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# To Peg or to Float? Optimal Monetary Policy for Emerging Countries of Different Riskiness

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**Abstract**

We study the differential impact of US monetary spillovers into emerging countries of different riskiness, and the implications for optimal monetary policies. By constructing a banking sector risk index, we first show that higher banking sector risk amplifies the negative impact on emerging countries' real economy and financial market due to contractionary US monetary shocks on top of other risks studied in literature. We then develop a two-country New-Keynesian model with financial frictions in both the US and the emerging country that can help to account for the empirical findings. We incorporate a new modelling feature that by investing in emerging market economies (EMEs) with riskier banks, US bankers face a tighter financing constraint, thus require a higher return from the riskier EME in the deterministic steady state. Further, safer EMEs limit dollar debt exposure by more than riskier EMEs, resembling macroprudential policies of the safer EME. We find that riskier EMEs experience larger output drop, more capital outflow, steeper asset price decline and larger currency depreciation following an unexpected US monetary policy rate hike, and exchange rate stabilizing monetary policies tend to exacerbate welfare losses. For safer EMEs, however, fixed exchange rate policy can outperform inflation targeting policies.

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## 1. Introduction

Dollar dominance has been widely documented in literature. As of 2018, 63% of international debts and nearly 40% of global payments are denominated in dollar (Eichengreen and Xia (2019)). As global financial integration deepens, global systematically important banks (G-SIBs) channeling funds cross-borders gives rise to a potent global financial cycle characterized by co-movements in asset prices, credit flows and financial leverage across countries, presenting new challenges to policy makers of the emerging and developing economies. First, with dollar's prevalence from cross-border capital flows to trade, US monetary shocks spill over to emerging countries through exchange rate fluctuations, which are further amplified by episodes of volatile capital inflows and outflows instigated by leveraged global investors. Second, as US monetary spillovers affect countries across the board through global financial cycles (Rey (2013)), whether emerging countries' monetary policy choice — that is, to peg to the dollar or to float and adopt an inflation targeting policy — still makes a difference, and if it does, which policy choice would be optimal? While conventional wisdom suggests floating, there is renewed interest in exchange rate stabilizing policies which may help lessen the debt repayment burden given high liability dollarization in emerging markets. We argue, however, that assessments of the impact of US monetary spillovers and policy implications need to take heterogeneity in country characteristics into account.

In this paper, we ask whether US monetary spillover effects differ for safer and riskier emerging countries, and whether their optimal monetary policy implications differ. We first provide empirical evidence that higher risks, especially banking sector risks, amplify the negative impact on emerging countries due to contractionary US monetary shocks. There has been an expanding literature on the global impact of US monetary shocks (Rey (2013); Kalemli-Ozcan (2019); Miranda-Agrippino and Rey (2020)), and several studies examined how variations in country heterogeneities contribute to the differential US monetary spillover effects. Iacoviello and Navarro (2019) found that higher financial vulnerability, a composite measure of account current account deficit, foreign reserves, inflation, and external debt, contributes to larger GDP decline following US rate hikes. Building on their work, we depart from previous studies[3] by zooming in on banking sector risks of the emerging countries, for which we constructed a new measure for each country in our sample. To do so, we first mapped the credit ratings by Fitch, Moody's and S&P of the three largest banks by total asset values

[3] Georgiadis (2016), for example, found that high financial integration, low trade integration, more rigid labour markets and financial systems that are less efficient and shallower are associated with larger spillovers.

for each country to a standardized numeric scale; we then took the average of the ratings across the banks for each period. We relied on local projection techniques (Jorda (2005)) to estimate the marginal effect of bank risks on US monetary spillovers, and found that countries with high bank risk, such as Turkey or Indonesia, which are at the 75th percentile ranked by our bank risk measure, would witness a larger decline in GDP from pre-shock level by 1 percent compared to economies with low bank risk, such as Israel or Taiwan, which are at the 25th percentile. Stock market index of the emerging economies with high bank risk are estimated to suffer a steeper decline by 8 percentage points than countries with low bank risk.

We focus on the banking sector because of its prominent role in channelling funds globally. Eichengreen, Gupta, and Masetti (2018) documents that a large proportion of the non-FDI flows into and out of the emerging markets — which have long been perceived to be the fickler type of capital flows — are mainly accounted for by bank-related loans and deposits[4]. Likewise, by looking at cross-border flows by counterparty, Bruno and Shin (2015) show that bank-to-bank flows are the largest category of cross-border debt flows, especially in the years leading up to the global financial crisis[5]. Given that banking sector is a linchpin in cross-border non-FDI capital flows, we zoom in on the banking sector as we examine the differential cross-border spillover effects on EMEs of different riskiness following a contractionary US monetary shock.

In the second half of the paper, we develop a DSGE model accounting for the differences between US monetary spillovers into safer and riskier EMEs[6] and examine their optimal monetary policy implications. The model features financial frictions that constrain banks' intermediation in both the emerging country and the US on top of an otherwise standard two-country mid-scale New Keynesian framework. Modelling banks in both countries allows us to generate financial market synchronization between the US and the EME. We make three contributions to the literature. First, we incorporate two novel modelling features of a safer EME: A safer EME faces a lower borrowing rate from the US bank in the deterministic steady state, and a safer EME limits its exposure to dollar debt by more than a riskier EME, resembling macroprudential policies. Cross-border financial flows are captured by US banks' dollar lending to emerging country banks and not vice versa, as most EMEs are net debtors in dollar. Second, model-simulated impulse responses show that riskier EMEs experience larger output

[4] See Figure 2 and Figure 4 of Eichengreen, Gupta, and Masetti (2018).
[5] See Figure 1 of Bruno and Shin (2015).
[6] We use "safer and riskier EMEs" and "EMEs with safer and riskier banks" interchangeably in describing our model-simulated results since we only consider one dimension of riskiness in our model.

drop, more capital outflow, steeper asset price decline and larger currency depreciation following an unexpected US monetary policy rate hike, which are consistent with our empirical findings. Welfare analyses suggest that for riskier EMEs, exchange rate stabilizing monetary policies tend to exacerbate welfare losses, whereas for safer EMEs, fixed exchange rate policy can outperform inflation targeting policies. These policy implications stand in contrast to previous studies that usually advocate flexible exchange rate regimes without considering country heterogeneities. Third, we find that due to US monetary policy uncertainty, US bankers diversify their investment and increase their lending to the emerging country in the stochastic steady state, with the increase being larger for the safer EME. Stochastic steady state values of the cross-border asset price and EME domestic asset price are both higher than in the deterministic steady state.

Cuadra and Nuguer (2018) similarly studied the differential impact of negative US capital quality shocks on EMEs of low and high risks. While they studied the optimal macro-prudential policy, our focus is on the optimal monetary policy. Importantly, we depart in the modelling features of riskier EME banks. In Cuadra and Nuguer (2018), banks of the riskier EME have a *lower* borrowing rate from the US in the steady state. In contrast, we assume US banks will face a tighter financing constraint due to their exposure to riskier EME-issued assets, therefore demand a *higher* return from banks of the riskier EME in the steady state. For banks of the safer EME, their foreign borrowing rate might be lower than their domestic borrowing rate in the steady state. Without restrictions, these safe EME banks would borrow in foreign currency only, all else equal. However, these banks are refrained from doing so in the model because they will face tighter financing constraints as their foreign borrowings increase. Safer EME banks will therefore borrow less from US banks. We interpret this modelling feature as an analogy to safer EME banks' prudential regulations to reduce foreign currency debts[7].

The remainder of the paper is structured as follows. Section 2 presents the empirical strategy and results. Details on data are left in the appendices. Section 3 lays out the theoretical model and calibration. Section 4 discusses the model-generated impulse responses of safe and risky EMEs to contractionary US monetary shocks. Section 5 examines welfare implications of fixed exchange rate and inflation targeting policies for safe and risky EMEs. Section 6 concludes.

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[7] For example, Bank of Korea has imposed reserve requirements for foreign currency deposits, foreign exchange stability levy and foreign currency liquidity coverage ratio alongside with other prudential regulations to stabilize the foreign exchange system. See https://www.bok.or.kr/eng/main/contents.do?menuNo=400188.

## 2. EME Riskiness and Responses to US Monetary Shocks

In this section, we examine how US monetary shocks affect emerging countries of different risk levels using the local projection method by Jorda (2005). Our empirical strategy closely follows Iacoviello and Navarro (2019). Specifically, we estimate responses of GDP and stock market price, $y_{i,t+h}$, of country $i$ at horizon $t+h$ to higher US interest rates[8]:

$$y_{i,t+h} = \alpha_{i,h} + \beta_h u_t + \sum_{v \in V} \beta_h^v \left(e_{i,t-1}^v u_t\right)^{\perp} + A_{h,i} Z_{i,t} + \epsilon_{i,t+h}, \qquad for\ h = 0, 1, 2, \dots H \tag{1}$$

where $\alpha_{i,h}$ is the country-specific fixed effect, and $u_t$ is the pre-estimated US monetary shock series[9]. $\{\beta_h\}$ captures the average response of output or stock market price to the US monetary shock across countries. Controls $Z_{i,t}$ include four lags of $y_{i,t+h}$, as well as a country-specific quadratic trend. $e_{i,t}^v$ is the exposure index for variable $v$ that captures riskiness of emerging country $i$. We consider four exposure variables: exchange rate regime, trade openness with the US, external vulnerability and banking sector risk. The first three indices follow from Iacoviello and Navarro (2019). We interact each of the exposure indices $e_{i,t}^v$ with US monetary shock $u_t$, and the four interaction terms $\left(e_{i,t-1}^v u_t\right)$ are standardized, mapped to the unit interval through logistic transformation, re-centered between the 25th and 75th percentile, and orthogonalized through a recursive regression procedure so that each interaction term $\left(e_{i,t-1}^v u_t\right)^{\perp}$ is orthogonal to the US monetary shock variable and the interaction terms ordered before it. Higher values of exchange rate regime index imply fixed exchange rate regimes and higher values of trade openness with the US index imply high trade integration with US. External vulnerability index is a weighted average of inflation, current account deficit as a share of GDP, external debt less foreign exchange reserves as a share of GDP and foreign exchange reserves as a share of GDP. Our sample includes 24 emerging countries from 1990q1 to 2016q3.

We now turn to the construction of banking sector risk measure. We first obtain the credit ratings of three locally owned banks with the largest total asset values of each country[10].

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[8] Subscript $i$ is a country index, and subscript $t$ and $h$ are time indices. $u_t$ is the value of US monetary shock variable at time $t$, and $y_{i,t+h}$ is the value of the dependent variable (GDP) of country $i$ at time $t+h$, or $h$ periods after the shock.

