ln(Y_t^e - Y_{ss}^e) \tag{19}$$

where the parameter α_2 governs the degree of cyclicality of fiscal policy.[6] Thegovernment adjusts

[6]Note that one can combine eq(18) and eq(19) to substitute away the surplus term.

itsspending and borrowing to respond to shocks to the economy. For example, when the government issues debt in foreign currency, a local currency depreciation is associated with an increase in the real value of debt payment, causing G_t to contract and thus reducing output through an aggregate demand channel.

2.2 The advanced economy

AE variables are superscripted with c. The household, capital producer, production firm sectors and monetary policy in the AE are modeled in the same way as in the EM. The modeling of the financial sector is different and is described below.

Financial intermediaries**.** The financial intermediaries directly receive funding from deposits of AE households, invest in the domestic capital stock and make loans to EM financial intermediaries. For the representative AE financial intermediary j, the balance sheet in real terms is given by:

$$N_{j,t}^c + D_{j,t}^c = Q_t^c K_{j,t}^c + V_{j,t}^e/(RER_t)^{1-ld} + V_{j,t}^{Ge}/(RER_t)^{1-ldg} \tag{20}$$

where $N_{j,t}^c$ is the net worth, $D_{j,t}^c$ are deposits from the domestic households in AE and $Q_t^c K_{j,t}^c$ is the investment in the capital stock in the AE.

Each period, financial intermediary j's real net worth is the return generated from last period investment in domestic capital stock and EM loans, less the debt repayment to domestic depositors:

$$\begin{aligned} N_{j,t}^c = \quad & R_{k,t}^c Q_{t-1}^c K_{j,t-1}^c + \frac{R_{b,t-1}}{(\pi_t^c)^{ld}(\pi_t^e)^{1-ld}} V_{j,t-1}^e/(RER_t)^{1-ld} \\ & + \frac{R_{t-1}^{govt}}{(\pi_t^c)^{ld}(\pi_t^e)^{1-ld}} V_{j,t-1}^{Ge}/(RER_t)^{1-ldg} - \frac{R_{t-1}^c}{\pi_t^c} D_{j,t-1}^c \end{aligned} \tag{21}$$

where V_t^e and V_t^{Ge} are the debt supply of the AE financial intermediaries.

Incentive constraint. The AE FIs face the same type of incentive constraint as EM FIs:

$$J^c_{j,t} \geq \kappa^c(Q^c_t K^c_{j,t}) + \kappa_t^{c,EM}[(V^e_{j,t}/(RER_t)^{1-ld} + V^{Ge}_{j,t}/(RER_t)^{1-ldg})] \tag{22}$$

The maximization problem of the AE financial intermediaries is:

$$J^c_{j,t} = \max_{K^c_{j,t}, V^e_{j,t}, V^{Ge}_{j,t}, D^c_{j,t},} E_t \Lambda^c_{t+1|t}[(1-\theta)N^c_{i,t+1} + \theta J^c_{i,t+1}] \tag{23}$$

subject to eq(20), eq(21) and eq(22).

Similar to eq(7), AE FI net worth evolution is given by:

$$\begin{aligned} N^c_t = \quad & \theta\{(R^c_{k,t} - \tfrac{R^c_{t-1}}{\pi^c_t})Q^c_{t-1}K^c_{t-1} + \tfrac{n}{1-n}[(\tfrac{R_{b,t-1}}{(\pi^c_t)^{ld}(\pi^e_t)^{1-ld}} - \tfrac{R^c_{t-1}}{\pi^c_t})(\tfrac{RER_{t-1}}{RER_t})^{1-ld}V^e_{t-1}] \\ & + \tfrac{n}{1-n}[\tfrac{R^{govt}_{t-1}}{(\pi^c_t)^{ld}(\pi^e_t)^{1-ld}} - \tfrac{R^c_{t-1}}{\pi^c_t})(\tfrac{RER_{t-1}}{RER_t})^{1-ldg}V^{Ge}_{t-1}] + \tfrac{R^c_{t-1}}{\pi^c_t}N^c_{t-1}\} \end{aligned} \tag{24}$$

The first order condition w.r.t. $K^c_{j,t}, V^e_{j,t}, V^{Ge}_{j,t}$ are (where γ^c_t is the Lagrangian multiplier associated with eq(22). The market clearing condition is $V^{Ge}_t = B^{Ge}_t$.)

$$\Lambda^c_{t+1|t}\left[(1-\theta) + \theta J^{c'}_{j,t+1}\right]\left[\frac{R^c_{k,t}}{(\pi^c_{t+1})} - \frac{R^c_t}{\pi^c_{t+1}}\right] = \kappa^c_t \gamma^c_t \tag{25}$$

$$\Lambda^c_{t+1|t}\left[(1-\theta) + \theta J^{c'}_{j,t+1}\right]\left[\frac{R_{b,t}}{(\pi^c_{t+1})^{ld}(\pi^e_{t+1})^{1-ld}}\left(\frac{RER_t}{RER_{t+1}}\right)^{1-ld} - \frac{R^c_t}{\pi^c_{t+1}}\right] = \kappa^c_t \gamma^c_t \tag{26}$$

$$\Lambda^c_{t+1|t}\left[(1-\theta) + \theta J^{c'}_{j,t+1}\right]\left[\frac{R^{govt}_{b,t}}{(\pi^c_{t+1})^{ldg}(\pi^e_{t+1})^{1-ldg}}\left(\frac{RER_t}{RER_{t+1}}\right)^{1-ldg} - \frac{R^c_t}{\pi^c_{t+1}}\right] = \kappa^c_t \gamma^c_t \tag{27}$$

Understanding the Mechanism: A first look at the relationship between currency mismatches, exchange rates and lending. Before turning to the full general equilibrium solution and numerical simulation of the model, it is informative to shed light on the key mechanisms at work with a help of simple comparative static exercises based on the equilibrium conditions derived above.

In this class of models, it is straightforward to show that the value of a bank is linear in its net worth when the constraint is binding. Therefore, when the net worth of a bank goes down, the value of a bank also goes down according to eq(21) and tightens the incentive constraint according to (22). This results in a contraction in lending and a higher Lagrangian multiplier γ_t^c. Interest rate spreads of EM borrowing rate (relative to AE deposit rate) rise according to eq (26) and eq(27).

The key factor distinguishing the strength of the spillovers from AEs to EMs is therefore the impact of an EM exchange rate depreciation on the net worth of banks. Table 1 shows the sign of these effects in a partial equilibrium setting based on the net worth equations of a representative bank in EMs and AEs (eq (7) and eq(20) respectively). When EM debt is denominated in dollars ($ld = ldg = 1$), an exchange rate depreciation directly leads to a decline in the net worth of the EM bank, while having no direct effect on the net worth of the AE bank. This is the classical original sin case. Conversely, when EM debt is denominated in local currency ($ld = ldg = 0$), the direct impact of an exchange rate depreciation on EM net worth is zero, but the depreciation has a negative impact on the net worth of AE banks, since their liabilities are in dollars and part of their assets are in the EM currency.

Note that these comparative exercises serve as a useful illustration tool, they are partial equilibrium in nature and do not fully capture the general equilibriun efft of the shock. For instance, a decline in AE net worth under the original sin redux leads to an increase in the borrowing rate charged by AE banks to EM banks, in turn reducing the net worth of the latter. The numerical solution discussed in the subsequent section accounts for these general equilibrium effects, which are nevertheless in line with the partial equilibrium effects obtained from these comparative statics exercises.

2.3 Model calibration

The model is parameterized to quarterly frequency. Table 2 reports the parameters used. We first set the country size of EM (n) to be 0.32, matching the long-term average of aggregate of 16 EM countries' GDP relative to the US GDP.[7]

For the household block, we set risk aversion coefficient (σ) to 2. We set discount factor (β) to be 0.9925, implying a steady state real interest rate of 3%. The home bias in goods for EM and AE are $\nu^e = 0.85$ and , $\nu^c = 0.95$, so that the country-size adjusted openness is 0.9. We set the inverse of Frisch elasticity (ψ) at 2.5, which is the median estimate of a survey paper by Reichling et al. (2015). Disutility of labor (χ) is set at 0.35 such that the steady state labor is normalized to 1. The portfolio adjustment cost parameter (γ_B) is set at 0.0001. In the baseline case, we set the amount of domestic deposit (φ_D) to zero and we investigate the role of domestic deposits in section 3.3.

On the production side, we take a standard capital share (α) value of 0.33. The capital depreciation rate and adjustment costs are set at 0.025 and 8, which are standard values from the literature. The domestic cross good elasticity of substitution (σ_p) is set at 6. We take the cross-country elasticity of good substitution (η) as 1.5, consistent with the trade elasticity estimated by Backus et al. (1992) which is widely used in the literature. The probability of keeping prices fixed (ς, Calvo pricing) is set to 0.82, consistent with the estimate of Justiniano et al. (2011).

The FI block is calibrated such that it matches long-run steady state values of observed data. We calibrate the exogenous survival rate (θ), capital injection share (δ_T), EM and AE financial friction parameters (κ_e,κ_c) such that the model reproduces the following four key moments in the

[7]We follow the approach of grouping EM countries into a block as in Erceg et al. (2006) and Akinci and Queralto (2018). The countries are Brazil, Chile, Colombia, Czech Republic, Indonesia, Israel, Korea, Mexico, Malaysia, Peru, Philippines, Poland, Singapore, Thailand, Turkey and South Africa, which are commonly referred to as inflation targeting EMs. See also Engel and Park (2022) and Devereux and Wu (2022) for a similar set of EMs.

data: 1) an EM government external bond return of 6%, which is the average return of the J.P Morgan Emerging Market Bond Index (EMBI); 2) an EM equity return of 9%, which is the average return of MSCI stock index; 3) & 4) long-run FI leverages of 4.8 and 3.8 for the US and the average of the 16 EMs, respectively.[8] The calibrated values are: $\theta = 0.93$, $\delta_T = 0.0077$, $\kappa_c = 0.4205$ and $\kappa_e = 0.5220$. While these parameter values are calibrated, they are within the range of values that the literature has been using. For example, a survival rate θ of 0.93 has been used in Gertler et al. (2020) and a target leverage of 4 is used in Gertler and Karadi (2011).

On the government side, we calibrate monetary policy such that it plays a minimal role in the baseline case. We set the Taylor coefficient on inflation to be $\lambda_\pi^e = \lambda_\pi^c = 1.01$ and the Taylor coefficient on output gap to be $\lambda_y^e = \lambda_y^c = 0$. We set the persistence on lagged interest rate λ_r to be 0.82, consistent with estimate from Justiniano et al. (2011). We report an extended analysis with different calibrations of monetary policy in the Appendix B.3, showing that our key findings are robust to the specific calibration of the monetary policy rule. On the fiscal side, we estimate the fiscal balance response to quadratically detrended GDP based on a panel dataset by Kose et al. (2022) from 1990-2021, which gives an estimate of 0.3 for the cyclical fiscal reaction parameter (α_2), an estimate consistent with the literature (see Hofmann et al. (2021). α_1 is set to zero so the government does not run perpetual surplus or deficit. We set the steady state government spending to GDP at 4% and tax rate at 20%, matching the average discretionary government spending and tax rate of the 16 EMs.

The model is solved by first-order approximation around the non-stochastic steady state. In the baseline case, we assume that the constraint is always binding.[9] Given our primary interest in understanding the implications of shocks that lead to capital outflows and a depreciation of the EM

[8] These moments are time-series averages over the period 2006-2019. The leverage ratio data is obtained from the World Bank Open Data.

[9] We extend the analysis to an occasionally binding constraint case in section Appendix B.5.

currency, we build the simulation exercise around a 100 basis points increase (tightening) in the AE risk free rate.

3 Original sin vs original sin redux

We simulate the impact of an AE monetary tightening under two different scenarios: (i) without financial friction in the AE financial sector in section 3.1; (ii) with financial friction in the AE financial sector in 3.2. In the appendix, we also analyze the case of FX hedging and different calibrations of the monetary policy rule.

3.1 Absence of advanced economy financial friction

As a benchmark, we first analyze the model dynamics when AE financial constraints are absent, i.e. $\kappa_c = 0$. Figure 2 plots the IRFs (% deviation from the steady-state) for the case of loans from the AE (or global) lenders in foreign currency (original sin, OS: $ld, ldg = 1$, blue dashed lines) and in local currency (original sin redux, OSR: $ld, ldg = 0$, red solid lines) in response to a 100 basis points monetary tightening shock in the AE.

Under both scenarios, the AE monetary tightening is associated with a drop in AE output, a decline in AE FI net worth and an EM currency depreciation.[10] The impact on EM financial conditions and real economy however differ significantly under OS compared to OSR. When the loans are denominated in foreign currency (OS), the EM experiences a significant tightening in financial conditions. The currency depreciation harms EM FIs' net worth due to the currency mismatch between their assets and liabilities. This leads to an increase in borrowing costs, falling asset prices, a credit contraction, and consequently a sharp fall in investment. EM GDP drops by

[10] The impact of the 100 bps monetary policy shock on the AE policy rate itself is smaller at about 80 basis points, reflecting the endogenous response through the Taylor rule.

0.40% at the peak, driven primarily by the drop in real investment.

When loans are denominated in local currency, EM GDP increases relative to the steady-state level on impact. This reflects the conventional trade channel of the exchange rate mainly due to the expenditure switching effect that pushes up EM net exports. The financial channel of the exchange rate is largely absent in this case. Since there is no financial friction in the AE financial sector, the borrowing rate faced by EM intermediaries is effectively unchanged, because the increase in the AE interest rate is compensated by the expected appreciation of the EM currency.

The results of this exercise illustrate the strong macro-financial repercussions of the financial channel of exchange rates operating through EM borrower balance sheets under OS. In the absence of financial frictions on AE balance sheets, local currency debt largely insulates the EM economy from the financial channel by moving the exchange rate vulnerability from the balance sheet of the financially constrained EM financial sector to the unconstrained AE financial sector. We refer to this as “Original sin redemption”.

3.2 Presence of advanced economy financial friction

For the case when financial frictions are also present in the AE financial sector in addition to the EM financial sector, we set κ_c to be the baseline value of 0.4205, as discussed in the calibration above. Figure 3 and figure 4 plot the impulse responses for two cases where there is a 100 basis point monetary tightening shock in the AE in the presence of financial frictions on the side of both AE lenders and EM borrowers.: In figure 3 we show the case of 1) $ld, ldg = 1$ (OS) and 2) $ld, ldg = 0$ (OSR) to demonstrate the difference between OS and OSR. In figure 4 we show the case of 1) $ld, ldg = 1$ (OS) and 2) $ld = 1, ldg = 0$, a more empirically realistic case of foreign currency corporate debt and local currency sovereign debt.

The blue dashed line in Figure 3, which represents the OS case, behaves similar to the blue dashed line in Figure 2. With financial frictions in the AE financial sector, the OS scenario features a stronger reduction in EM GDP by about 1.6% which is as before driven by a large drop in EM investment. The effect is more than three times as large as when there are no financial frictions in AE financial sector, highlighting the importance of these frictions in the transmission of global spillovers.

This is also reflected in the IRFs of the OSR case (red solid lines) in Figure 3, which now behave very differently from the case when there is no AE financial friction (red lines in Figure 2). EM real GDP now drops substantially also under the OSR scenario, by slightly more than 1%. Because AE financial intermediaries face a financial constraint, the reduction in their net worth brought about by the AE monetary tightening translates into a reduction in credit supply to EMs, pushing EM borrowing rates up and EM asset prices and FI net worth down. The unexpected EM currency depreciation erodes the local currency loan return for AE FIs, which further impairs AE FIs' net worth and therefore pushes up the lending rate to EM FIs even more than the monetary tightening.

This shows that once we consider the implications of local currency borrowing in a general equilibrium setting with financial frictions in financial sectors being present globally, local currency borrowing does not imply a redemption from original sin. That said, while the spillovers are qualitatively similar under the OS and OSR scenarios when AE financial frictions are present, the effects are quantitatively smaller under OSR, suggesting that moving from foreign currency to local currency borrowing does yield an improvement in EM resilience to global financial spillovers.

Du and Schreger (2021) show that overcoming the original sin is primarily a feature in the sovereign debt market while the private sector still borrows from abroad mostly in foreign currency. We report this more empirically realistic case of foreign currency corporate debt and local currency sovereign debt in figure 4. The blue dash line in figure 3 and figure 4 are identical, ie. both corporates and sovereigns borrow in foreign currency. The red solid line shows the case of $ld = 1, ldg = 0$, so foreign currency borrowing by the corporate sector and local currency borrowing by the government sector. The IRFs suggest that there are stronger contractionary effects when the government borrows in foreign currency but still significant when it borrows in local currency. When the government borrows in local currency (red lines in figure 4), the AE intermediaries' networth drop is more severe. When the government borrows in foreign currency (blue lines in figure 4) the output reduction is directly impacted by government spending reduction due to the dollar appreciation. This results in a bigger output contraction than the OSR case and still above the OS case.

The results do not hinge in the assumption of unhedgded FX exposures of EM borrowers under OS or AE lenders under OSR. This is shown in Appendix B.1 where we replicate the simulations switching off the exchange rate feedback effect on borrower or lender balance sheets as a simple way to capture the effect of hedging of financial FX risk. Even when the exchange rate amplification effects are switched off, the spillovers are sizable for both OS and OSR, being as before somewhat smaller in the latter case.

3.3 Policy implications

Having established the persistence of spillovers of a foreign financial tightening to EMs under OSR, we next delve into an analysis of policy implications. We assess the usefulness of additional policy tools to address financial spillovers in the context of OSR (local currency debt as the baseline), specifically of FX intervention and capital flow management measures.[11] We also explore the role

[11]The capital flow management tax can be interpreted as a form of macroprudential policy. An alternative macroprudential policy would be one which targets the capital requirement of domestic financial sector. Given our focus on foreign shocks and foreign capital flows and the absence of domestic deposits and investors in the baseline scenario, our model is better equipped to analyze capital flow measures as opposed to domestically oriented macroprudential measures.

of financial development to address the root cause of EMs' vulnerability to spillovers in the longer run. In Appendix B.2, we report results of these policy analyses for the alternative case of foreign currency debt (original sin).

FX intervention. We model (sterilized) FX intervention as in Devereux and Yetman (2014) assuming that FX intervention is conducted with the goal to stabilize the exchange rate around its steady state level. Specifically, we assume that the monetary authority conducts FX intervention by adjusting FX reserves in response to the exchange rate with the following rule:

$$\Delta FR_t = \left(\frac{RER_t}{RER_{SS}}\right)^{\chi} - 1 \tag{28}$$

where RER_{SS} is the steady state RER and χ is a parameter that governs the strength of intervention.

We further assume that changes in FX reserves are financed by lump sum taxes or transfers, which is equivalent to sterilization operations conducted in the form of sales and purchases of sterilization bonds that drain or inject liquidity. We can then express the change in FX reserves in the following way:

$$\Delta FR_t + (1-\Psi)T_t^e + \Psi TB_t^e = FR_t - R_{t-1}^c FR_{t-1} + (1-\Psi)T_t^e + \Psi TB_t^e = 0 \tag{29}$$

where FR_t is the level of FX reserves at time t and Ψ is the share of reserves that is distributed to the financial sector. . We set $\chi = 1$, following estimate of RER and foreign reserves relationship estimated by Choi and Taylor (2022) for developing countries.

Figure 5 shows the impulse responses for an AE monetary tightening shock when FX intervention is activated. We consider two types of FX intervention, namely the case when the sterilization operation targets households ($\Psi = 0$) and alternatively the case when it targets the financial sector ($\Psi = 1$, Equation 29). When households are the counterparty of the sterilization operation, the intervention is essentially ineffective. The IRFs with FX intervention (red dashed lines) are basically identical with those when there is no intervention (blue lines, not visible as superimposed by red lines). This is consistent with the finding of Backus and Kehoe (1989) that FX intervention is ineffective in a frictionless market.

The effectiveness of FX intervention increases substantially when sterilization operations are conducted with the financial sector (yellow dotted lines), as is typically the case in reality. GDP falls much less in this case. The intervention also succeeds in dampening the depreciation of the exchange rate. The main effect of the intervention is however the stabilization of EM FIs' balance sheets through the sterilization operation as it involves selling foreign reserves and transferring the proceeds to FIs. The associated injection of liquid funds frees up resources in the EM financial sector, buffering the drop in net worth and enhancing its lending capacity. This relaxes the financial constraint faced by EM FIs precisely when an exogenous shock tightens it, dampening the fall in investment and ultimately of GDP.

These results illustrate the potential benefits of FX intervention as a stabilizing policy tool. A fully fledged cost-benefit analysis of FX intervention would need to also capture the costs of intervention, specifically the costs of carrying reserves and moral hazard risk that may lead to excessive risk taking by private agents.

Capital flow tax. We next consider the effectiveness of capital flow measures in cushioning the impact of an AE monetary tightening. We illustrate this point by modeling capital flow measures through a time varying tax on cross-border capital flows to the EM. The tax takes the following form:

$$\tau_t^{inflow} = \tau_0 \left(\frac{V_t^e}{V_{steadystate}^e} - 1 \right)$$

This implies that the tax on capital inflows is an increasing function of the total capital inflow into the EM (V_t^e) relative to its steady state value ($V_{steadystate}^e$). Therefore, during episodes of capital outflows, the tax rate decreases to offset the effects of the outflow shock to some extent. Figure 6 shows that having such a tax in place can help cushion the impact of the shock by mitigating the degree to which borrowing costs in the EM rise and depress investment and output. Similar to the case of FX intervention, our results for the capital flow tax are illustrating the potential benefits of having the tool in place, rather than a precise cost-benefit analysis, for which we would have to model the costs of imposing such taxes more realistically.

Financial development. In Figure 7, we compare the effects of an AE monetary tightening shock in an OSR scenario with 25% of the EM FI funds sourced from domestic deposits (red lines) compared to the baseline OSR scenario with no domestic deposits (blue lines). In both cases, AE GDP and FIs' net worth reductions are similar. However, the borrowing rate that the EM faces is much lower in the case with domestic deposits. The smaller increase in the borrowing cost translates into a small reduction of EM FIs' net worth and investment, resulting in a smaller drop in EM GDP.

The reduction in the vulnerability of EMs to foreign shocks when the domestic investor base is larger occurs via two channels. First, domestic investors evaluate their returns in the domestic currency. As a result, there is no currency mismatch problem on either the borrower or the lender's balance sheet. Second, lending from the domestic investor base to the domestic firm is only subject to one layer of financial frictions, namely those involving the domestic FIs. On the other hand, lending from foreign investors is subject to two layers of financial frictions - those involving the foreign and the domestic FIs respectively. Since the reduction in credit supply in the wake of an AE monetary tightening is to a significant extent transmitted through the financial constraints of the AE financial sector, reducing dependence on this source of funding also reduces vulnerability to foreign financial shocks.

The beneficial effects of a deeper domestic investor base suggested by the analysis in this section should not be interpreted as supporting financial autarky. They should rather be seen as offering support to policies that promote deep and liquid financial markets which would allow EM borrowers to shift funding from foreign to local markets in the face of external shocks. Moreover, domestic investors investing abroad form a natural counter-party for foreign lenders or EM financial intermediaries looking to hedge EM currency exposure, since the former are long foreign currency and short local currency. They therefore promote the development of FX derivatives markets that enable access to the benefits of hedging currency exposures illustrated in Appendix B.1.

4 Evidence

The main prediction of the model is that in response to a US monetary tightening, EM output, in particular investment, falls significantly under foreign currency external borrowing (OS) and somewhat less but still significantly under local currency external borrowing (OSR) due to AE financial frictions. We first test these predictions of the model for the spillover effects of US monetary policy shocks on real investment in EMs and AEs. In the next step, we then assess how the spillovers operate through FI net worth in both EMs and in the US, which is the core transmission mechanism in our model.

Spillover effects on investment. We conduct a panel analysis using quarterly cross-country data on investment and external borrowing by currency for a group of 16 EMs (the same group of EM inflation targeters in the calibration section) and 20 AEs.

In order to assess how the response of real investment to a US monetary tightening shock depends on the currency denomination of external debt and how the effect differs between EMs and AEs, we estimate a panel regression model specified as as follows:

$$
\begin{aligned}
y_{i,t+h} - y_{i,t-1} = {} & \alpha_{os} os_{it-1} + \alpha_{osr} osr_{i,t-1} + \alpha_D D_{i,t-1} + \beta_r \triangle r^{us}_{t-1} \\
& + \beta_{os} * \triangle r^{us}_{t-1} * os_{it-1} + \beta_{osr} \triangle r^{us}_{t-1} * osr_{it-1} \\
& + \beta_D \triangle r^{us}_{t-1} * D_{it-1} + \beta_X X_{i,t-1} + \alpha_t + \alpha_i + \varepsilon_{i,t}
\end{aligned}
\tag{30}
$$

We measure original sin (os_{it}) by the ratio of USD denominated external debt to GDP, and original sin redux (osr_{it}) by the ratio of local currency denominated external debt to GDP.[12] D_{it} is the ratio of total external debt to GDP (including USD, local currency and all other foreign currencies). $\triangle r^{us}_{t-1}$ is the US monetary policy shock, computed using the narrative approach of Romer and Romer (2004) (updated to 2012 based on the subsequently available data). $X_{i,t-1}$ are additional controls including lagged values of the change in the VIX (as a proxy for global investor risk aversion), the change in the domestic policy rate, and US and domestic GDP growth and inflation. We use the pooled as well as fixed effects OLS estimators and cluster standard errors by country.

Table 3 present the results for EMs (columns 1 and 2) and AEs (columns 3 and 4). To focus on the main results, we report only the relevant coefficients and refer the readers to the Appendix B.4 for full regression tables. We focus on the two year (8 quarter) horizon, matching the period of peak investment impact in our model simulations (Figure 3). The results are in line with the predictions of the model. For EMs, we find that higher degrees of OS tend to lead to statistically sharper declines in investment in EMs in response to a US monetary contraction ($\beta_{os} < 0$). This is the canonical OS effect that has been studied in the literature. Second, even after controlling for OS, higher local currency borrowing from abroad (OSR) also leads to a statistically sharper decline in investment in response to the shock ($\beta_{osr} < 0$), albeit with a lower magnitude than OS. This is, to our knowledge, the first macro-level evidence in favor of the OSR hypothesis,[13] and confirms

[12] We linearly interpolate the annual data for these variables to quarterly frequency. Furthermore, we regress osr_{it} on os_{it} in a first stage regression and use residuals from this regression to avoid issues associated with multicollinearity.

[13] See Bertaut et al. (2023) for additional micro-level evidence.

the message from the model that while local currency borrowing yields an improvement, it does not yield redemption from OS. We do not see a significant effect of either original sin or its redux for AEs (columns 3 and 4), suggesting that despite borrowing substantially from abroad in both local and foreign currency, AEs are not as vulnerable to external shocks as EMs due to their deeper financial markets.

The net worth mechanism. The net worth of EM and US FIs is a key conduit for the spillovers of US monetary policy to EMs in our model. To examine whether this mechanism is borne out in the data, we we conduct two empirical exercises to assess the impact of US monetary policy shocks on FI net worth and how it is related to OS and OSR.

First, we use annual data on bank capital to total assets (a proxy for net worth) from the World Bank as the dependent variable in equation 30. Panel (a) in Table 6 summarizes the results. The coefficients on the interaction terms between the US monetary policy shock and our measures of OS and OSR are in line with the predictions of the model. In particular,the negative impact of a US monetary tightening on net worth of EM financial intermediaries increases significantly in the degree of OS and it increases less strongly but also significantly in the degree of OSR. This is exactly what we find in our model simulations.

Second, we use quarterly data on US intermediary capital ratios from He et al. (2017) to assess the impact of the US monetary policy shock on US FI net worth and how it interacts with OS and OSR in EMs. In our model, movements in the net worth of lenders (US financial intermediaries) is a key transmitter of spillovers to EMs, dropping more strongly under OSR than under OS. To test this implication of the model, we estimate the following quarterly regression:

$$
\begin{aligned}
y_{t+h} - y_{t-1} = {} & \alpha_l y_{t-1} + \alpha_{og} og_{t-1} + \beta_r \triangle r^{us}_{t-1} + \beta_{og} * \triangle r^{us}_{t-1} * og_{t-1} \\
& + \beta_D \triangle r^{us}_{t-1} * D_{t-1} + \alpha_D D_{t-1} + \beta_X X_{t-1} + \varepsilon_t
\end{aligned}
\tag{31}
$$

where y is the log of the US intermediary capital ratio (proxy for the net worth). og measures the relative degree of global original sin redux to original sin ratio as the share of total EM external debt liabilities in local currency in total EM external debt liabilities, constructed based on Benetrix et al. (2019) dataset. D_t is the ratio of total (across all currencies) EM external debt liabilities to GDP. $\beta_{og} < 0$ would suggest that an increase in the original sin redux relative to original sin would imply a sharper fall in the capital ratio (corresponding to a sharper decline in net worth) for the US FIs, as predicted by our model.