[9] US monetary shocks is identified as the residuals from regressing the federal funds rate on its own lags and a set of controls, including current and lagged inflation, US GDP, foreign GDP, and corporate spreads, and time trend. See Iacoviello and Navarro (2019) for details.

[10] Except for Hong Kong, of which the major banks are UK-owned.

Whenever available, we consider the following ratings by three agencies: (1) foreign currency short term debt/short term rating by Moody's, (2) short term issuer default rating by Fitch, and (3) short term foreign issuer credit rating by S&P. We then map each agency's ratings to a standardized scale of 1 to 4 based on the Credit Quality Step (CQS) rating scale[11]. Table **2** shows the details of the mapping between short term ratings by the three agencies and CQS values[12]. Higher CQS values indicate higher banking risk. Finally, for each period we take the equally weighted average of the CQS values across banks for each economy in each period. Table **3** lists the details of the banks considered for each economy, their rating data availability and their average CQS values over the sample period. For instance, the CQS values for Singapore averaged across its three largest banks and across the sample period is equal to 1.27, making it the country with the safest banking sector out of the list[13].

To illustrate whether our measure captures banking risk, we plot the incidence rates of banking crisis of the sample countries against our banking risk measure in Figure **1**. Banking crisis incidence data are from the Harvard Behavioral Finance & Financial Stability Project, which record a one in the years when banking crisis took place and a zero otherwise. The plot shows that countries measured to be of higher banking sector risk tend to have higher frequencies of banking crisis occurring.

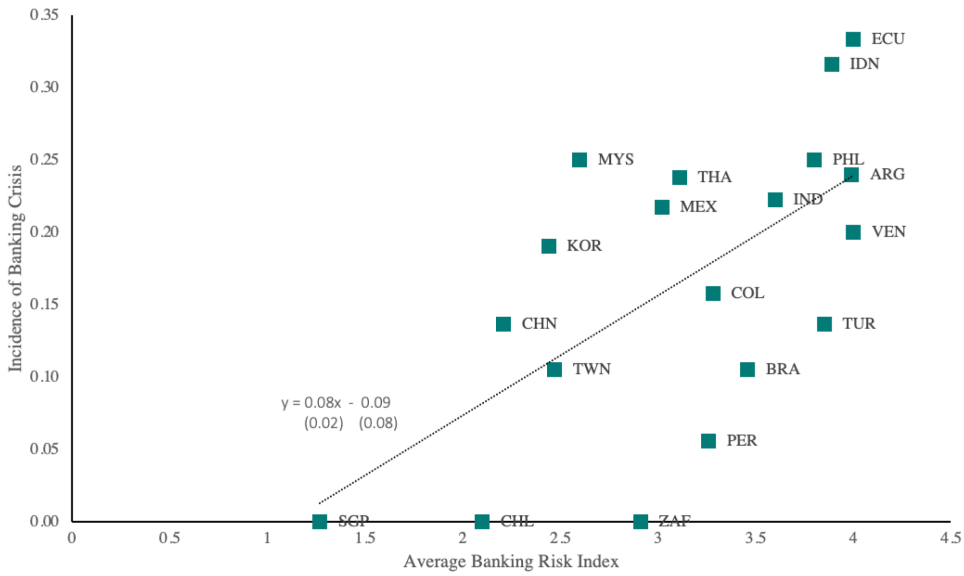


**Figure 1**: Scatter plot of banking crisis incidence rate and average banking risk index.

[11] The CQS is developed by the Joint Committee of the European Supervisory Authorities.
[12] We adopt the same procedure from Iacoviello and Navarro (2019) and fill in the missing values by backward extrapolation. Table **4** in Appendix A.4 shows the availability of the stock market indices of the sample countries and their data sources. Botswana, Colombia, Ecuador and Jordan were dropped out of the sample.
[13] We understand that for emerging countries, domestic systematically important banks can be state-owned banks, the riskiness of which would be largely affected by the government. Less than 30 percent of the banks in our sample are state-owned, and over 80 percent of the banks are universal commercial banks. Further, our measure of banking riskiness is based on credit ratings, which would have already taken government support into account.

In Figure 2 below we plot the impulse response of US Fed funds rate, normalized to be of one percentage point increase on impact, following a contractionary US monetary shock in the left panel, and the right panel shows the impulse response of the US GDP. US output decreases soon after the shock and reaches a trough of more than 1.5 percent reduction from the pre-shock level. The estimate is in line with the existing literature. Using US monetary shocks identified with an informationally robust instrument, Miranda-Agrippino and Ricco (2021) estimated that US industrial production decreases and reaches a trough of about 1.5-percentage-point reduction after US 1-year interest rate increases by one percentage point.

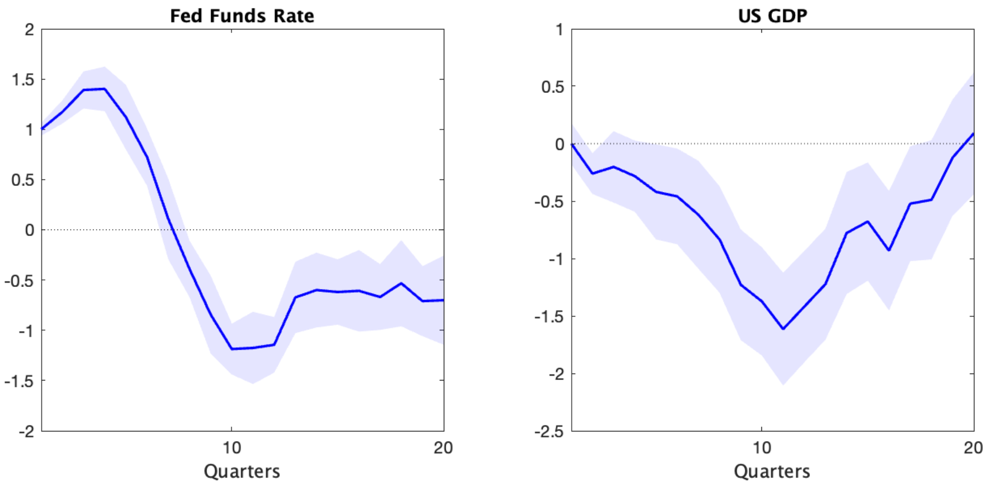


**Figure 2**: Left: Impulse response of Fed Funds Rate (percentage point), scaled to be 1 percent on impact. Right: Impulse response of US GDP (percent deviation from pre-shock level). Shaded area: 1 standard deviation band based on Driscoll and Kraay (1998) robust standard errors.

We show GDP and stock market price responses of emerging countries to a contractionary US monetary shock in Figure 3. Blue dashed lines are the cumulative impulse responses $\{\beta_h\}$ of emerging countries with low risk levels while red solid lines are the cumulative responses of countries with high values of the respective risk index, $\{\beta_h\} + \{\beta_h^v\}$. Essentially, $\{\beta_h^v\}$ captures the marginal response to the US monetary shock when risk index $e_{i,t-1}^v$ increases from the 25th to the 75th percentile, which is plotted in Figure 4. Countries with higher trade connection with the US suffer larger declines in GDP after a contractionary US monetary shock, shown in Column (b) of both Figure 3 and Figure 4. There is no significant difference between peggers and floaters in their GDP responses (see Column (a)), which is consistent with the "insulation puzzle" in Corsetti et al. (2021). More importantly, higher banking risk contributes to larger GDP decline. About two years after the shock, countries with high bank risk, such as Turkey or Indonesia, which are at the 75th percentile ranked by our bank risk measure, would witness a larger decline in GDP from pre-shock level by 1 percent compared to economies with low bank risk, such as Israel or Taiwan. Banking sector risk also stands out as the most important risk measure in amplifying the drop in stock market price due to contractionary US monetary shocks (see Column (c) of the lower panel in Figure 3). Stock market indices of the emerging economies with high bank risk are estimated to suffer a steeper decline by 8 percentage points than economies with low bank risk.

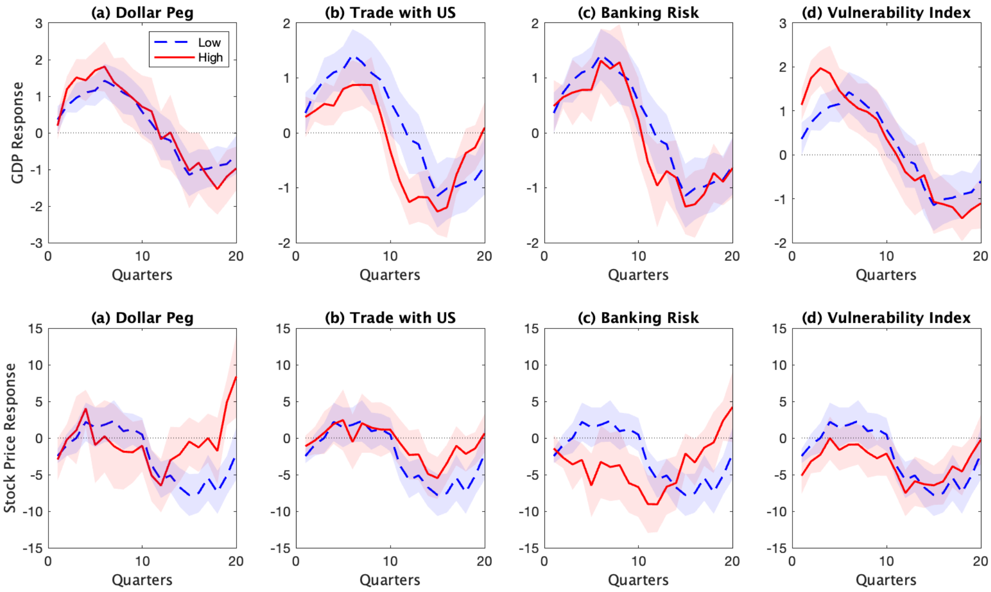


**Figure 3**: EME GDP and stock market index responses (in percent) to US monetary shock by index. Notes: The four indices are orthogonal to each other, with the "low" index referring to the value of each index at 25th percentile and "high" referring to the value of each index at 75th percentile.