Table 6, panel (b), shows the results of the estimation results for a four quarter horizon, again corresponding to the peak impact period in our model simulations. The sign of β_{og} is negative and significant, especially when additional controls like US GDP and inflation are accounted for. These results suggest that, all else equal, the net worth of US FIs falls more strongly in response to a US monetary contraction when US FIs face higher levels of original sin redux relative to original sin in EMs, as predicted by the model.

5 Conclusion

The results of our model-based analysis highlight that while EMs can reduce their vulnerability to external financial shocks by overcoming OS and borrowing in domestic currency, they cannot fully eliminate it if AE lenders are financially constrained and domestic financial markets remain shallow. Activation of additional policy tools, such as FX intervention and capital flow measures, can help address the persisting challenges faced by EMs from fluctuations in global financial conditions. These results are consistent with the observation that EMs have remained vulnerable to capital flow swings even after overcoming OS and that they have responded to this challenge through a pragmatic design of their macro-financial stability frameworks, commonly combining inflation targeting with FX intervention, macroprudential tools and capital flow management measures (BIS (2019)). In the longer run, reducing vulnerability to external shocks requires addressing its root cause, which is the shallowness of EM financial markets reflected in particular in a thin domestic investor base.

There are several directions for further research. For instance, in the different scenarios considered in this paper, the currency of denomination of debt and the share of domestic deposits are held fixed. While this appears to be a restrictive assumption, there is a large body of evidence documenting that sources of funding (for both firms and financial institutions) are fairly sticky, especially at business cycle frequencies considered in this paper.[14] Nevertheless, allowing for endogenous switching between sources and currency of funding would be an interesting extension of our analysis going forward.[15]

The focus of the paper is positive and we do not explore implications for optimal policy. An extension of the analysis to characterize optimal policy in the presence of multiple policy instruments could be a useful avenue for future research against the background of the ongoing debate about the design of macro-financial stability frameworks in EMs.

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[14] See for instance Khwaja and Mian (2008), Jiménez et al. (2012) and Paravisini (2008).

[15] A number of papers have conceptually analyzed specific aspects of the currency compositions of sovereign and private debt. Sovereign currency composition has been studied in Du et al. (2020); Engel and Park (2022); Ottonello and Perez (2019); Devereux and Wu (2022), highlighting the role of monetary credibility and ability to conduct foreign exchange intervention. Private currency composition has been studied in Gopinath et al. (2020); Drenik et al. (2022); Salomao and Varela (2022), highlighting the role of hedging revenue, interest rate saving and redistribution concerns.

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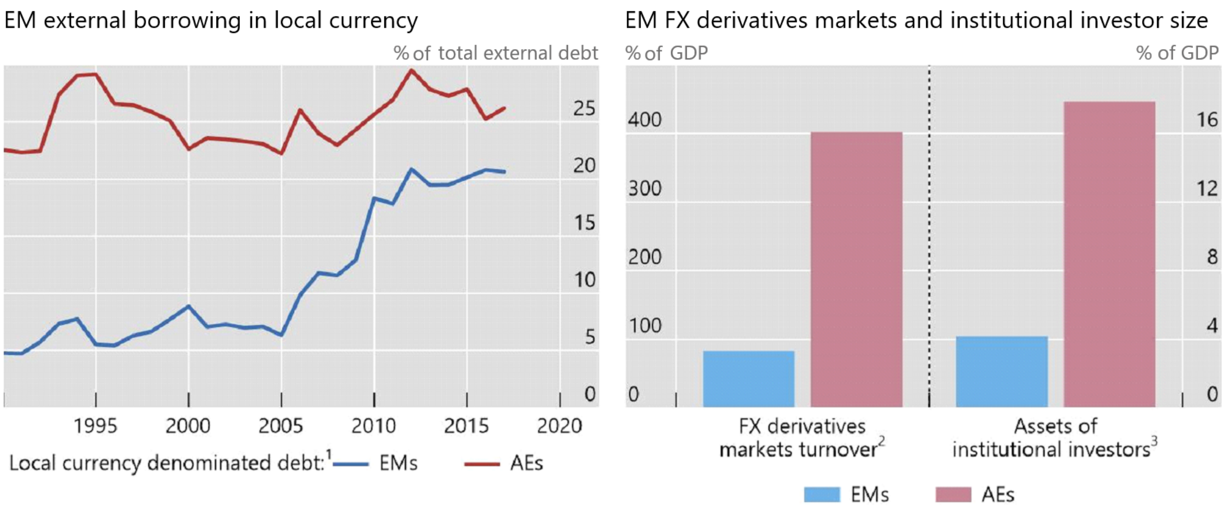
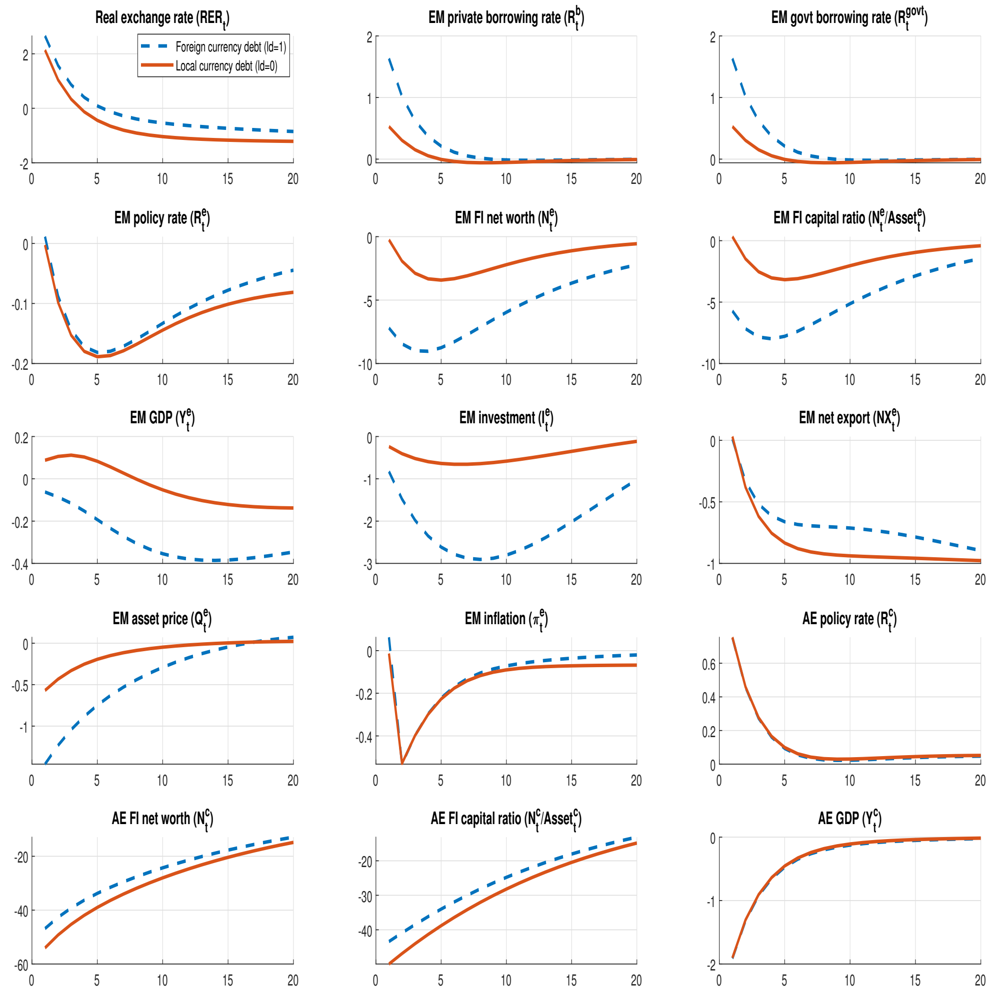
Figure 1: EM external borrowing and financial market shallowness



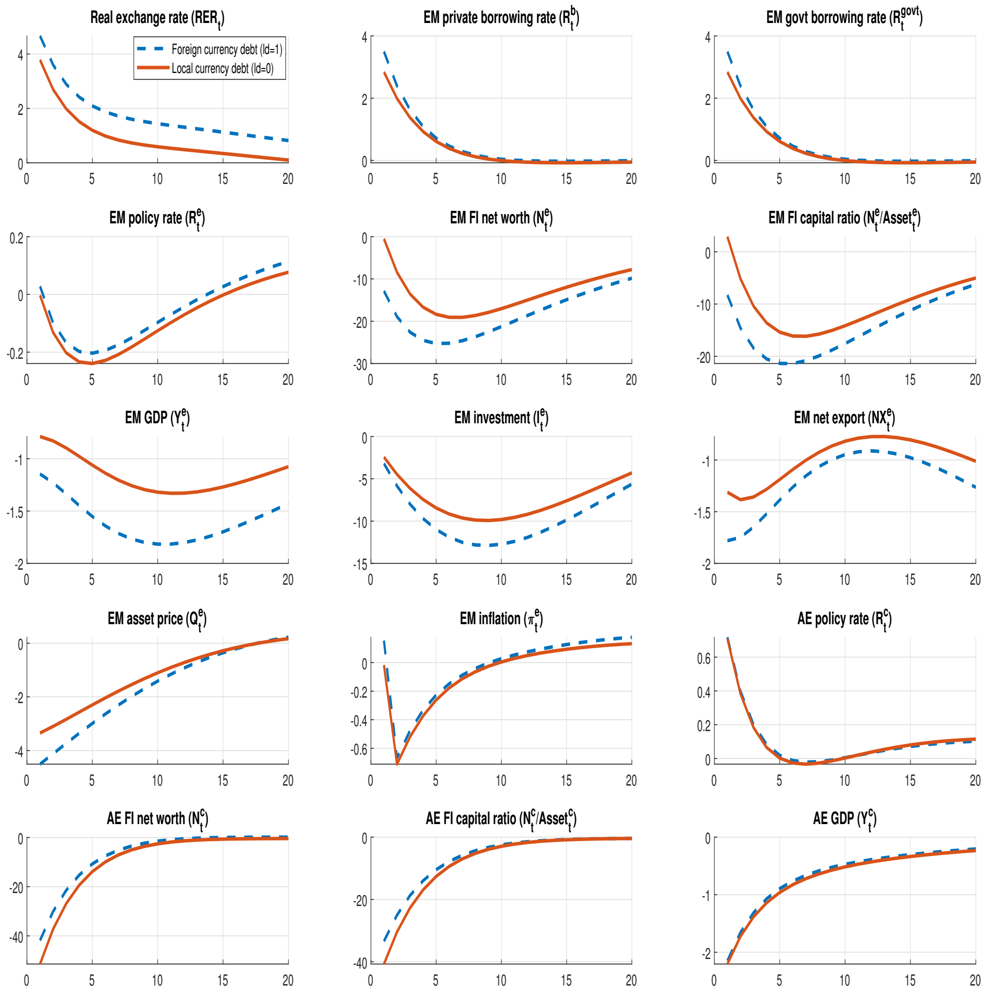
Notes: 1. Median across a balanced sample of 16 EMEs and 8 AEs. For EMs, BR, CL, CO, CZ, ID, IL, KR, MX, MY, PE, PH, PL, SG, TH, TR and ZA. For AEs, AU, CA, CH, DK, GB, JP, NO and NZ. 2. Average daily turnover in FX derivatives markets. Medians based on a sample of 16 EM currencies and 6 AE currencies. For EMs, BRL, CLP, COP, CZK, IDR, INR, KRW, MXN, PEN, PHP, PLN, THB, TRY and ZAR. For AEs, AUD, CAD, GBP, NOK, NZD and SEK. 3. Sample medians based on 8 EMEs and 3 AEs. For EMs, BR, CL, ID, KR, MX, TR and ZA. For AEs, AU, CA and GB. Source: Benetrix et al. (2019); BIS triennal survey (2016); BIS.

Figure 2: Advanced economy monetary tightening without global lender financial friction



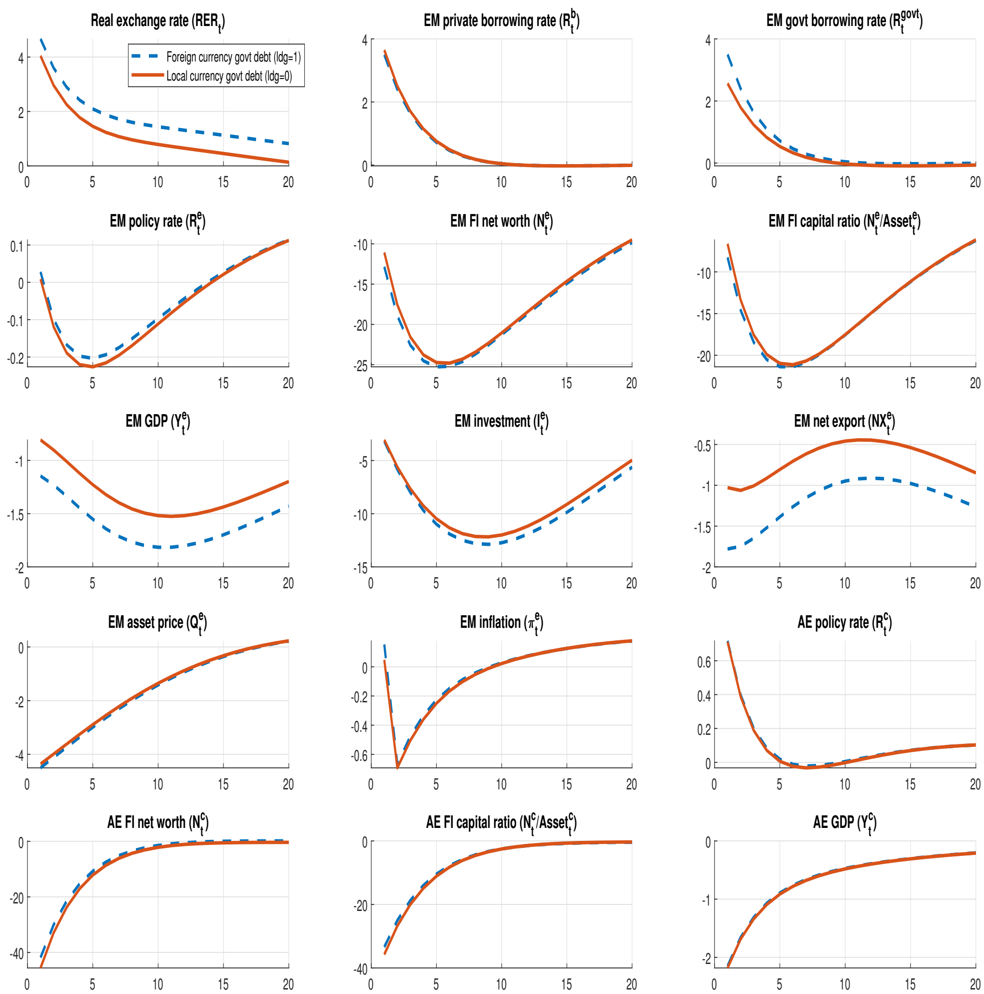
Notes: Simulations for $\kappa^c = 0$, i.e. the case when the AE financial intermediaries are unconstrained. The figure shows impulse responses (percentage deviations from steady state) to a 100 basis points increase in the advanced economy policy (risk-free) rate.

Figure 3: Advanced economy monetary tightening with global lender financial friction



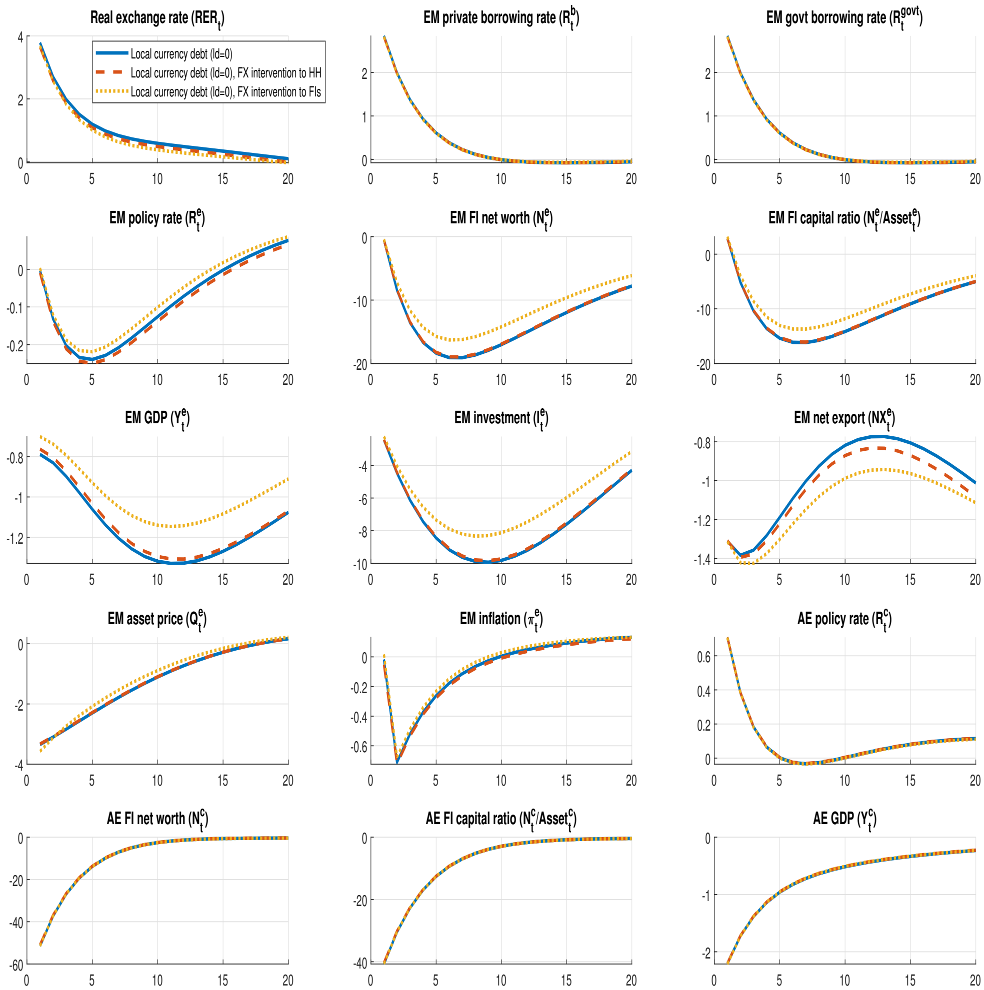
Notes: Simulations for $\kappa^c = 0.4205$, the case when the AE financial intermediaries are constrained and calibrated to empirical long-term intermediary leverage. The figure shows impulse responses (percentage deviations from steady state) to a 100 basis points increase in the advanced economy policy (risk-free) rate.

Figure 4: Foreign and local currency sovereign debt with foreign currency debt in the EM FI sector and AE financial friction



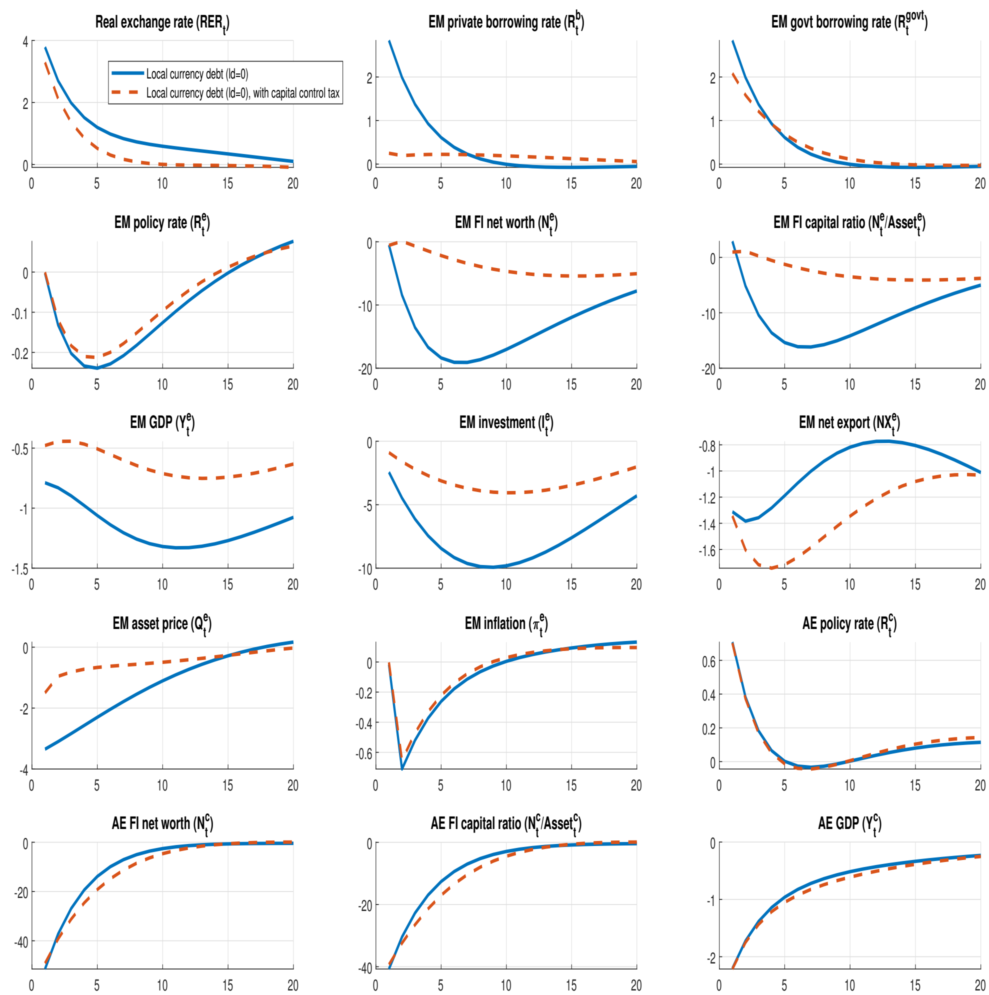
Notes: Impulse responses to a 100 basis points increase in the AE risk-free rate. Percentage deviations from steady state. The figure shows impulse responses (percentage deviations from steady state) to a 100 basis points increase in the advanced economy policy (risk-free) rate.

Figure 5: Advanced economy monetary tightening: the role of sterilized FX intervention



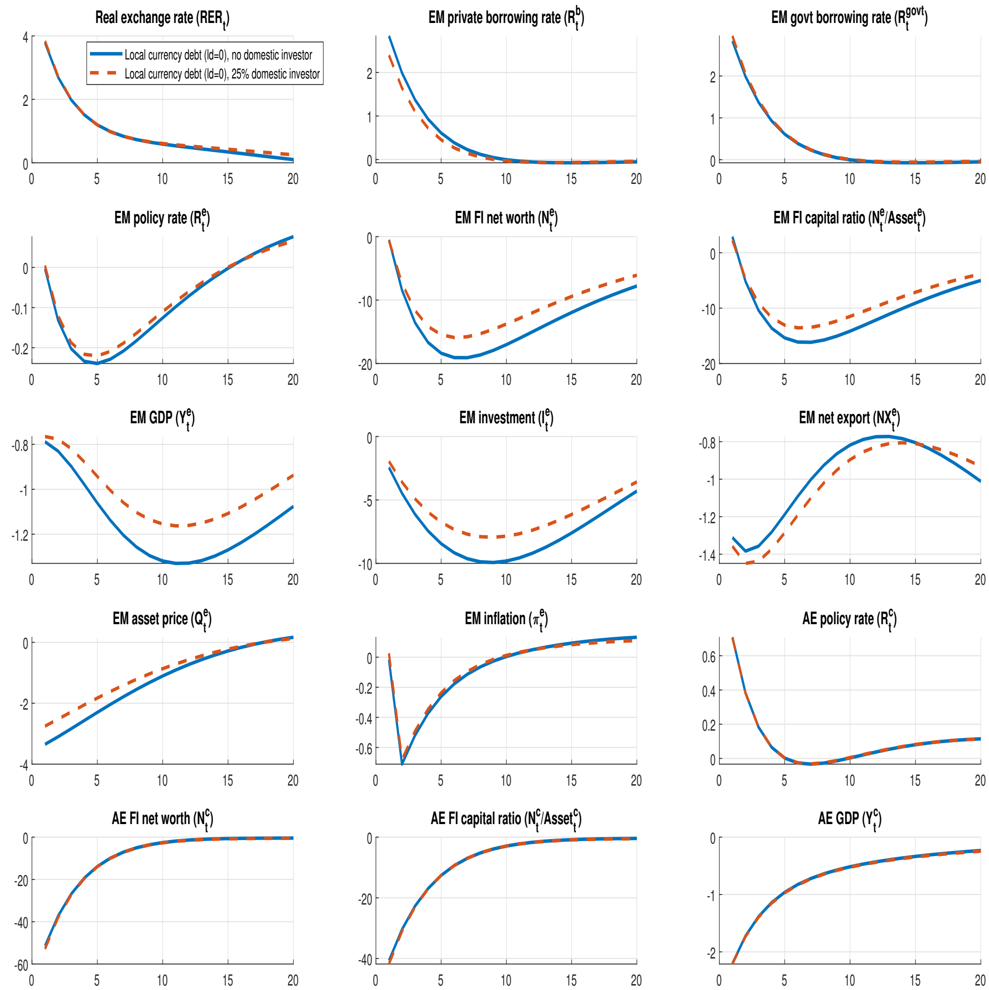
Notes: Simulations under the assumption that the EM follows a FX intervention rule in response to exchange rate deviation (RER_t) from the steady state. The figure shows impulse responses (percentage deviations from steady state) to a 100 basis points increase in the advanced economy policy (risk-free) rate.

Figure 6: Advanced economy monetary tightening: the role of capital flow tax



Notes: Simulations under the assumption that the EM follows a capital flow tax rule in response to private external credit (V_t^e) deviation from the steady state. The figure shows impulse responses (percentage deviations from steady state) to a 100 basis points increase in the advanced economy policy (risk-free) rate.

Figure 7: Advanced economy monetary tightening: the role of the domestic investor base



Notes:Simulations under the assumption that 25% of the EM financial intermediaries deposit are funded by domestic depositors (as opposed to 0% under the baseline case). The figure shows impulse responses (percentage deviations from steady state) to a 100 basis points increase in the advanced economy policy (risk-free) rate.

Table 1: Direct (Partial Equilibrium) Impact of Exchange Rate on Net Worth of AE and EM Banks

	Networth change of EM banks ($\frac{\partial N^e_{i,t}}{\partial RER}$)	Networth change of AE banks ($\frac{\partial N^c_{i,t}}{\partial RER}$)
Original Sin ($ld = ldg = 1$)	$\frac{-R_{b,t-1}}{(\pi^c_t)^{ld}(\pi^e_t)^{1-ld}} V^e_{i,t-1} < 0$	0
Original Sin Redux ($ld = ldg = 0$)	0	$-\frac{1}{(RER_t)^2}\left[\frac{R_{b,t-1}}{(\pi^c_t)^{ld}(\pi^e_t)^{1-ld}} V^e_{j,t-1} + \frac{R^{govt}_{t-1}}{(\pi^c_t)^{ld}(\pi^e_t)^{1-ldg}} V^{Ge}_{j,t-1}\right] < 0$

This table shows the sign of the direct, partial equilibrium response of EM and AE net worth to an increase in the EM real exchange rate (EM depreciation), based on equations 7 and 20.