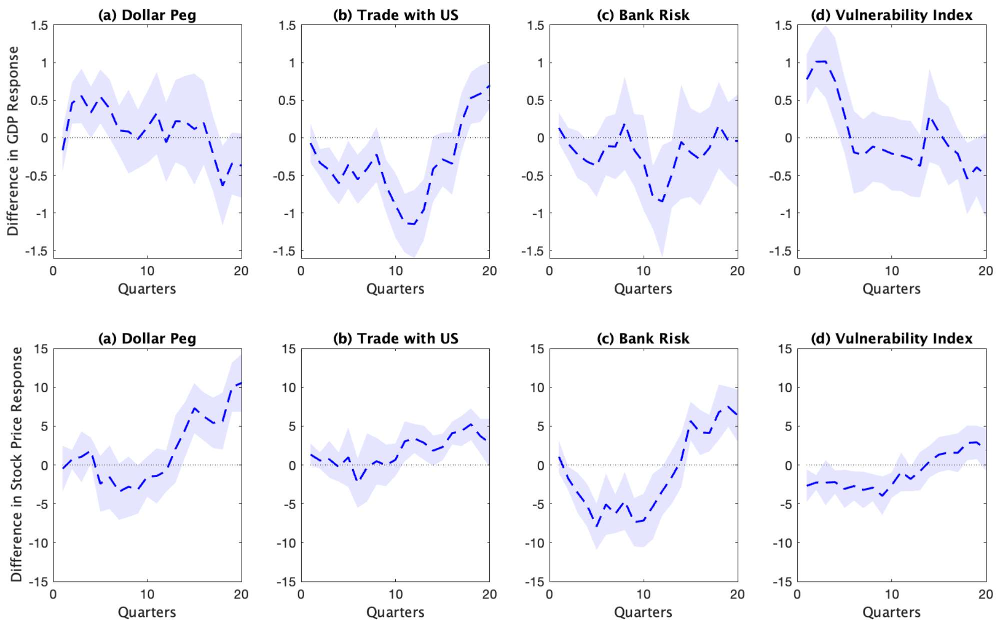


**Figure 4**: Differences in EME's GDP and stock market index responses (in percent) to US monetary shock when risk increases from low to high levels. Notes: "Low" level refers to the 25th percentile and "high" level refers to the 75th percentile of each measure. Shaded area: 1 standard deviation band based on Driscoll and Kraay (1998) robust standard errors. Sample period: 1990Q1 - 2016 Q3.

Overall, the empirical exercises in this section lend support that banking sector risk amplifies the negative impact on emerging countries' real economy and financial market due to US monetary shocks. Motivated by the empirical observations, we develop a DSGE model that allows us to study the differences in US monetary spillovers into EMEs with safe and risky banks and the optimal monetary policy implications in the next section.

## 3. The Model

### *3.1 US and EME Banking Sectors*

The model builds on Gertler and Kiyotaki (2010). Our focus is on US monetary spillover to EMEs when financial frictions are present in both the US and EME banking sector. Bankers in both economies are constrained by how much they can borrow to finance investments. To prevent bankers from accumulating enough wealth to overcome the constraint, we assume that each period with i.i.d. probability $\sigma^*(\sigma)$ a US (EME) banker continues to operate, and with probability $1-\sigma^*$ (for EME banks: $1-\sigma$ ) she exits. Assume the measure of non-bankers (i.e., workers) and bankers are $1-f^*$ and $f^*$ respectively (for EME: $1-f$ and $f$ ), to keep these measures constant, in each period workers become bankers with probability $\frac{(1-\sigma^*)f^*}{1-f^*}$ (for EME: $\frac{(1-\sigma)f}{1-f}$). Each new banker also receives a share of $\frac{\xi_b^*}{f^*}$ (for US: $\frac{\xi_b}{f}$) out of the value of capital stock as an initial endowment.

Both the US and EME banks receive deposits from households and lend to domestic firms of the US and the EME. They receive a return from their claims on domestic firms and repay households at the US and EME risk-free rate. The cross-border capital flow is modelled as US banks' dollar-denominated loans to the EME banks and not vice versa, capturing liability dollarization of the EMEs and the fact that most EMEs are net borrowers in dollar. We next spell out the details of the model.

#### *3.1.1 US Banks*

The banking system in the EME and in the US are asymmetric in the sense that in addition to financing US firms, US banks also provide credits to EME banks while EME banks only invest in EME firms. We assume EME banks borrow from US banks in US dollars, capturing liability dollarization of the emerging countries. For each individual US bank $i$ in period $t$, its balance sheet identity can be written as:

$$q_t^* S_{it}^* + q_{bt}^* D_{it}^{b*} = N_{it}^* + D_{it}^* \tag{2}$$

where $S_{it}^*$ is state-contingent securities issued by US firms and $q_t^*$ is the asset price. $D_{it}^{b*}$ is the US dollar debt assets issued by EME banks (in US per-capita terms) while $q_{bt}^*$ is the price of these state-contingent cross-border assets. $N_{it}^*$ is US banks' net worth and $D_{it}^*$ is US households' deposits with the US bank. US variables are all denoted with a star.

The US banks' flow of funds constraint is given by:

$$q_t^* S_{it}^* + q_{bt}^* D_{it}^{b*} + R_t^* D_{it-1}^* \leq [Z_t^* + (1-\delta^*) q_t^*] S_{it-1}^* + [Z_t / Q_t + q_{bt}^* (1-\delta)] D_{it-1}^{b*} + D_{it}^*, \tag{3}$$

where the left-hand side is US banks' purchase of domestic and EME assets and its interest and debt repayment to US households. The right-hand side is total value of US banks' existing asset holdings and newly issued deposits.

We define the gross rate of return on US firm-issued securities and EME bank-issued assets to be:

$$R_{kt}^* = \frac{[Z_t^* + (1-\delta^*) q_t^*]}{q_{t-1}^*} \tag{4}$$

$$R_{bt}^* = \frac{[Z_t / Q_t + q_{bt}^* (1-\delta)]}{q_{bt-1}^*} \tag{5}$$

where $Z_t^*$ and $Z_t$ are dividends (or real capital rental cost) of the US and EME firm-issued assets. $\delta^*$ is US capital depreciation rate. All terms are in units of US CPI. $Q_t$ is the real exchange rate and is defined to be $Q_t = e_t P_t^* / P_t$. $e_t$ is the nominal exchange rate, expressed as price of US dollar in EME currency. An increase in $Q_t$ is thus real exchange rate depreciation for the EME. Equation (5) says that each unit of US banks' lending to EME banks is a claim to the future returns of one unit of the asset that the EME bank holds. With these, we can rewrite equation (3) as:

$$q_t^* S_{it}^* + q_{bt}^* D_{it}^{b*} + R_t^* D_{it-1}^* \leq R_{kt}^* q_{t-1}^* S_{it-1}^* + R_{bt}^* q_{bt-1}^* D_{it-1}^{b*} + D_{it}^* \tag{6}$$

Combine US banks' balance sheet identity (2) and flow of funds constraint (6), we obtain the evolution equation of net worth for an individual bank $i$ as:

$$N_{it+1}^{*} = (R_{kt+1}^{*} - R_{t+1}^{*})q_t^{*}S_{it}^{*} + (R_{bt+1}^{*} - R_{t+1}^{*})q_{bt}^{*}D_{it}^{b*} + R_{t+1}^{*}N_{it}^{*} \quad (7)$$

At the end of period $t$, the bank maximizes its present value of future net worth:

$$V_{it}^{*} = \mathbb{E}_t \sum_{j=1}^{\infty}(1-\sigma^{*})\sigma^{*j-1}\Lambda_{t,t+j}^{*}N_{it+j}^{*} \quad (8)$$

where $\Lambda_{t,t+1}^{*}$ is the stochastic discount rate between period $t$ and $t+1$.

*3.1.1.1 US Banks' Financing Constraint and EME Riskiness*

US banks' financing are constrained through an agency friction problem. We assume that each period, US bankers may default and abscond with a fraction $\theta^{*}$ of its total assets. US households thus will only lend to a bank if its continuation value $V_{it}^{*}$ is larger than the benefit to abscond:

$$V_{it}^{*} \geq \theta^{*}(q_t^{*}S_{it}^{*} + (1+\gamma_b^{*})q_{bt}^{*}D_{it}^{b*}) \quad (9)$$

Here $\theta^{*}$ can be thought of as the inverse measure of US banks' risk bearing capacity. The higher the $\theta^{*}$ is, the more constrained US banks will be. If $\gamma_b^{*} > 0$, then lending to EME banks is considered riskier than lending to US firms, and US banks' balance sheet would be further constrained. We use $\gamma_b^{*}$ as a measure of the riskiness of investing in EME. We will show later that higher $\gamma_b^{*}$ implies tighter financing constraint for US investors, and US investors will require a higher return from the EME in the steady state as a compensation for taking on risk as they lend to the emerging country. This is a new feature in our model.

We can rewrite US banks' value function in recursive form as:

$$V_{it}^{*} = \max_{S_{it}^{*}, D_{it}^{b*}, D_{it}^{*}} \mathbb{E}_t \Lambda_{t,t+1}^{*}\{(1-\sigma^{*})N_{it+1}^{*} + \sigma^{*}(\max V_{it+1}^{*})\} \quad (10)$$

Skipping details of derivation, the equilibrium conditions for US banking sector are:

$$\Omega_t^{*} = 1 - \sigma^{*} + \sigma^{*}(\Phi_t^{*}\mu_t^{*} + \upsilon_t^{*}) \quad (11)$$

$$\Phi_t^{*} = \phi_t^{*} + \gamma_b^{*}\phi_{bt}^{*} \quad (12)$$

$$\upsilon_t^* = \mathbb{E}_t \Lambda_{t,t+1}^* \Omega_{t+1}^* R_{t+1}^* \tag{13}$$

$$\mu_t^* = \mathbb{E}_t \Lambda_{t,t+1}^* \Omega_{t+1}^* (R_{kt+1}^* - R_{t+1}^*) \tag{14}$$

$$\mu_t^{b*} = \mathbb{E}_t \Lambda_{t,t+1}^* \Omega_{t+1}^* (R_{bt+1}^* - R_{t+1}^*) \tag{15}$$

$$\mu_t^{b*} = (1 + \gamma_b^*) \mu_t^* \tag{16}$$

where $\Omega_t^*$ is the shadow value of US banks' net worth. Combined, $\Lambda_{t,t+1}^* \Omega_{t+1}^*$ is the augmented discount rate for US bankers between period $t$ and $t+1$. $\Phi_t^*$ is the weighted sum of US banking sector total leverage ratio $\phi_t^*$ and the leverage ratio for investment in the EME $\phi_{bt}^*$. $\upsilon_t^*$ is the cost of deposits. $\mu_t^*$ is the US home asset return premium, which is the expected difference between future capital return and real risk-free rate. $\mu_t^{b*}$ is the cross-border asset return premium. As shown in Equation (16), the two premiums are correlated with a factor $(1 + \gamma_b^*)$. Equations (14) - (16) imply that if $\gamma_b^* = 0$, $\Lambda_{t,t+1}^* \Omega_{t+1}^* R_{bt+1}^* = \mathbb{E}_t \Lambda_{t,t+1}^* \Omega_{t+1}^* R_{kt+1}^*$. In other words, US banks will intermediate until the marginal return on US firm-issued securities and claims on EME banks are matched. If $\gamma_b^* > 0$, then $\mu_t^{b*} > \mu_t^*$, and hence $\mathbb{E}_t \Lambda_{t,t+1}^* \Omega_{t+1}^* R_{bt+1}^* > \Lambda_{t,t+1}^* \Omega_{t+1}^* R_{kt+1}^*$. US banks require a higher return on claims on EME banks to compensate for their tighter financing constraint arising from exposure to EME bank-issued assets. Further, US banks would charge a higher premium on its lending to EME banks with higher $\gamma_b^*$ values, which we use as a measure for EME riskiness. Finally, in the rarer case that $\gamma_b^* < 0$, then $\mu_t^{b*} < \mu_t^*$, and hence $\mathbb{E}_t \Lambda_{t,t+1}^* \Omega_{t+1}^* R_{bt+1}^* < \Lambda_{t,t+1}^* \Omega_{t+1}^* R_{kt+1}^*$.