Table 2: Model calibration

Variable	Definition	Value	Notes
Household			
σ	Household risk aversion	2	Standard
ν^e, ν^c	Trade openness	0.85, 0.95	Size adjusted openess of 0.9
β	Discount factor	0.9925	3% real interest rate
ψ	Inverse of Frisch elasticity	2.5	Reichling et al. (2015)
γ_B	Portfolio adjustment cost	0.0001	
Trade / goods markets			
n	Size of EM	0.32	Sum of 16 EMs
ς	Prob. of price fixed (Calvo)	0.82	Justiniano et al. (2011)
η	Cross-country elasticity	1.5	Backus et al. (1992)
σ_p	Domestic cross-good elasticity	6	Standard
Financial sector			
θ	FI survival rate	0.93	Jointly calibrated to match
δ_T	FI capital injection share	0.0077	EM bond return of 6% (average of EMBI),
κ^e	Divertable fraction in EM	0.5220	EM equity return of 9% (average of MSCI),
κ^c	Divertable fraction in AE*	0.4205	and 16 EMs and US financial
			leverage of 3.8 and 4.8
Capital producer			
ς	Capital adjustment cost	8	Standard
δ	Capital depreciation	0.025	Standard
Monetary authority			
$\lambda_r^e = \lambda_r^c$	Monetary policy persistence	0.82	Justiniano et al. (2011)
$\lambda_\pi^e = \lambda_\pi^c$	Taylor coefficient on inflation	1.01	Minimal (see Appendix B.3 for robustness)
$\lambda_y^e = \lambda_y^c$	Taylor coefficient on output gap	0	Minimal (see Appendix B.3 for robustness)
Fiscal sector			
α_2	Fiscal response to output fluctuation	0.3	Estimated from Kose et al. (2022)
τ	Tax rate	0.2	Average of 16 EMs
G^{SS}/GDP	Steady state govt spending to GDP	0.04	Average of EMs discretionary spending

*Notes: These parameters change across exercises.

Table 3: Impact of a US monetary tightening on real investment

Regression of eq(30) with change in log real investment				
	(1)	(2)	(3)	(4)
	Eight quarter change in log real investment			
	EMs		AEs	
$\triangle r^{us}_{t-1} * osr_{it-1}$	-0.32**	-0.23**	-0.013	-0.011
	(0.13)	(0.11)	(0.019)	(0.018)
$\triangle r^{us}_{t-1} * os_{it-1}$	-0.43**	-0.31**	-0.049	-0.031
	(0.16)	(0.11)	(0.073)	(0.074)
$osr_{i,t-1}$	-0.35***	-0.24	-0.057*	-0.086
	(0.11)	(0.30)	(0.031)	(0.059)
os_{it-1}	-0.33**	-0.23	-0.041	-0.13
	(0.12)	(0.36)	(0.086)	(0.20)
p($\triangle r^{us}_{t-1} * osr_{it-1}$=$\triangle r^{us}_{t-1} * os_{it-1}$)	0.049**	0.078*	0.54	0.74
Observations	1,051	1,051	1,491	1,491
R Squared	0.103	0.185	0.257	0.326
Number of Countries	16	16	20	20
Sample	EM	EM	AE	AE
Country FE	NO	YES	NO	YES

Notes: *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors clustered by country in parentheses. See Appendix B.4 for the full table with all the coefficients reported. Sample includes 16 EMs (BR, CL, CO, CZ, ID, IL, KR, MX, MY, PE, PH, PL, SG, TH, TR, ZA) and 20 AEs (AT, AU, BE, CA, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, JP, NL, NO, NZ, PT, SE). p($\triangle r^{us}_{t-1} * osr_{it-1}$=$\triangle r^{us}_{t-1} * os_{it-1}$) reports the p-value of statistical test of whether the coefficients of $\triangle r^{us}_{t-1} * osr_{it-1}$ and $\triangle r^{us}_{t-1} * os_{it-1}$ are different. Estimates based on equation 30 at a eight-quarter horizon.

Table 4: Impact of a US monetary tightening on financial intermediary net worth

Regression of eq(30) with change in log EM capital ratio
Regression of eq(31) with change in log US capital ratio

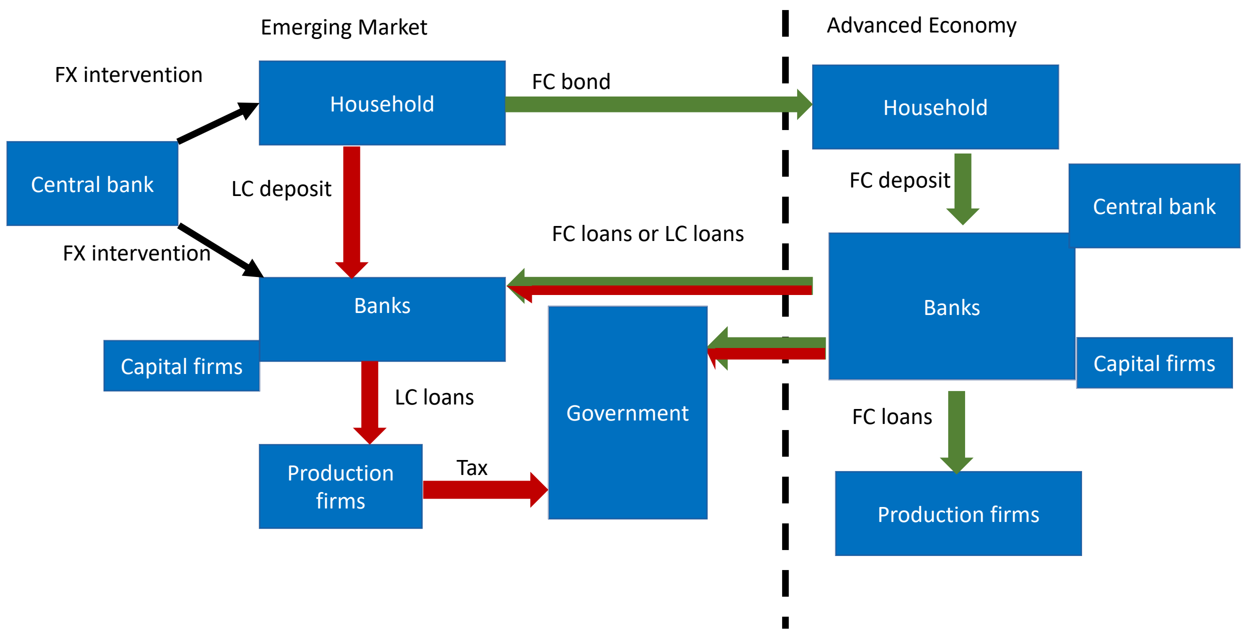
(a) $\triangle ln(CapitalRatio_{EM})$		(b) $\triangle ln(CapitalRatio_{US})$		
$\triangle r^{us}_{t-1} * osr_{it-1}$	-0.22*	$\triangle r^{us}_{t-1} * og_{t-1}$	-0.67*	-0.92***
	(0.12)		(0.36)	(0.31)
$\triangle r^{us}_{t-1} * os_{it-1}$	-0.40**	og_{t-1}	0.017	-0.11
	(0.16)		(0.15)	(0.16)
$osr_{i,t-1}$	-0.63			
	(0.47)			
os_{it-1}	-0.66			
	(0.38)			
p($\triangle r^{us}_{t-1} * osr_{it-1}$=$\triangle r^{us}_{t-1} * os_{it-1}$)	0.0028***			
Observations	101	Observations	73	73
R Squared	0.383	R-squared	0.142	0.294
Number of Countries	16			
Sample	EM			
Country FE	Yes			

Notes: * p<0.1, ** p<0.05, *** p<0.0. Robust standard errors are reported in parentheses (clustered by country for panel a). See Appendix B.4 for the full table with all the coefficients reported. Dependent variable for panel (a) is the two year change (based on annual data) in the bank capital to asset ratio (cross-country data sourced from the World Bank). Dependent variable of Panel (b) is is four quarter percentage change in log of Intermediary Capital Ratio for the US based on He et al. (2017). og denotes the ratio of global EM debt liabilities in local currency to total EM debt liabilities in USD and local currency, expressed in logs. $\triangle r^{us}_{t-1}$ denotes US monetary policy shocks identified using the narrative approach of Romer and Romer (2004). p($\triangle r^{us}_{t-1} * osr_{it-1}$=$\triangle r^{us}_{t-1} * os_{it-1}$) reports the p-values of statistical test of whether the coefficients of $\triangle r^{us}_{t-1} * osr_{it-1}$ and $\triangle r^{us}_{t-1} * os_{it-1}$ are different.

Appendix

A Graphical representation of the model

Figure 8: Graphical representation of the model



Notes: FC = foreign currency; LC = local currency

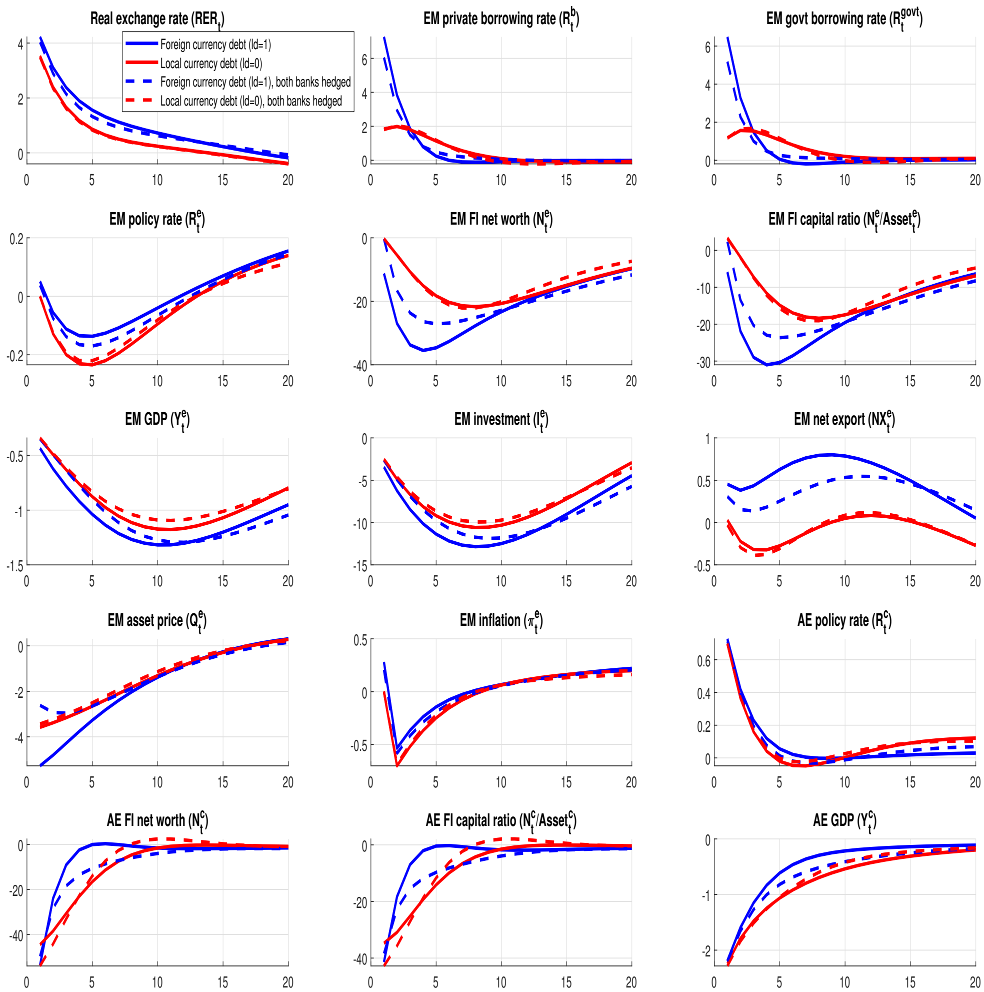
B Additional IRFs

B.1 Exchange rate amplification effects and FX hedging

In the presence of financial frictions on the side of AE lenders, the overall impact of an AE monetary tightening on financial conditions in EMs is the result of two effects: (i) the direct effect of the monetary tightening on the AE lender balance sheet constraining credit supply to EMs; and (ii) the amplification effect of the associated depreciation of the EM currency working through the borrower (OS) or lender (OSR) balance sheet. In order to disentangle the two effects, we replicate the simulations switching off the exchange rate feedback effect on borrower or lender balance sheets.

The results of this exercise are shown in Figure A.1. The solid lines replicate the baseline results shown in the previous sub-section, the broken lines show the effects when exchange rate feedback effects through borrower and lender balance sheets are switched off. The figure reveals that both under OS and OSR the amplification effects through exchange rate depreciation are considerable. The effects are materially reduced when the financial channel of the exchange rate is deactivated, but they remain economically significant. Thus, seen from a different perspective, these results suggest that the significance of the spillover effects of an AE monetary tightening do not hinge on the balance sheet effects of exchange rate depreciation alone. Even when the exchange rate amplification effects are switched off, the spillovers are sizable for both OS and OSR, being as before somewhat smaller in the latter case.

Figure A.1: Advanced economy monetary tightening: the role of financial exchange rate amplification effects



Notes: Impulse responses to a 100 basis points increase in the advanced economy risk-free rate. Percentage deviations from steady state.