US banks' sum of leverage ratios can be derived when the incentive constraint is binding:

$$\left(\phi_t^* + \gamma_t^{b*} \phi_{bt}^*\right) = \frac{\upsilon_t^*}{\theta^* - \mu_t^*}, \tag{17}$$

thus, the weighted sum of US banking sector leverage ratio is increasing in its risk bearing capacity $\frac{1}{\theta^*}$ and premium $\mu_t^*$.

In aggregate, we have

$$\phi_t^* N_t^* = q_t^* S_t^* + q_{bt}^* D_t^{b*} \tag{18}$$

$$\phi_{bt}^{*}N_t^{*} = q_{bt}^{*}D_t^{b*} \tag{19}$$

$$D_t^{*} = (\phi_t^{*} - 1)N_t^{*} \tag{20}$$

Each period only a fraction $\sigma^*$ of bankers survive to the next period, and exiting bankers transfer a fraction $\frac{\xi_b^*}{f^*}$ of total assets to new bankers. and the evolution of banks' net worth in aggregate is given by:

$$N_t^{*} = \sigma^{*}[(R_{kt}^{*} - R_t^{*})q_{t-1}^{*}S_{t-1}^{*} + (R_{bt}^{*} - R_t^{*})q_{bt-1}^{*}D_{t-1}^{b*} + R_t^{*}N_{t-1}^{*}] + (1-\sigma^{*})\xi_b^{*}(q_{t-1}^{*}S_{t-1}^{*} + q_{bt-1}^{*}D_{t-1}^{b*}) \tag{21}$$

*3.1.2 Home (EME) Banks*

For EME banks, the balance sheet identity is given by

$$q_tS_{it} = N_{it} + D_{it} + Q_tD_{it}^{be*}, \tag{22}$$

where the EME bank funds its loans to domestic firm at time $t$, $q_tS_{it}$, with its own net worth $N_{it}$, domestic households' deposits $D_{it}$ and borrowings from US banks, $Q_tD_{it}^{be*}$, converted to EME currency (in real terms). Note that here $D_{it}^{be*}$ is in per EME capita while $q_{bt}^{*}D_{it}^{b*}$ is in per US capita, otherwise they mean the same thing[14]. In other words, $D_t^{be*} = \frac{\xi^*}{\xi}q_{bt}^{*}D_t^{b*}$ where $\frac{\xi^*}{\xi}$ is the ratio of US population to EME population.

EME banks' flow of funds constraint is given by:

$$q_tS_{it} + R_tD_{it-1} + R_{bt}^{*}Q_tD_{it-1}^{be*} \leq [Z_t + (1-\delta)q_t]S_{it-1} + D_{it} + Q_tD_{it}^{be*}, \tag{23}$$

where $Z_t$ is the dividend payment (real capital rental rate) in period $t$ on loans funded in period $t-1$, and $\delta$ is capital's depreciation rate. All terms are in units of home CPI. $R_t$ is the real return on domestic deposits between period $t-1$ and $t$, and $R_{bt}^{*}$ is the gross interest rate on borrowings from US banks.

[14] We assume EME banks borrow in US dollar to reflect currency mismatch of EME banks' balance sheet. In addition, as US dollar assets entails a convenience yield, it will be cheaper for the EME bank to issue US dollar debt securities compared to home currency securities (see Jiang, Krishnamurthy, and Lustig (2020)).

Define the gross rate of return on bank assets to be:

$$R_{kt} = \frac{[Z_t + q_t(1-\delta)]}{q_{t-1}}, \tag{24}$$

we can thus rewrite equation (23) to be:

$$q_t S_{it} + R_t D_{it-1} + R_{bt}^* Q_t D_{it-1}^{be*} \leq R_{kt} q_{t-1} S_{it-1} + D_{it} + Q_t D_{it}^{be*} \tag{25}$$

Combine EME bank's balance sheet identity (22) and its flow of funds constraint (25), we get:

$$N_{it+1} = (R_{kt+1} - R_{t+1}) q_t S_{it} + \left(R_{t+1} - \frac{R_{bt+1}^* Q_{t+1}}{Q_t}\right) Q_t D_{it}^{be*} + R_{t+1} N_{it} \tag{26}$$

At the end of period $t$, the bank maximizes the present value of its expected future net worth according to:

$$V_{it} = \mathbb{E}_t \sum_{j=1}^{\infty} (1-\sigma)\sigma^{j-1} \Lambda_{t,t+j} N_{it+j} \tag{27}$$

*3.1.2.1 EME Banks' Financing Constraint and Bank Riskiness*

Similar to US banks, EME banks are constrained in how much they can borrow. Specifically, EME banks also face an incentive constraint that its continuation value must be greater than or equal to a fraction of its total asset value:

$$V_{it} \geq \theta\left(1 + \gamma_b x_{it}^{b*}\right) q_t S_{it} \tag{28}$$

Like the case of the US, $\theta$ captures the inverse of EME banks' risk bearing capacity. $x_{bit}^* = \frac{Q_t D_{it}^{be*}}{q_t S_{it}}$ is the ratio of EME bank's interbank borrowings from the US to its total asset value. Higher $\gamma_b$ values imply tighter financing constraint for the EME bank due to its exposure to dollar debt, which provides an incentive for the EME bank to borrow less from the US. In our model, safer[15] EMEs are associated with higher $\gamma_b$ values and tend to limit their dollar indebtedness in equilibrium, resembling macro-prudential policies in place in safer EMEs. This is a second feature that differentiates a safer EME from a riskier one.[16]

We now rewrite EME banks' value function in Bellman equation:

$$V_{it} = \max_{S_{it}, D_{it}^{be*}} \mathbb{E}_t \Lambda_{t,t+1} \{(1-\sigma) N_{it+1} + \sigma(\max V_{it+1})\} \tag{29}$$

EME banks thus maximize their valuation (29) subject to its borrowing constraint (28). Skipping details of derivation, in equilibrium EME banks intermediate until the following conditions are satisfied:

$$\mu_t = \mathbb{E}_t[\Lambda_{t,t+1} \Omega_{t+1} (R_{kt+1} - R_{t+1})] \tag{30}$$

$$\mu_t^b = \mathbb{E}_t[\Lambda_{t,t+1} \Omega_{t+1} \left(R_{t+1} - \frac{R_{bt+1}^* Q_{t+1}}{Q_t}\right)] \tag{31}$$

$$\upsilon_t = \mathbb{E}_t(\Lambda_{t,t+1} \Omega_{t+1} R_{t+1}) \tag{32}$$

$$\Omega_t = 1 - \sigma + \sigma[\,(1 + \gamma_b x_{bt}^*) \phi_t \mu_t + \upsilon_t] \tag{33}$$

$$\mu_t^b = \gamma_b \mu_t \tag{34}$$

The leverage ratio of EME banks is given by:

$$\phi_t = \frac{\upsilon_t}{(\theta - \mu_t)(1 + \gamma_b x_{bt}^*)} \tag{35}$$

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[15] We use "safer EMEs" and "EMEs with safer banks" interchangeably here since we only consider one-dimension of risk in our model.

[16] Different $\gamma_b$ values imply different financing constraint tightness when EME borrows from US banks. In some existing literature, higher $\gamma_b$ values are associated with riskier EMEs, and implies lower borrowing rate from the US, all else equal. In the this paper, we calibrate this parameter to ensure that steady state US and EME risk-free rate, capital return and spreads, $R^*$, $R$, $R_k^*$, $R_k$, $R_k^* - R^*$, $R_k - R$ are the same for safe and risky EMEs while cross-border rate $R_b^*$ is left to vary. Riskier EMEs are associated with higher $\gamma_b^*$ and lower $\gamma_b$ values. See Section *3.6* for details.

EME banking sector leverage ratio $\phi_t$ is increasing in EME banks' risk bearing capacity $\frac{1}{\theta}$ and the interest rate spread $\mu_t$ while decreasing in restrictions on EME banks' exposure to dollar borrowings. All else equal, a safer EME would have a lower leverage ratio than a riskier EME due to higher $\gamma_b$ values.

In aggregate, we have

$$q_t S_t = \phi_t N_t \tag{36}$$

$$Q_t D_t^{be*} = x_{bt}^* \phi_t N_t \tag{37}$$

Each period only a fraction $\sigma$ of bankers survive to the next period, and exiting bankers transfer a fraction $\frac{\xi_b}{f}$ of total capital stock to new bankers. Thus, in aggregate, evolution of total net worth can be rewritten from previous equation (26) as:

$$N_t = \sigma\left[(R_{kt} - R_t)q_{t-1}S_{t-1} + \left(R_t - \frac{R_{bt}^* Q_t}{Q_{t-1}}\right)Q_{t-1}D_{t-1}^{be*} + R_t N_{t-1}\right] + (1-\sigma)\xi_b q_{t-1}S_{t-1} \tag{38}$$

*3.2 Home (EME) Households*

*3.2.1 Households and Labor Market*

The rest of the model builds on influential works such as Christiano, Eichenbaum, and Evans (2005). We describe the decisions optimizing agents have to make while deferring full descriptions of equilibrium conditions to the Appendix[17]. The model features Calvo-type wage setting as in Erceg, Henderson, and Levin (2000). 'Labor contractors' produce homogeneous factor of production $L_t$ by combining differentiated labor inputs $L_{it}$ according to a linear homogeneous technology $L_t = [\int_0^1 L_{it}^{\frac{1}{\theta_w+1}} di]^{1+\theta_w}$.

Profit-maximizing labor contractors' demand for $L_{it}$ is given by:

$$L_{it} = L_t(\frac{W_{it}}{W_t})^{-\frac{1+\theta_W}{\theta_w}}, \tag{39}$$

[17] See Appendix A.5.

where $W_{it}$ is the nominal wage of type-$i$ labor supplier and aggregate wage index is $W_t = [\int_0^1 W_{it}^{-\frac{1}{\theta_w}} di]^{-\theta_w}$.

Household $i$ maximizes its life-time utility:

$$\max_{C_t, D_t, B_t, L_t} \mathbb{E}_t\{\sum_{j=0}^{\infty} \beta^j [\frac{\sigma_u}{\sigma_u - 1}(C_{t+j} - bC_{t+j-1})^{\frac{\sigma_u - 1}{\sigma_u}} - \frac{\chi_0}{1+\chi} L_{it+j}^{1+\chi}]\}$$

subject to the budget constraint:

$$P_t C_t + P_t D_t + B_t \leq W_{it} L_{it} + P_t R_t D_{t-1} + R_t^n B_{t-1} + \mathcal{W}_{it} + \pi_t \ ,$$

where $R_t^n$ is nominal interest rate, $B_t$ is households' holdings of nominal one-period riskless bonds. $\mathcal{W}_{it}$ is cash flow from household $i$'s portfolio of state-contingent securities and $\pi_t$ is firm and bank profits. Parameter $b$ captures households' habit formation. When $b > 0$, household's marginal utility of current consumption is an increasing function of the household's consumption in the previous period.

Aggregate consumption index $C_t$ is produced according to a CES technology:

$$C_t = \left[\gamma^{\frac{1}{\rho}} C_{H,t}^{\frac{\rho-1}{\rho}} + (1-\gamma)^{\frac{1}{\rho}} (\psi_{ct} C_{F,t})^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}} \tag{40}$$

and consumer price index (CPI) is given by:

$$P_t = \left(\gamma P_{H,t}^{1-\rho} + (1-\gamma) P_{F,t}^{1-\rho}\right)^{\frac{1}{1-\rho}} \tag{41}$$

where $\gamma$ is the degree of home bias in household consumption expenditure, $\rho$ is the intertemporal elasticity of substitution between home-produced goods $C_{H,t}$ and imported goods $C_{F,t}$, and $\pi_{ct}$ is CPI inflation. $\psi_{ct}$ reflects costs of adjusting consumption share of imports given by $\psi_{ct} = 1 - \frac{\psi_{FC}}{2}\left(\frac{C_{F,t}/C_{H,t}}{C_{F,t-1}/C_{H,t-1}} - 1\right)^2$, so that import share will be less sensitive to changes in the relative price of imports. Given a fixed budget, the cost-minimizing aggregate consumption index producer chooses $C_{H,t}$ and $C_{F,t}$ to produce the aggregate consumption bundle $C_t$.

Each period, a fraction $(1 - \xi_w)$ of households are allowed to set wages optimally as they maximize life-time utility, while the remaining households index their wages according to $W_{it} = W_{it-1}\pi_{wt-1}^{\iota_w}$, where $\pi_{wt} = \frac{W_t}{W_{t-1}}$ is the period-$t$ wage inflation.

*3.3 Home (EME) Firms and Price Setting*

*3.3.1 Final Goods Producers*

Home country final goods producers (retail firms) produce aggregate domestic output $Y_t$ using intermediate goods $Y_{it}$ as inputs according to a CES technology $Y_t = [\int_0^1 Y_{it}^{\frac{1}{\theta_p+1}} di]^{1+\theta_p}$ and the aggregate price level of domestic final goods is given by $P_{H,t} = [\int_0^1 P_{Hit}^{-\frac{1}{\theta_p}} di]^{-\theta_p}$. Taken aggregate domestic goods price level $P_{H,t}$ and intermediate goods price $P_{Hit}$ as given, final goods producers choose level of input $Y_{it}$ to minimize cost subject to its production function. The demand for intermediate good $i$ can be shown to be $Y_{it} = Y_t(\frac{P_{Hit}}{P_{H,t}})^{-\frac{1+\theta_p}{\theta_p}}$.

*3.3.2 Intermediate Goods Producers*

Home intermediate goods producer $i$ produces according to Cobb-Douglas production technology $Y_{it} = A_t K_{it}^{\alpha} L_{it}^{1-\alpha}$ where $A_t$ is the technology and follows an exogenous stochastic process. Take aggregate real wage rate $\omega_t$ and real capital rental cost $Z_t$ as given, firms choose factor inputs $L_{it}$ and $K_{it}$ in perfectly competitive factor markets to minimize real costs of production subject to its production function. In equilibrium, an optimizing firm produces according to:

$$\omega_t = \frac{1-\alpha}{\alpha}\frac{K_t}{L_t} Z_t \qquad (42)$$

and the real marginal cost is given by:

$$mc_t = A_t^{-1}\left(\frac{\omega_t}{1-\alpha}\right)^{1-\alpha}\left(\frac{Z_t}{\alpha}\right)^{\alpha} \qquad (43)$$

Intermediate goods producers choose the price that maximizes discounted real profits. Each period a fraction $1 - \xi_p$ of firms can change their prices while the remaining firms index their price according to $P_{Hit} = P_{Hi,t-1}\pi_{t-1}^{\iota_p}$ where $\pi_t = \frac{P_{Ht}}{P_{Ht-1}}$ is domestic goods price index inflation. We can then write intermediate firms' profit maximizing problem to be:

$$\max_{P_{Hit}} \sum_{j=0}^{\infty} \xi_p^j \mathbb{E}_t \{\frac{\Lambda_{t,t+j}}{P_{t+j}} [\prod_{k=1}^{j} \pi_{t+k-1}^{\iota_p} P_{Hit} Y_{it+j|t} - MC_{t+j} Y_{it+j|t}]\} \tag{44}$$

subject to the demand faced by firm $i$:

$$Y_{it+j|t} = \left(\frac{P_{Hit+j}}{P_{H,t+j}}\right)^{-\frac{(1+\theta_p)}{\theta_p}} Y_{t+j} \tag{45}$$

where $Y_{it+j|t}$ is demand for intermediate good $i$ given firm $i$ last set its optimal price $P_{Hit}$ in period $t$.

*3.3.3 Capital Goods Producers*

Capital goods producers use final output $Y_t$ to make new capital goods subject to adjustment costs. New capital goods are sold at market price $q_t$. The objective of capital producers is to maximize their expected discounted profits by choosing input $I_t$. The representative capital goods producer solves:

$$\max_{I_{t+j}} \mathbb{E}_t \{\sum_{j=0}^{\infty} \Lambda_{t,t+j} [q_{t+j} I_{t+j} - \left(1 + \frac{\Psi_I}{2}\left(\frac{I_{t+j}}{I_{t+j-1}} - 1\right)^2\right) I_{t+j}]\} \tag{46}$$

where $\phi_{It} = \frac{\Psi_I}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2 I_t$ is the capital adjustment costs.

In equilibrium, price of capital goods is equal to the marginal cost of investment:

$$q_t = 1 + \frac{\Psi_I}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2 + \Psi_I \left(\frac{I_t}{I_{t-1}} - 1\right) \frac{I_t}{I_{t-1}} - \mathbb{E}_t \{\Lambda_{t,t+1} \Psi_I \left(\frac{I_{t+1}}{I_t} - 1\right) \left(\frac{I_{t+1}}{I_t}\right)^2\} \tag{47}$$

Similar to consumption goods, investment goods $I_t$ is a composite of domestic ($I_{Ht}$) and imported ($I_{Ft}$) investment goods produced by an aggregator according to CES technology:

$$I_t = \left[\gamma^{\frac{1}{\rho}} I_{H,t}^{\frac{\rho-1}{\rho}} + (1-\gamma)^{\frac{1}{\rho}} \left(\psi_{It} I_{F,t}\right)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}} \tag{48}$$

where $\psi_{It}$ reflects costs of adjusting share of imported investment goods given by $\psi_{It} = 1 - \frac{\psi_{FI}}{2}\left(\frac{I_{F,t}/I_{H,t}}{I_{F,t-1}/I_{H,t-1}} - 1\right)^2$ . Given a fixed budget, the aggregate investment goods producer chooses inputs $I_{H,t}$ and $I_{F,t}$ to minimize its discounted expected costs of producing the aggregate investment good subject to its production function.

*3.4 Foreign (US) Economy*

Except for the banking sector, US economy is symmetric to home economy with price and wage rigidity.

*3.5 Market Clearing and Equilibrium Conditions*

*3.5.1 Home goods and capital market equilibrium*

Home goods market equilibrium implies:

$$Y_t = C_{H,t} + I_{H,t} + \frac{\xi^*}{\xi}\left(C^*_{F,t} + I^*_{F,t}\right) + \frac{\Psi_I}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2 I_t \qquad (49)$$

where $\frac{\xi^*}{\xi}$ is the relative population size of the US and the EME economy. Capital goods evolve according to:

$$S_t = (1-\delta)K_t + I_t \qquad (50)$$

$$K_{t+1} = S_t \qquad (51)$$

*3.5.2 Balance of Payments*

Home economy's trade deficit is funded by foreign borrowings[18]:

$$p_{F,t}\left(C_{F,t} + I_{F,t}\right) - p_{H,t}\frac{\xi^*}{\xi}\left(C^*_{F,t} + I^*_{F,t}\right) = Q_t D_t^{be*} - R^*_{bt} Q_t D_{t-1}^{be*} \qquad (52)$$

*3.5.3 Monetary Policy*

[18] Balance of payments equation can also be written as

$$C_t + I_t + p_{H,t}\frac{\Psi_I}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2 I_t - p_{H,t}Y_t = Q_t D_t^{b*} - R^*_{bt} Q_t D_{t-1}^{b*}$$

We assume that the EME central bank follows a CPI inflation targeting rule when we analyze impulse responses of EME macroeconomic and financial variables to unexpected US interest rate rise:

$$R_t^n = \left(R_{t-1}^{n\gamma_r}\right)\left(R_{ss}^n \pi_{ct}^{\varpi_\pi}\ \right)^{1-\gamma_r} \varepsilon_t^r \tag{53}$$

where $R_{ss}^n$ is the steady state value of domestic nominal interest rate. $\varepsilon_t^r$ is an exogenous monetary policy shock.