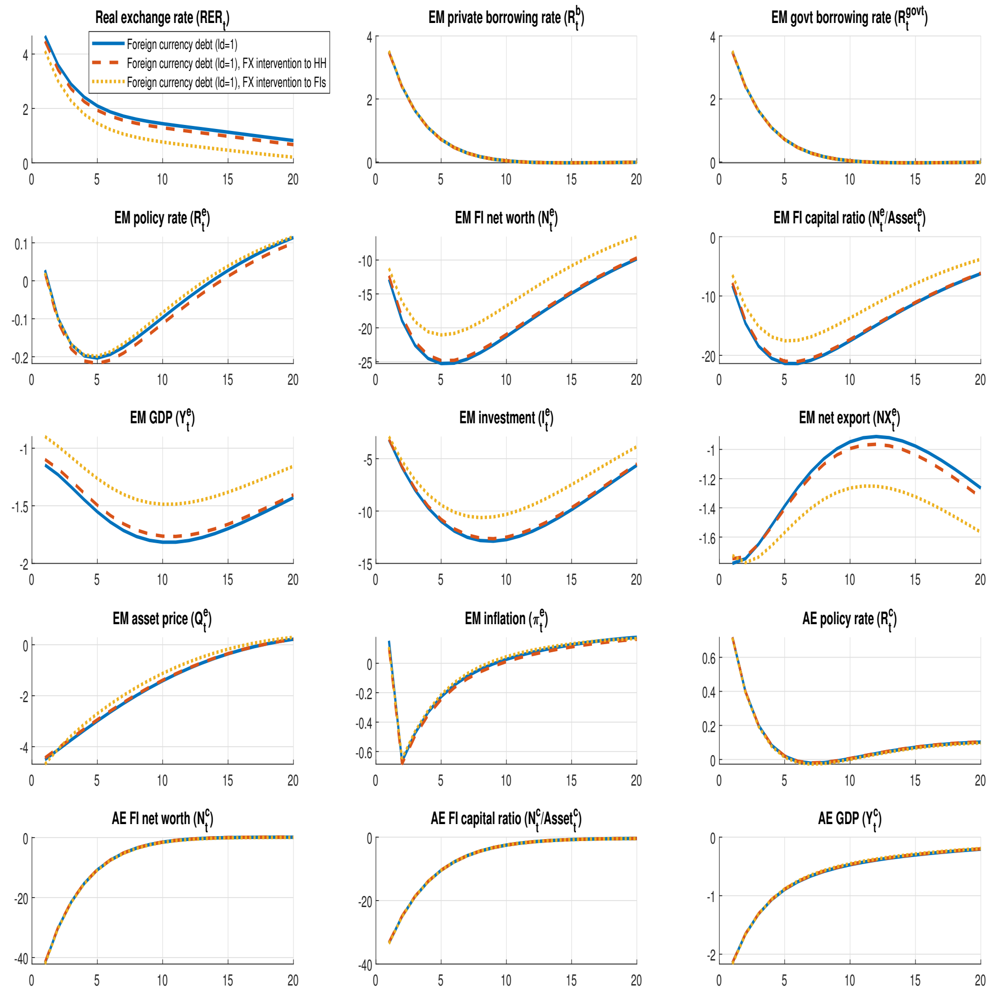
This finding also implies that the existence of macro-financial repercussions of an AE monetary tightening qualitatively do not depend on the assumed extent of hedging of exchange rate risk. The analysis so far assumes no hedging so that an exchange rate change fully impacts economic agents, in particular financial intermediary balance sheets, through currency mismatches. While hedging markets in EM currencies are less liquid than those in AE currencies as shown before, it is still reasonable to assume that some part of exchange rate risk in EMs is hedged, not least since FIs are often required to hedge such risk by regulation. The results shown in Figure A.1 suggest that even in the unrealistic extreme case of full hedging of exchange rate risk on intermediary balance sheets, the spillovers to EMs remain considerable.[16]

B.2 Section 3.3 under foreign currency borrowing

In this subsection, we report the IRFs in section 3.3 that analyze the implications of FX intervention, capital flow tax and domestic investor base but under foreign currency setting. The results are qualitatively similar to the cases reported in the main text.

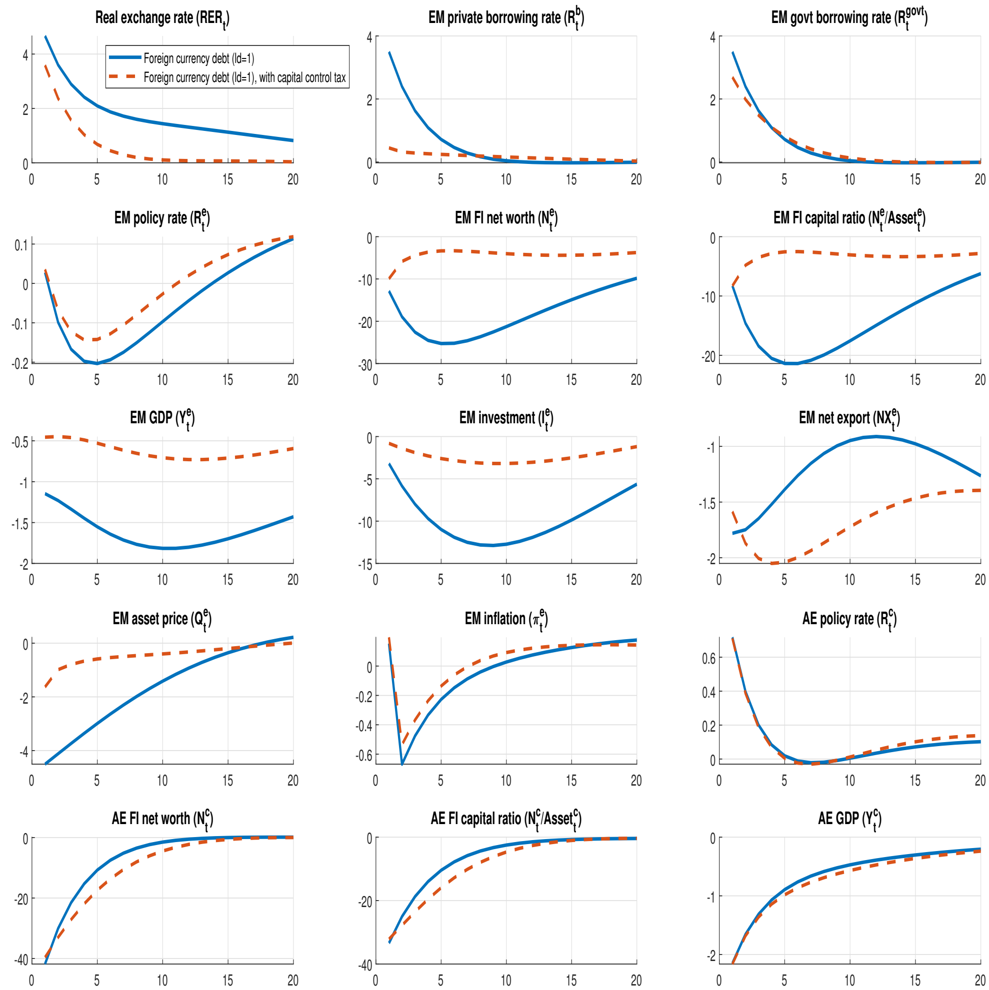
[16]Assuming away exchange rate feedback effects on balance sheets is of course an extremely simplistic characterization of hedging policies. In reality, hedging will not be complete. The real world situation is therefore somewhere between the two polar cases of no hedging, which we is our baseline considered so far, and full hedging. Moreover, hedging comes at a cost and the exchange rate risk will ultimately have to be borne by someone. That said, the simplistic perspective taken here is still fit for purpose to make the general point. A fully fledged modeling and integration of hedging is beyond the scope of this paper and is therefore left for future research.

Figure A.2: Advanced economy monetary tightening: the role of sterilized FX intervention under foreign currency borrowing



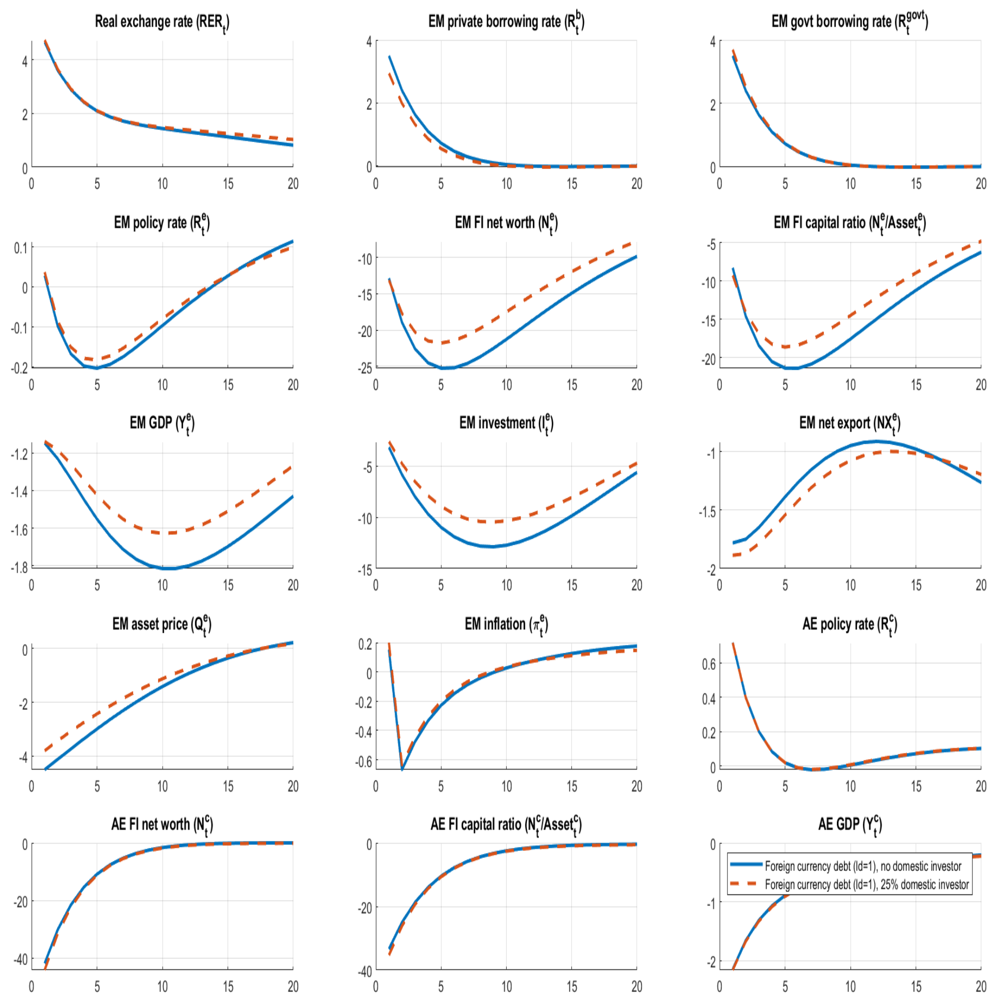
Notes: Impulse responses to a 100 basis points increase in the AE risk-free rate. Percentage deviations from steady state.

Figure A.3: Advanced economy monetary tightening: the role of capital flow tax under foreign currency borrowing



Notes: Impulse responses to a 100 basis points increase in the advanced economy risk-free rate. Percentage deviations from steady state.

Figure A.4: Advanced economy monetary tightening: the role of the domestic investor base under foreign currency case

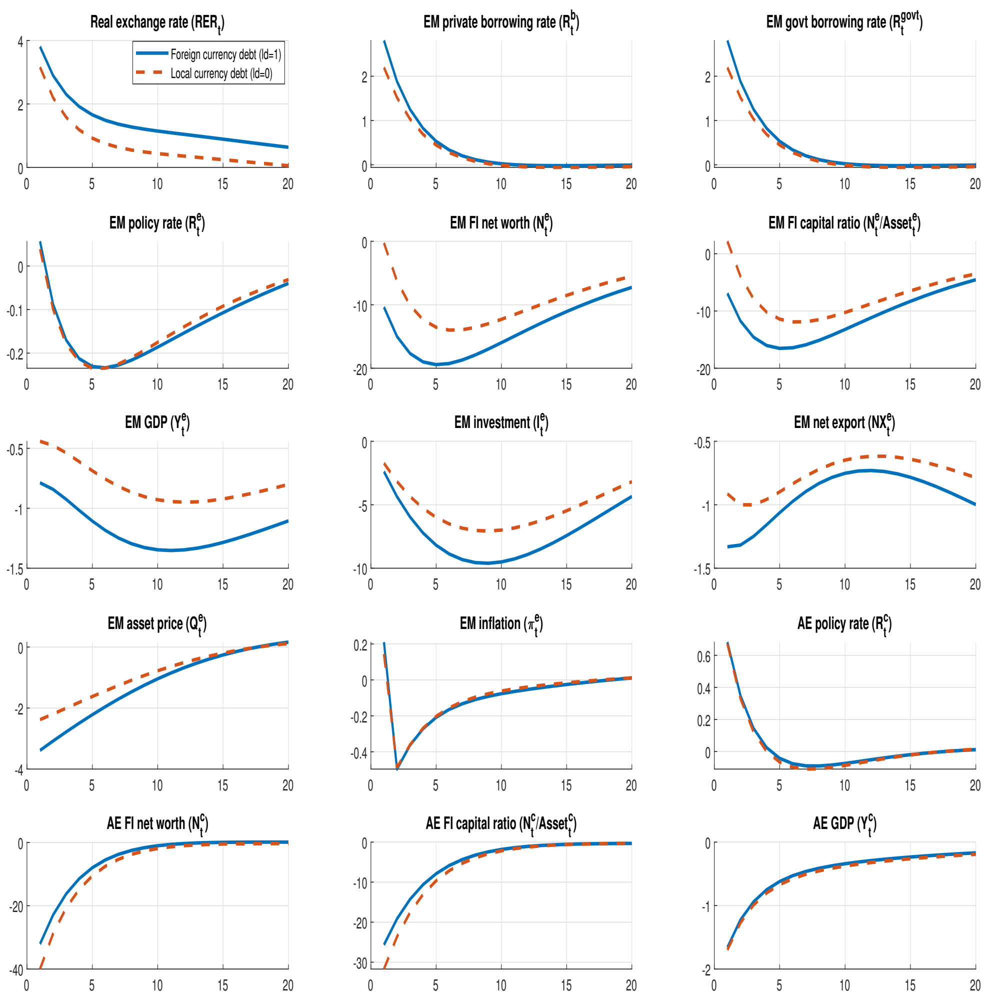


Notes: Impulse responses to a 100 basis points increase in the advanced economy risk-free rate. Percentage deviations from steady state.