The US central bank is assumed to follow a Taylor rule:

$$R_t^{n*} = (R_{t-1}^{n*})^{\gamma_r} \left(R_{ss}^{n*} (\pi_{ct}^*)^{\varpi_\pi^*} \left(\frac{Y_t^*}{Y_{ss}^*}\right)^{\varpi_y^*}\right)^{1-\gamma_r} \varepsilon_t^{r*} \tag{54}$$

where $R_{ss}^{n*}$ and $Y_{ss}^*$ are the steady state values of US nominal interest rate and output. $\varepsilon_t^{r*}$ is an exogenous monetary policy shock process.

*3.6 Exogenous Processes*

We focus on the spillover effects of US monetary policy shocks given by the following exogenous process:

$$\varepsilon_t^{r*} = \rho_r^* \varepsilon_{t-1}^{r*} + u_t^{r*}, u_t^{r*} \sim \mathcal{N}(0, \sigma_r^*) \tag{55}$$

*3.7 Calibration*

Detailed calibration of the parameters is shown in Table **1**. Calibration of most parameters follow conventional values in literature. US discount factor $\beta^*$ is set to 0.995 and the EME counterpart $\beta$ is set to 0.9925. The size of the US economy is set to be three times of the EME: $\frac{\xi^*}{\xi} = 3$[19].

For open economy parameters, EME home bias $\gamma$ is set to 0.8, implying that US home bias $\gamma^*$ is around 0.9 (1-0.2$\frac{\xi}{\xi^*}$). Wage and price markup $\theta_w$ and $\theta_p$ are both set to 0.2. Capital Share

[19] These parameter values are taken from Ozge and Queralto (2019), Reifschneider (2016) and Carrillo et al. (2018). The high $\beta^*$ value is meant to capture a decline in US natural rate. The EME discount rate is calibrated to Mexico. In practice, the population size of US relative to EMEs can vary from 1.2 (US : Indonesia) to 75 (US : Brunei). A hypothetical ratio of 3 is similar to the population size of US relative to Thailand, Vietnam, Philippines, Mexico or Turkey.

$\alpha$ is 0.33 and intertemporal elasticity of substitution $\sigma_u$ is set to 1, implying log utility. Depreciation rate $\delta$ is set to 0.025. These parameter values are conventional, and their US counterparts are set to the same values. Following Erceg et al. (2006), trade price elasticity $\rho$ is set to 1.5, and the trade adjustment cost parameter, $\psi_{FC}$ and $\psi_{FI}$, are both set to 10.

Parameters governing nominal rigidity are taken from estimates by Justiniano et al. (2010). These include price rigidity, wage rigidity, price indexation and wage indexation. Other parameters include habit formation parameter $b$, inverse Frisch elasticity of labor supply and investment adjustment cost are also based on their estimates.

For monetary policy coefficients, we calibrate US Taylor rule parameters $\varpi_\pi^*$ and $\varpi_y^*$ to be 1.5 and 0.125 respectively. These are commonly used values in literature. For impulse response analyses, EME policy parameter $\varpi_\pi$ also takes the conventional value of 1.5. Both US and EME interest rate persistence $\gamma_r$ is set to 0.82, based on estimates from Justiniano et al. (2010). Standard deviation and persistence of US monetary policy shock, $\sigma_r^*$ and $\rho_r^*$ are based on estimates by Ozge and Queralto (2019).

We now turn to the calibration of financial sector parameters. EME and US bank transfer rates $\xi_b$ and $\xi_b^*$ are calibrated to target steady state leverage ratio $\phi$ and $\phi^*$ to be 5. Bankers' survival rate, $\sigma$ is set to be 0.95. The steady state spread between EME capital return and risk-free rate, $R_k - R$, is set to be 200 basis points annually, and the ratio of US dollar debt to home deposits is set to be 30 percent in steady state. These imply EME bank transfer rate $\xi_b$ to be 0.0756 and $\theta$ to be 0.3905. The three target values and bankers' survival rate value follow Ozge and Queralto (2019). For the US banking sector, the annual spread between US capital return and risk-free rate $R_k^* - R^*$ is calibrated to be 60 basis points. It is between the spread of 3-month commercial paper rates over Fed funds rate, which is about 10 basis points on average between 1997 and 2016, and the spread of Baa corporate bond yield over 10-year treasury yield, which averages to 200 basis points between 1990 and 2016[20]. Given $\gamma_b^*$, US risk-free rate $R^*$ and the spread $R_k^* - R^*$, steady state value of $R_b^*$ can be calculated as $(1+\gamma_b^*)(R_k^* - R^*) + R^*$. Larger $\gamma_b^*$ values (i.e., riskier EMEs) imply higher cross-border borrowing rate $R_b^*$ in steady state. Finally, $\gamma_b$ can be calculated as $\frac{R-R_b^*}{R_k-R}$. We calibrate $\gamma_b$ so that steady state US and EME risk-free rates, capital return and spreads, $R^*, R, R_k^*, R_k, R_k^* - R^*, R_k - R$ are the same

[20] The annual spread between US capital return and risk-free rate $R_k^* - R^*$ was calibrated to be 100 basis points in Gertler and Karadi (2011). Calibrating the spread to be 100 basis points will reduce the range of values for EME riskiness parameter $\gamma_b^*$ that yield unique and stable solution. Nevertheless, our key results still hold if we were to use 100 basis points and restrict ourselves to a narrower range of $\gamma_b^*$ values.

for EMEs with safe and risky banks while cross-border rate $R_b^*$ is left to vary. We change as few parameters and steady state values as possible to not obscure the driving mechanism.

Note that higher $\gamma_b^*$ values naturally require lower $\gamma_b$ values to keep EME risk-free rate and capital return unchanged. While larger $\gamma_b^*$ means US investors perceive the EME to be riskier, and US investors' financing constraint will be tighter by investing in the EME thus requiring a higher cross-border return $R_b^*$ in compensation, a lower $\gamma_b$ means less financing constraint on EME banks to borrow from the US. We interpret this as the lack of prudential policies and sound risk management to limit exposure to foreign currency debt for EMEs with risky banks. Nevertheless, as we will see below, if EME's financing constraint tightness due to foreign borrowing (i.e., $\gamma_b$) is the dominating mechanism, we would expect impulse responses' direction to be the opposite of what we have. For example, with larger $\gamma_b^*$ (hence smaller $\gamma_b$ for the EME) values, we would expect capital outflows to be less than the case with smaller $\gamma_b^*$ (hence bigger $\gamma_b$ for the EME) values, but what we see is the opposite. We also confirm that our results are not driven by the "outside equity" mechanism in Gertler et al. (2012). By making cross-border return $R_b^*$ non-contingent, the simulated impulse responses are similar, but that both risky and safe EME consumption and output drop by more given that cross-border borrowings do not offer additional hedging in this case. Optimal monetary policy recommendations also remain similar (See Appendix A.3 for details).

## 4. Monetary Spillovers

In this section we examine the impact of US monetary spillovers on EME macroeconomic and financial variables. Throughout this section, the EME is assumed to commit to an inflation targeting rule and $\varpi_\pi$ in equation (53) is set to be 1.5 which is conventional in literature. The riskier EME is calibrated to have $\gamma_b^* = 1$ while the safer EME's $\gamma_b^*$ value is calibrated as 0.1. Impulse responses of the riskier EME is shown in blue solid lines, and the impulse responses of the safer EME are shown in green dashed lines.

### *4.1 Consumption and Output Decrease by More for the Risky EME*

Figure **5** shows the impulse responses of key EME macroeconomic variables to a one standard deviation increase in the US monetary policy rate. Output and consumption of the risky EME (blue solid lines) drop by more than the safe EME (green dashed lines). The larger decline is partly driven by the larger drop in imports consumption $C_F$ (see Figure **6**).

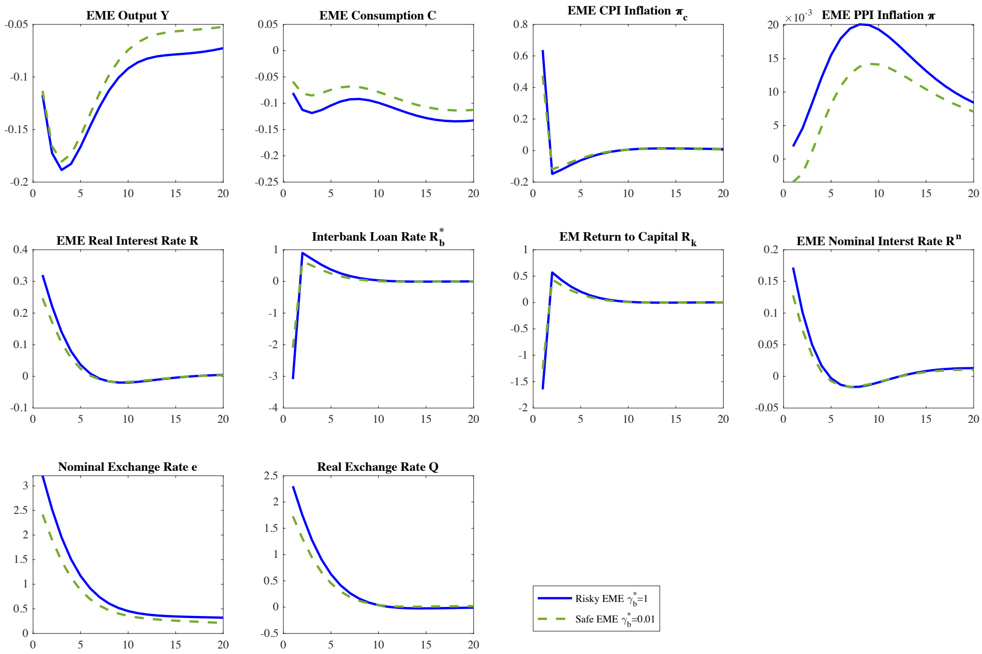


**Figure 5**: Impulse responses of key EME macroeconomic variables to a one standard deviation (20 basis points) increase in the US monetary policy rate. Increase in the value of $e$ and $Q$ means depreciation of EME currency. Notes: $y$ axis: percentage deviation from the steady state; $x$ axis: quarters from the shock.

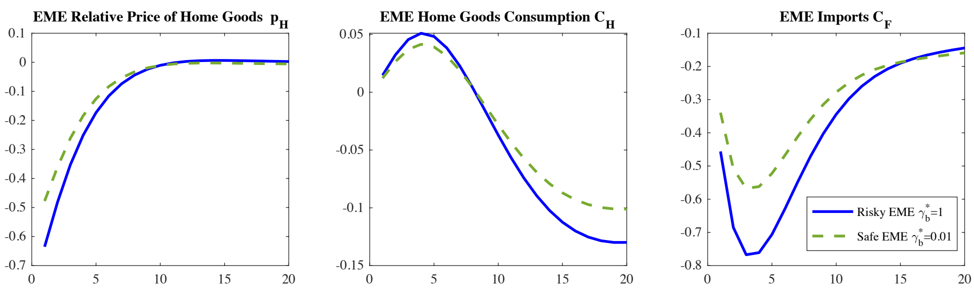


**Figure 6**: Impulse responses of EME macroeconomic variables to a one standard deviation (20 basis points) increase in the US monetary policy rate. Notes: $y$ axis: percentage deviation from the steady state; $x$ axis: quarters from the shock.

### *4.2 Real Exchange Rate Depreciates by More for the Risky EME*

The initial drop in interbank loan rate $R_b^*$ and return on capital $R_k$ is larger in the risky EME reflecting larger drop in both EME domestic and international financial market asset prices. Both nominal and real exchange rates, $e$ and $Q$, depreciate (increase) by more in the risky EME. Note that $\mathbb{E}_t(\widetilde{R^*_{bt+1}} + \widetilde{Q_{t+1}} - \widetilde{Q_t}) = \frac{R}{R_b^*}\widetilde{R_t} + \frac{R-R_b^*}{R_b^*(R_k-R)}\mathbb{E}_t(R_k\widetilde{R_{kt+1}} - R\widetilde{R_t})$[21] where the second term on the right hand side is the spread between expected future return on capital $\widetilde{R_{kt+1}}$ and the pre-determined EME real interest rate $\widetilde{R_t}$. All else equal, higher EME real interest rate $\widetilde{R_t}$

[21] Variables with a tilde denotes percentage deviation from the deterministic steady state.

(the first term on the right-hand side) and lower expected future foreign borrowing rate $\widetilde{R^*_{bt+1}}$ tend to appreciate EME home currency (i.e., $\widetilde{Q_t}$ decreases), and vice versa. For the safe EME, in deterministic steady state $R - R_b^* > 0$, therefore higher spread $R_k\widetilde{R_{kt+1}} - R\widetilde{R_t}$ tend to appreciate EME home currency, all else equal. For the risky EME, in deterministic steady state $R - R_b^* < 0$ and higher expected spread $R_k\widetilde{R_{kt+1}} - R\widetilde{R_t}$ tend to depreciate EME home currency, all else equal. As both the expected one period ahead foreign borrowing rate $\widetilde{R^*_{bt+1}}$ (see Figure 7 (a)) and spread $R_k\widetilde{R_{kt+1}} - R\widetilde{R_t}$ (see Figure 7 (c)) is higher for the risky EME than the safe EME , real exchange rate depreciates by more for the risky EME, but note that the larger depreciation is mainly driven by the larger increase in foreign borrowing rate $\widetilde{R^*_{bt+1}}$. In other words, US banks requiring a higher return on risky EMEs is the main factor that further drives down the risky EME currency vis-à-vis US dollar value in this model.

The depreciation in EME home currency also causes relative price of EME home goods $p_H$ to drop (see Figure 6). CPI inflation $\pi_c$ increases by more in the risky EME due to higher imports price following the larger depreciation, which in turn triggers a larger nominal interest rate response. Higher import price depresses demand for imports by more in the risky EME, resulting in a larger reduction in total consumption of the risky EME shown in Figure 5.

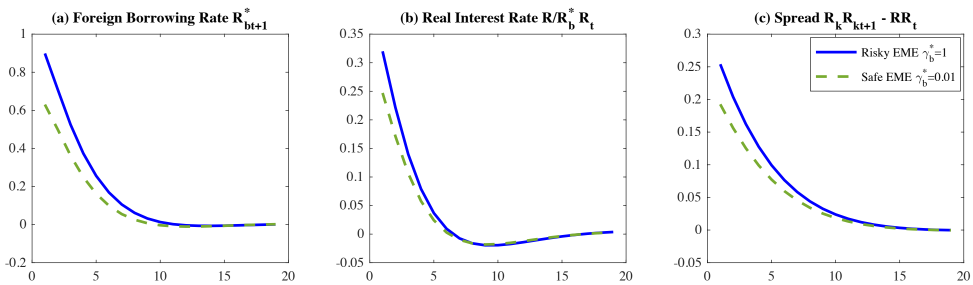


**Figure 7**: Impulse responses of EME financial variables to a one standard deviation (20 basis points) increase in the US monetary policy rate. Notes: $y$ axis: percentage deviation from the steady state; $x$ axis: quarters from the shock.

*4.3 Steeper Asset Price and Net Worth Drop for the Risky EME*

We now look at EME financial market variables displayed in Figure 8. The initial decrease in both EME asset price $q$ and cross border asset price $q_b^*$ is larger for the risky EME. This is consistent with the larger initial decline in EME capital return $R_k$ and return on loans to EME $R_b^*$ shown previously in Figure 5. Premium on domestic asset $\mu$ also increases by more for the risky EME. Consistent with past empirical observations, the risky EME experiences larger capital outflows than the safe EME as US investment $D^{be*}$ falls by more for the risky EME than the safe EME.

Net worth $N$ of the banking sector drops by more in the risky EME, which is due to the larger initial fall in capital return $R_k$[22]. The drop in asset prices, net worth and cross-border borrowing depress EMEs' asset and capital accumulation. It is not surprising that the negative impact is larger for the risky EME than the safe EME as shown in Figure **8** that the risky EME's asset $S$ and capital $K$ both drop by more.

Following the larger drop in net worth $N$, leverage $\phi$ and shadow value of net worth $\Omega$ both increase by more for the risky EME. Costs of deposits $\upsilon$ also increase by more for the risky EME as its real interest rate $R$ is higher.

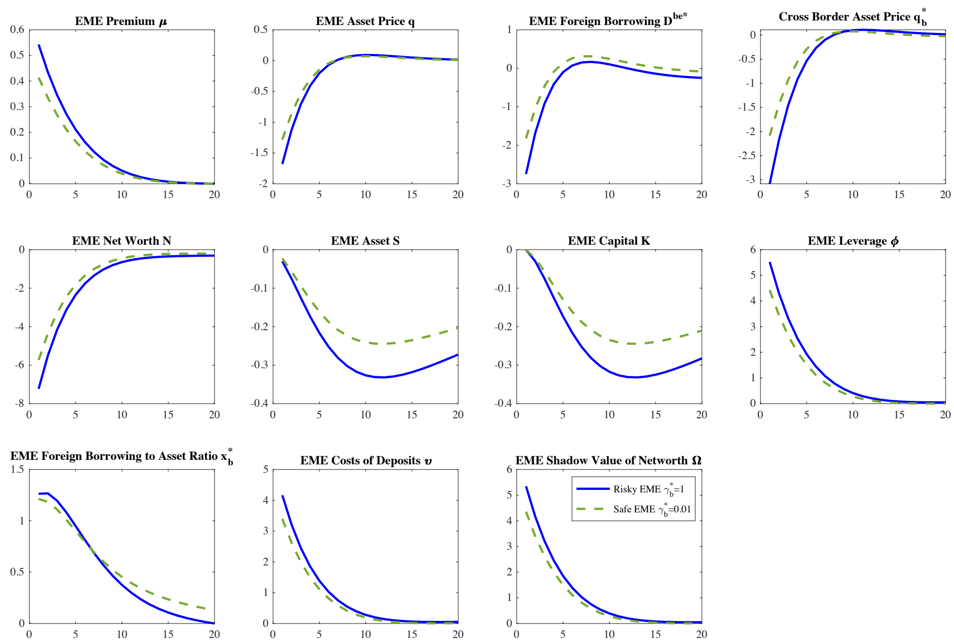


**Figure 8**: Impulse responses of key EME financial variables to a one standard deviation (20 basis points) increase in the US monetary policy rate. Notes: $y$ axis: percentage deviation from the steady state; $x$ axis: quarters from the shock.

### *4.4 Impulse Responses of the US*

On the other hand, the differences in impulse responses of key macroeconomic and financial variables of the US with the risky and the safe EME are much more muted as shown in Figure **9** and **10**. Note that the US leverage ratio $\phi_b^*$ for its holdings of EME asset is higher with safe EME than risky EME. This is mainly due to the cross-border asset price $q_b^*$ is much lower with

[22] This can be seen from the log-linearized form of net worth evolution equation (38): $\widetilde{N_t} = [(1-\sigma)\xi_b\phi + \sigma(R_k - R)\phi] * (\widetilde{q_{t-1}} + \widetilde{S_{t-1}}) + \sigma\phi(R_k\widetilde{R_{kt}} - R\,\widetilde{R_{t-1}}) + \sigma x^{b*}\phi[R\widetilde{R_{t-1}} - (R_b^*\widetilde{R_{bt-1}^*} + R_b^*\widetilde{Q_t} - R\widetilde{Q_{t-1}})] + \sigma(R - R_b^*)x^{b*}\phi\widetilde{D_{t-1}^{be*}} + \sigma R(\widetilde{R_{t-1}} + \widetilde{N_{t-1}})$ . In particular, $\sigma\phi(R_k\widetilde{R_{kt}} - R\,\widetilde{R_{t-1}})$ and $\sigma R(\widetilde{R_{t-1}} + \widetilde{N_{t-1}})$ are the dominant terms.

the risky EME[23]. The initial drop in net wroth $N^*$ is slightly larger for the case with safe EME because of higher US domestic real borrowing cost $R^*$ and lower expected one period ahead return on cross-border investment $R_b^*$. The lower net worth $N^*$ in turn pushes up US overall leverage ratio $\Phi^*$, shadow value of net worth $\Omega^*$ and premiums on domestic and cross-border investment return $\mu^*$ and $\mu_b^*$.

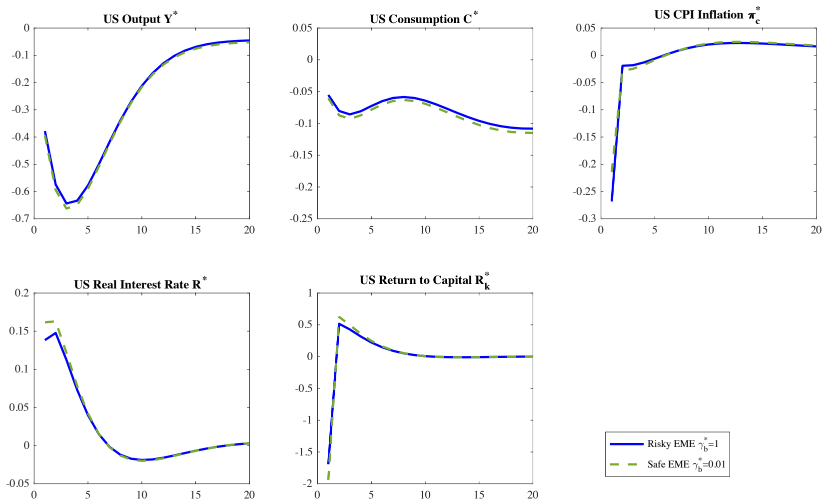


**Figure 9**: Impulse responses of key US macroeconomic variables to a one standard deviation (20 basis points) increase in the US monetary policy rate. Notes: $y$ axis: percentage deviation from the steady state; $x$ axis: quarters from the shock.