B.3 Baseline IRFs under different calibrations of monetary policy

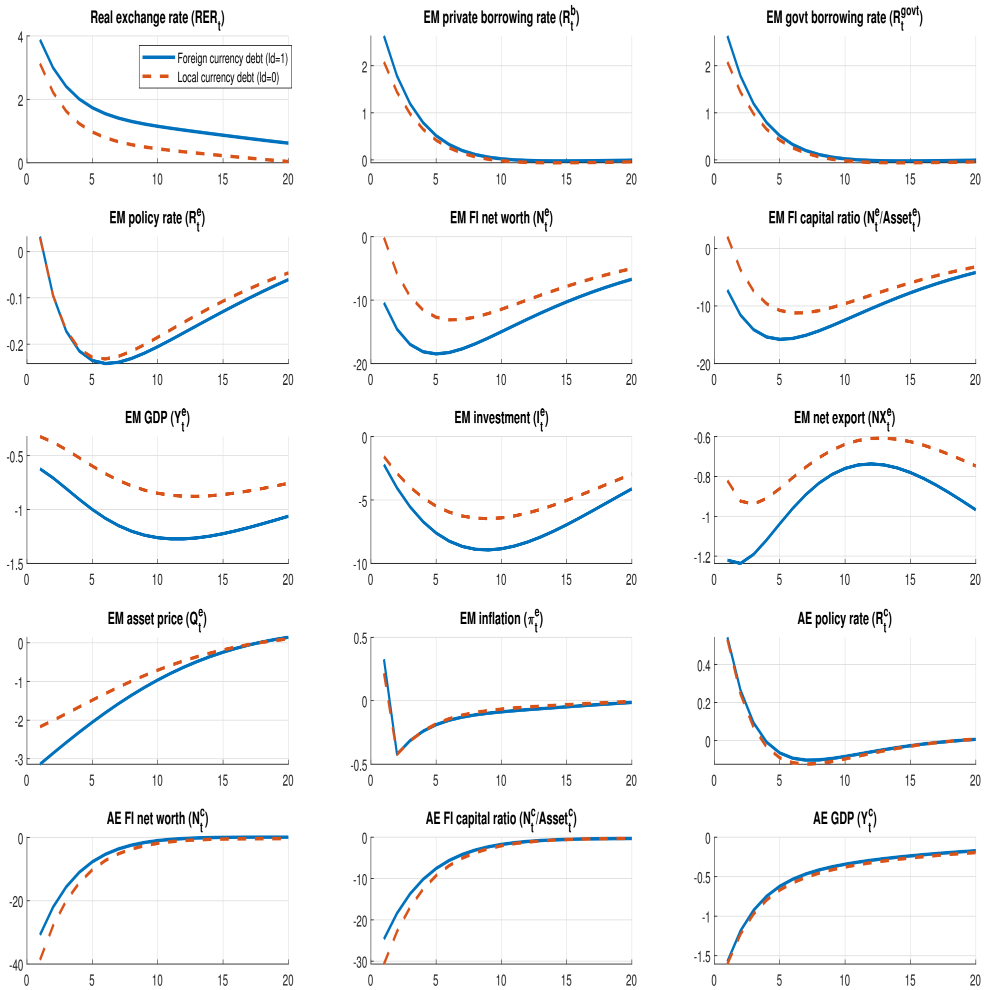
In the main text, we report the IRFs with minimal monetary policy in which the Taylor rule coefficient on inflation is assumed to be 1.01 and zero for output gap. In this subsection, we present IRFs for six cases. We first increase Taylor coefficient to 1.5, and then further change the output gap coefficient to 0.5. We do this for only the EM, only the AE and both EM and AE (2 x 3 = 6). The results of the baseline analysis turn out to be robust to these variations in the calibration of monetary policy.

Figure A.5: Advanced economy monetary tightening: Both AE and EM Taylor coefficient on inflation = 1.5, output gap = 0



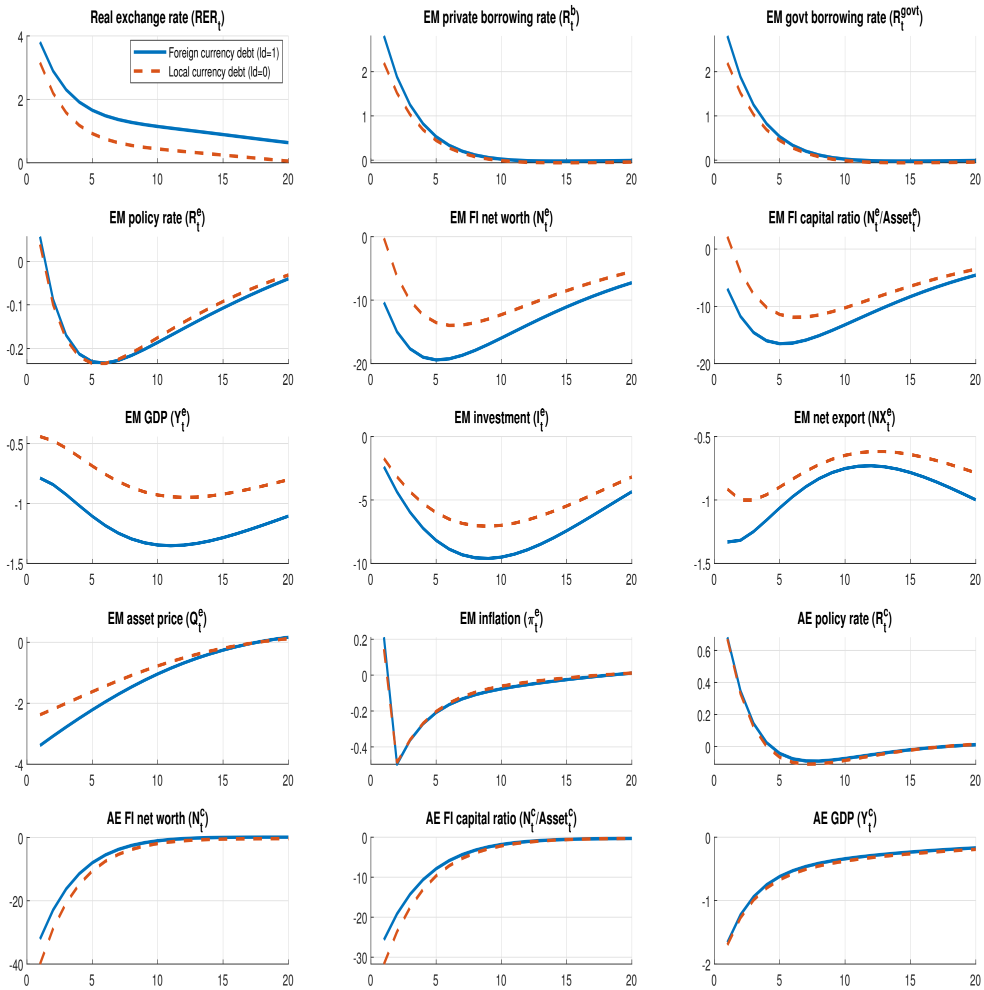
Notes: Impulse responses to a 100 basis points increase in the AE risk-free rate. Percentage deviations from steady state.

Figure A.6: Advanced economy monetary tightening: Both AE and EM Taylor coefficient on inflation = 1.5, output gap = 0.5



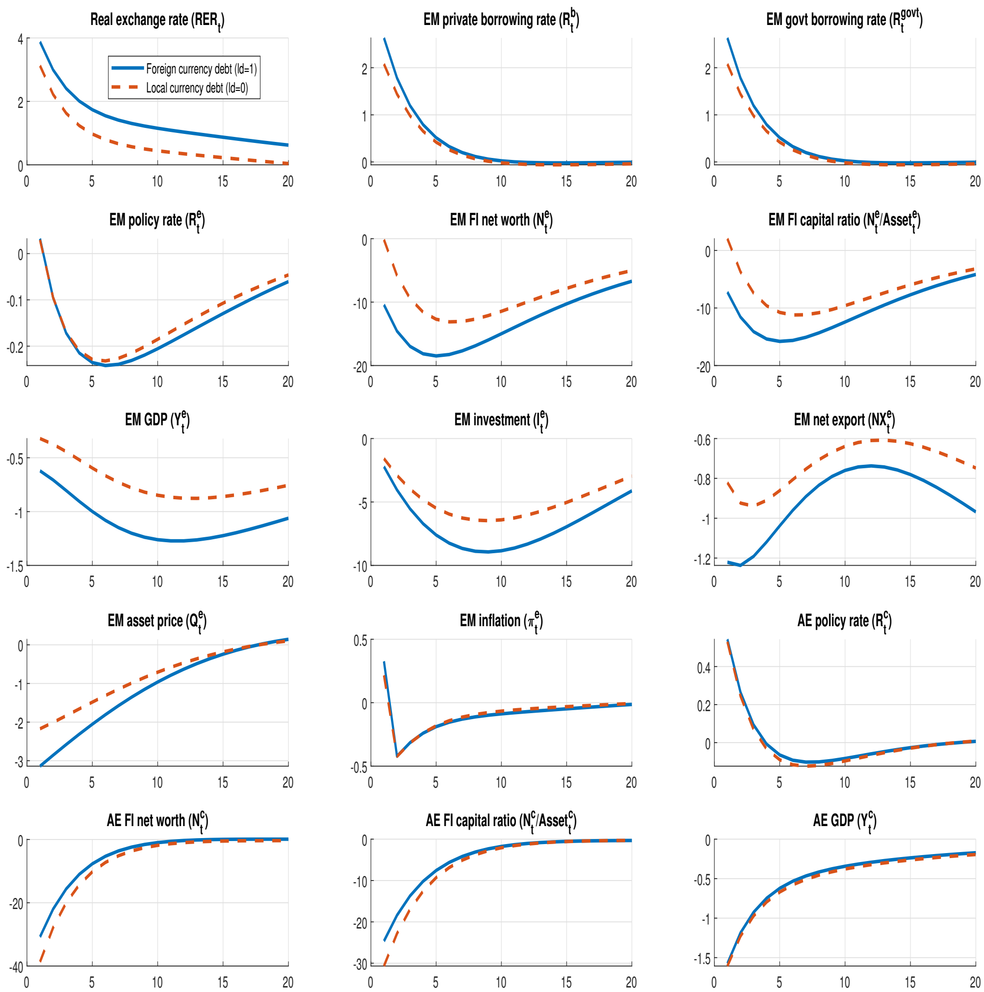
Notes: Impulse responses to a 100 basis points increase in the AE risk-free rate. Percentage deviations from steady state.

Figure A.7: Advanced economy monetary tightening: AE Taylor coefficient on inflation = 1.5, output gap = 0



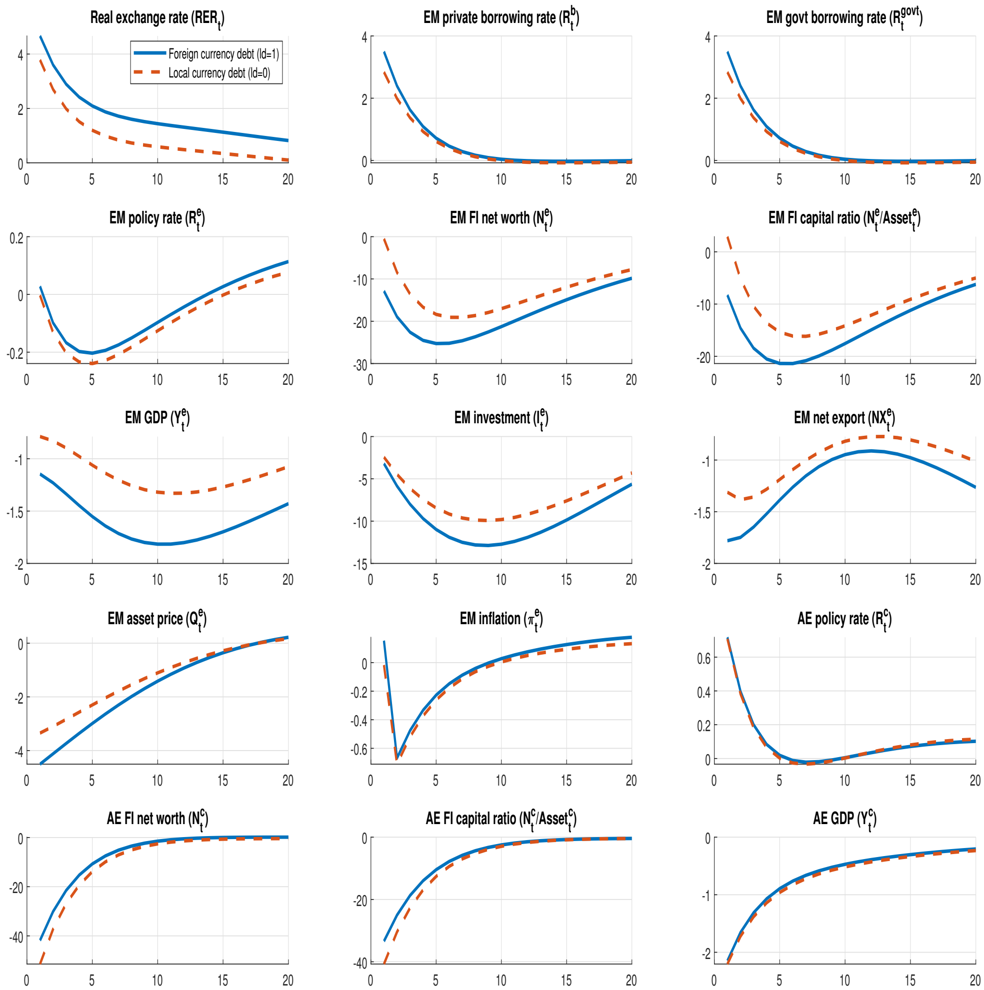
Notes: Impulse responses to a 100 basis points increase in the AE risk-free rate. Percentage deviations from steady state.

Figure A.8: Advanced economy monetary tightening: AE Taylor coefficient on inflation = 1.5, output gap = 0.5



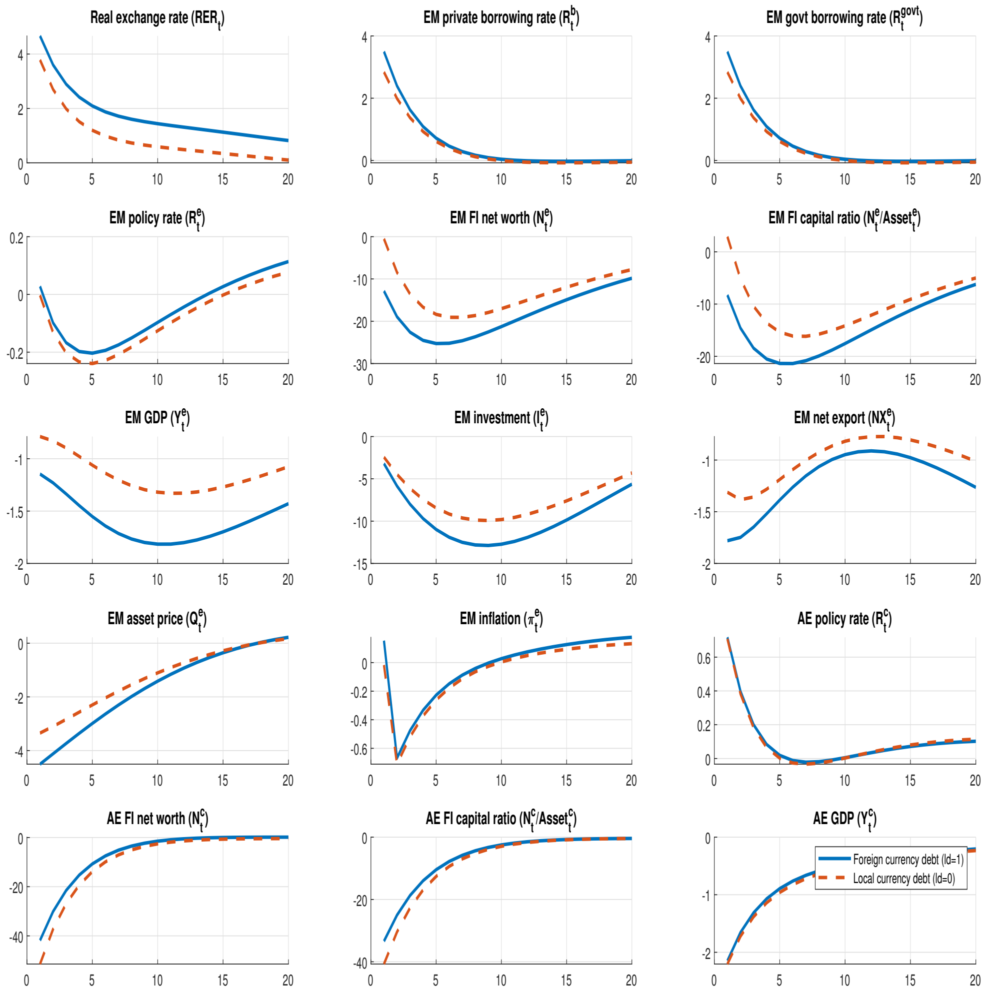
Notes: Impulse responses to a 100 basis points increase in the AE risk-free rate. Percentage deviations from steady state.

Figure A.9: Advanced economy monetary tightening: EM Taylor coefficient on inflation = 1.5, output gap = 0



Notes: Impulse responses to a 100 basis points increase in the AE risk-free rate. Percentage deviations from steady state.

Figure A.10: Advanced economy monetary tightening: EM Taylor coefficient on inflation = 1.5, output gap = 0.5



Notes: Impulse responses to a 100 basis points increase in the AE risk-free rate. Percentage deviations from steady state.

B.4 Full regression tables in section 4

Table 5: Impact of a US monetary tightening on real investment

	(1)	(2)	(3)	(4)
	Eight quarter change in log real investment			
	EMs		AEs	
$osr_{i,t-1}$	-0.35***	-0.24	-0.057*	-0.086
	(0.11)	(0.30)	(0.031)	(0.059)
os_{it-1}	-0.33**	-0.23	-0.041	-0.13
	(0.12)	(0.36)	(0.086)	(0.20)
$D_{i,t-1}$	0.0066	-0.026	0.016	0.024
	(0.038)	(0.072)	(0.026)	(0.046)
$\triangle r^{us}_{t-1}$	4.64***	4.70***	4.95***	4.45***
	(1.05)	(1.02)	(0.68)	(0.67)
$\triangle r^{us}_{t-1} * osr_{it-1}$	-0.32**	-0.23**	-0.013	-0.011
	(0.13)	(0.11)	(0.019)	(0.018)
$\triangle r^{us}_{t-1} * os_{it-1}$	-0.43**	-0.31**	-0.049	-0.031
	(0.16)	(0.11)	(0.073)	(0.074)
$\triangle r^{us}_{t-1} * D_{it-1}$	0.090**	0.065**	0.013	0.010
	(0.032)	(0.023)	(0.021)	(0.021)
$inflation_{t-1}$	-0.19	-0.047	0.79	0.27
	(0.36)	(0.35)	(0.49)	(0.39)
$\triangle GDP_{t-1}$	0.76*	0.44	2.35***	1.53**
	(0.41)	(0.35)	(0.70)	(0.70)
$\triangle GDP(US)_{t-1}$	-1.78*	-1.17	3.65***	3.32***
	(1.01)	(1.01)	(0.71)	(0.64)
$USinflation_{t-1}$	4.40*	3.65	0.89	1.64
	(2.42)	(2.60)	(2.09)	(2.11)
$\triangle policyrate_{t-1}$	-0.88**	-0.93**	-4.30***	-3.59***
	(0.35)	(0.35)	(0.92)	(0.78)
$\triangle ln(VIX)_{t-1}$	-5.97***	-5.41***	-2.82***	-3.35***
	(1.64)	(1.75)	(0.70)	(0.54)
Constant	6.79***	4.36*	0.091	3.61
	(1.45)	(2.17)	(1.88)	(2.18)
p($\triangle r^{us}_{t-1} * osr_{it-1}$=$\triangle r^{us}_{t-1} * os_{it-1}$)	0.049**	0.078*	0.54	0.74
Observations	1,051	1,051	1,491	1,491
R Squared	0.103	0.185	0.257	0.326
Number of Countries	16	16	20	20
Sample	EM	EM	AE	AE
Country FE	NO	YES	NO	YES

Notes: *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors clustered by country in parentheses. Sample includes 16 EMs (BR, CL, CO, CZ, ID, IL, KR, MX, MY, PE, PH, PL, SG, TH, TR, ZA) and 20 AEs (AT, AU, BE, CA, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, JP, NL, NO, NZ, PT, SE). p($\triangle r^{us}_{t-1} * osr_{it-1}$=$\triangle r^{us}_{t-1} * os_{it-1}$) reports the p-value of statistical test of whether the coefficients of $\triangle r^{us}_{t-1} * osr_{it-1}$ and $\triangle r^{us}_{t-1} * os_{it-1}$ are different. Estimates based on equation 30 at a eight-quarter horizon.

Table 6: Impact of a US monetary tightening on financial intermediary net worth

(a) $\triangle ln(CapitalRatio_{EM})$

$osr_{i,t-1}$	-0.63
	(0.47)
os_{it-1}	-0.66
	(0.38)
$D_{i,t-1}$	0.16
	(0.13)
$\triangle r^{us}_{t-1}$	-1.03
	(1.89)
$\triangle r^{us}_{t-1} * osr_{it-1}$	-0.22*
	(0.12)
$\triangle r^{us}_{t-1} * os_{it-1}$	-0.40**
	(0.16)
$\triangle r^{us}_{t-1} * D_{it-1}$	0.13***
	(0.036)
$inflation_{t-1}$	-0.30
	(0.30)
$\triangle GDP_{t-1}$	0.16
	(0.35)
$\triangle GDP(US)_{t-1}$	-0.85
	(1.05)
$USinflation_{t-1}$	2.17
	(1.98)
$\triangle policyrate_{t-1}$	-0.46
	(0.43)
$\triangle ln(VIX)_{t-1}$	4.32*
	(2.23)
Constant	-6.33
	(14.5)
p($\triangle r^{us}_{t-1} * osr_{it-1}$=$\triangle r^{us}_{t-1} * os_{it-1}$)	0.0028***
Observations	101
R Squared	0.383
Number of Countries	16
Sample	EM
Country FE	Yes

(b) $\triangle ln(CapitalRatio_{US})$

og_{t-1}	0.017	-0.11
	(0.15)	(0.16)
$\triangle r^{us}_{t-1}$	0.36	0.35
	(0.44)	(0.40)
$\triangle r^{us}_{t-1} * og_{t-1}$	-0.67*	-0.92***
	(0.36)	(0.31)
D_{t-1}	-0.18	-0.63
	(0.76)	(0.82)
$\triangle r^{us}_{t-1} * D_{t-1}$	-3.84**	-4.93***
	(1.59)	(1.46)
$\triangle ln(VIX)_{t-1}$		0.21
		(0.15)
$inflation_{t-1}$		-0.41***
		(0.12)
$\triangle GDP_{t-1}$		-0.047
		(0.055)
Constant	0.067	0.22
	(0.23)	(0.23)
Observations	73	73
R-squared	0.142	0.294

Notes: * p<0.1, ** p<0.05, *** p<0.0. Robust standard errors are reported in parentheses (clustered by country for panel a). Dependent variable for panel (a) is the two year change (based on annual data) in the bank capital to asset ratio (cross-country data sourced from the World Bank). Dependent variable of Panel (b) is is four quarter percentage change in log of Intermediary Capital Ratio for the US based on He et al. (2017). og denotes the ratio of global EM debt liabilities in local currency to total EM debt liabilities in USD and local currency, expressed in logs. $\triangle r^{us}_{t-1}$ denotes US monetary policy shocks identified using the narrative approach of Romer and Romer (2004). p($\triangle r^{us}_{t-1} * osr_{it-1}$=$\triangle r^{us}_{t-1} * os_{it-1}$) reports the p-values of statistical test of whether the coefficients of $\triangle r^{us}_{t-1} * osr_{it-1}$ and $\triangle r^{us}_{t-1} * os_{it-1}$ are different.

B.5 Occasionally binding financial constraints

This subsection examines the non-linearity of financial frictions. To do so, we set $\kappa^c = 0.085$, one-fifth of the baseline value. It results in an financially unconstrained steady state (Lagrangian multiplier $\gamma^c_{SS} = 0$) with an AE leverage of 10.7, close to the pre-2008 average in the US. We first solve the model linearly when the AE financial constraint does not bind at the steady state and when the EM borrows in local currency (ld=0). To compare with the previous analyses, we examine the model with a 100 basis point US monetary tightening shock. The IRFs are shown as blue lines in the upper panel of Figure A.11. They are similar to Figure 2 because the financial constraint does not bind in both cases.

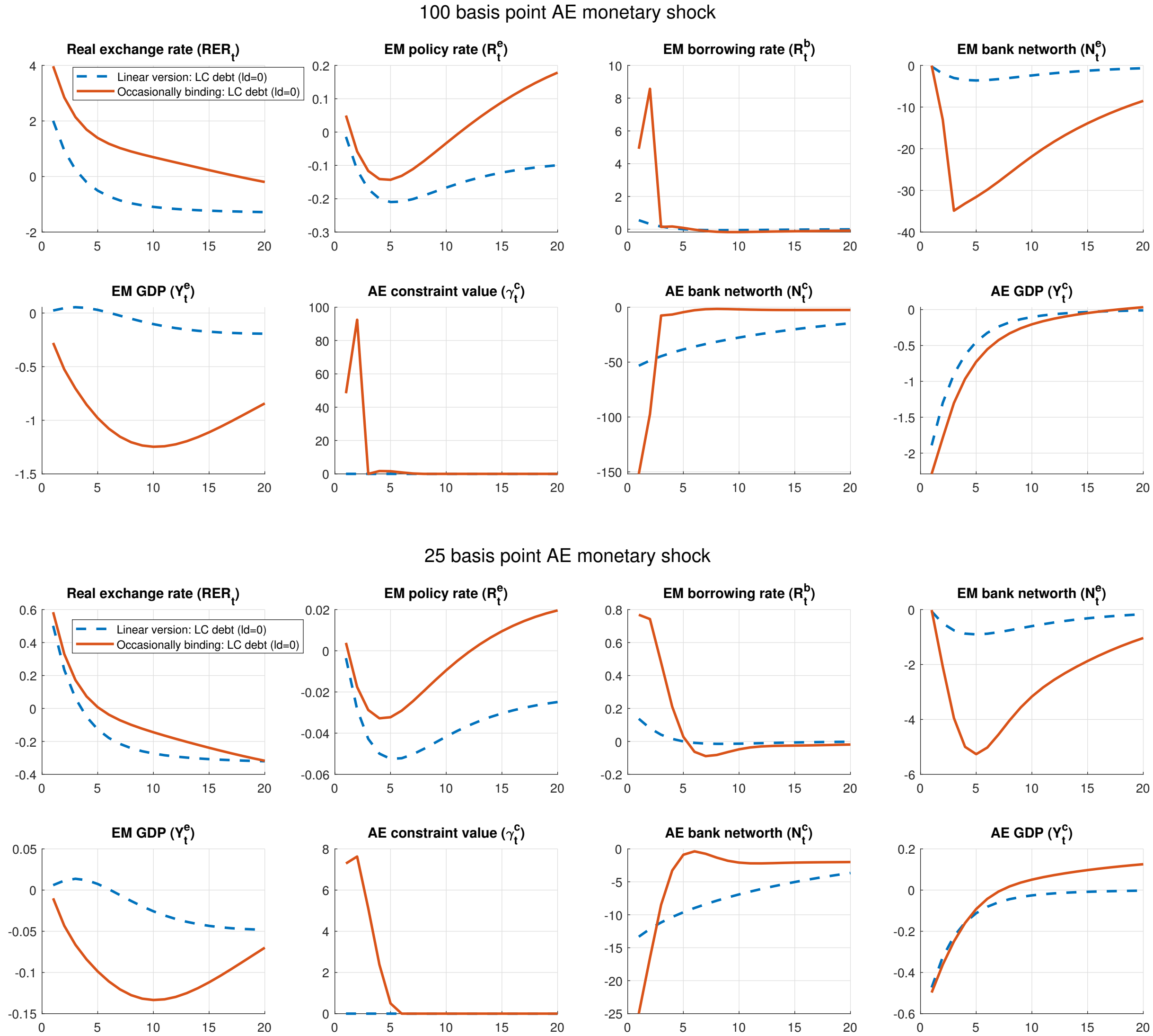
We then solve the model with occasionally binding constraint technique developed by Guerrieri and Iacoviello (2015),[17] where the AE financial constraint does not bind at the steady state but could potentially become binding in the wake of shocks. IRFs to a 100 basis point US monetary tightening shock are plotted as red lines in the upper panel of Figure A.11. The dynamics are very different in the two cases. In the occasionally binding version, the model switches from the non-binding regime to the binding regime so that the incentive constraint in eq(22) holds with equality. This is reflected as a positive value of Lagrangian multiplier (γ^c_t). When the constraint binds, the drop in AE net worth, EM net worth and EM GDP is more substantial. In the lower panel, we examine the case of a 25 basis point shock, the typical size of monetary tightening. The IRFs are similar to the upper panel, the model switches from the non-binding to the binding case immediately upon the shock, leading to larger contractions of AE net worth, EM net worth and EM GDP.

The occasionally binding version of the model highlights the importance of OSR. Even when the economy initially operates under no financial frictions, the financial frictions become binding

[17] Specifically, the model is solved twice, once with the constraint and once without, and each state is then evaluated to see whether the constraints bind or not. This approach yields non-linear dynamics, taking into account that the regime can switch in future periods.

and OSR materializes quickly even upon small tightening shocks. Overall, the results of the analysis under occasionally binding constraints are consistent with those obtained based on the more tractable baseline linear model with binding constraints.

Figure A.11: Occasionally binding constraint



Notes: Impulse responses to a 100 basis points (upper panel) and 25 basis points (lower panel) increase in the advanced economy risk-free rate from the model with occasionally binding constraints. Percentage deviations from steady state.