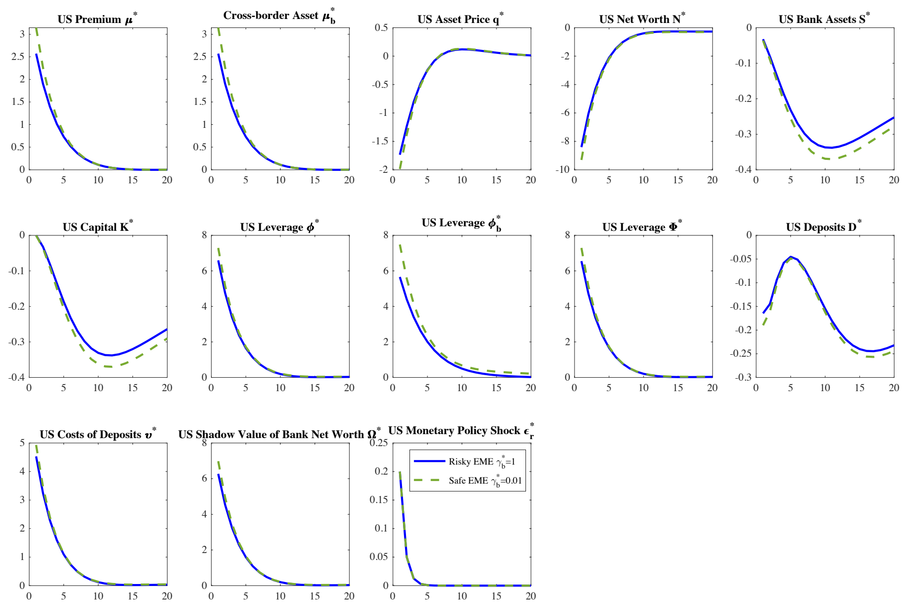


**Figure 10**: Impulse responses of key US financial variables to a one standard deviation (20 basis points) increase in the US monetary policy rate. Notes: $y$ axis: percentage deviation from the steady state; $x$ axis: quarters from the shock.

[23] Note that $\widetilde{\phi_{bt}^*} = \widetilde{q_{bt}^*} + \widetilde{D_t^{b*}} - \widetilde{N_t^*}$

*4.4 The Mechanism*

We next describe what's driving the differing impulse responses of the risky EME compared to the safe EME. Following a contractionary US monetary shock, US banks' financing constraint tightens, causing them to deleverage and engage in fire sale of both US firm-issued assets and EME bank-issued assets. The cross-border spillover is reflected in the increased required return ($\mathbb{E}_t R^*_{b,t+1}$) from the EME bank, and the increase is larger for the riskier EME since US banks suffer a tighter financing constraint by investing in the riskier EME. As foreign borrowing rate increases, EME banks' financing constraint also tightens, causing them to similarly deleverage and engage in fire sale of domestic assets. EME asset price ($q_t$) plunges as a result, and the decline is larger for the riskier EME. EME firms' borrowing spread $\mu_t$ increases, and the increase is larger for the riskier EME.

## 5. EME Riskiness Level and Optimal Monetary Policy

*5.1 Welfare Comparison and Optimal Monetary Policy*

In this section, we examine the optimal monetary policies for EMEs of different riskiness. We hope to address the debate of whether EMEs should adopt a peg or a floating exchange rate regime as they become financially integrated with the rest of the world using our framework. To this end, we rewrite the EME monetary policy equation (53) to be:

$$R_t^n = \left(R_{t-1}^{n\gamma_r}\right)\left(R_{ss}^n \pi_{ct}^{\frac{1-\varpi_e}{\varpi_e}} \left(\frac{e_t}{e_{ss}}\right)^{\frac{\varpi_e}{1-\varpi_e}}\right)^{1-\gamma_r} \varepsilon_t^r \tag{56}$$

Equation (56) is similar to the monetary policy specification in Gali and Monacelli (2016). When $\varpi_e = 0.01$, the EME follows a strict inflation targeting regime, and when $\varpi_e = 0.99$, the EME follows a strict peg regime. For $\varpi_e$ between these two values, the EME pursues some stabilization in both inflation and exchange rate and implements a hybrid regime.

To calculate welfare, we rewrite the EME households' lifetime utility function recursively:

$$Welf_t = U(C_t, L_t) + \beta \mathbb{E}_t Welf_{t+1}, \tag{57}$$

where $U(C_t, L_t)$ is the period utility function at time $t$. We compute the conditional welfare as in Schmitt-Grohe and Uribe (2007). Essentially, we will be comparing the stochastic steady state value of EME households' welfare $welf$ under different monetary policies and for countries of different riskiness levels. Stochastic steady state is the point that agents in the economy would choose when they factor in the possibility that shocks may realize in the future. We use conditional welfare measure as our purpose is to understand whether optimal monetary policy implications could be different for emerging countries with different bank riskiness. We therefore deliberately calibrate the model in such a way that the deterministic steady state cross-border borrowing cost is higher for the risky EME than the safe EME, while differences in other variables' deterministic steady state values are kept to a minimum.

Figure **1** (a) and (b) show the conditional welfare level for the risky and the safe EME across different policy parameter values. For the risky EME, a more inflation targeting oriented monetary policy (i.e., smaller $\varpi_e$ values) reduces welfare loss. For the safe EME, however, exchange rate stabilization monetary policies can outperform inflation targeting policies. We next ask what contributes to the different optimal monetary policy implications for the risky and the safe EME.

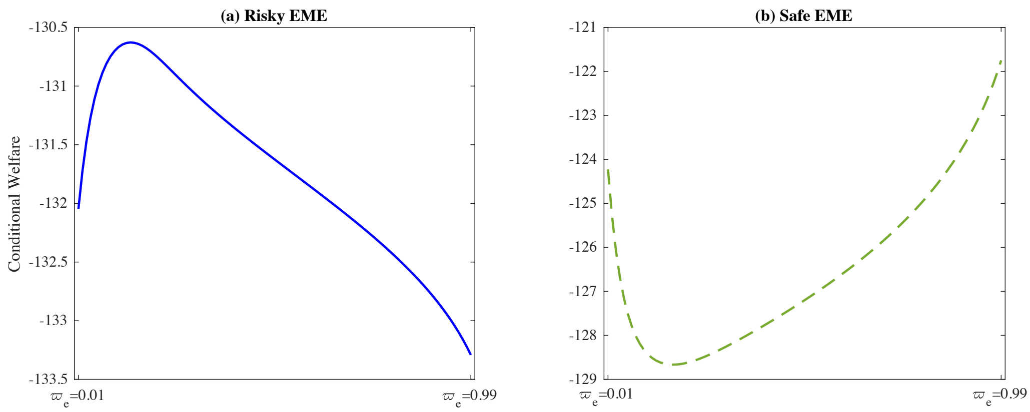


**Figure 1**:Conditional welfare measures for the (a) risky and (b) safe EME. Notes: $y$ axis: conditional welfare measure; $x$ axis: policy parameter $\varpi_e$. $\varpi_e = 0.01$ denotes strict inflation targeting; $\varpi_e = 0.99$ denotes strict peg.

### *5.2 Stochastic Steady State Consumption*

Figure **2** presents the uncertainty correction to welfare and its key components under two monetary policies—strict peg ($\varpi_e = 0.99$) and strict inflation targeting ($\varpi_e = 0.01$)—across different EME riskiness levels $\gamma_b^*$. As mentioned previously, conditional welfare is calculated as the stochastic steady state value of life-time utility $welf$ in equation (57), which essentially is the sum of the deterministic steady state value of $welf$ and an uncertainty correction term. Given the EME riskiness level, $\gamma_b^*$, the deterministic steady state value of $welf$ is the same for any policy (i.e., for any $\varpi_e$) but uncertainty correction terms will vary. Therefore, it is sufficient to compare the uncertainty correction terms for ranking policies.

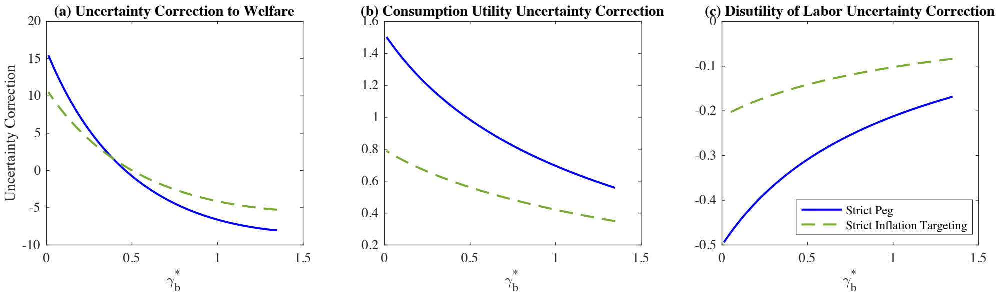


**Figure 2**: Components of conditional welfare measures across EME riskiness levels $\gamma_b^*$. Notes: $y$ axis: uncertainty correction; $x$ axis: EME riskiness $\gamma_b^*$. Smaller $\gamma_b^*$ denotes safer EMEs; larger $\gamma_b^*$ denotes riskier EMEs.

Figure 2 (a) shows that for safer EMEs (i.e., smaller $\gamma_b^*$), strict peg outperforms strict inflation targeting, and vice versa. It is also interesting to note that the uncertainty correction is positive for safer EMEs, meaning that safer EME households' lifetime utility in stochastic steady state is actually higher than deterministic steady state. These results are mainly driven by the increase in stochastic steady state consumption levels for safer EMEs compared to riskier EMEs, and the increase is more pronounced under strict peg (see Figure 2 (b)).

Figure 3 shows uncertainty correction to key macroeconomic variables for EMEs across different riskiness levels $\gamma_b^*$. Across $\gamma_b^*$, stochastic steady state values of both nominal and real interest rates are lower for safer EMEs than riskier EMEs, because the targets under either policies — exchange rate and CPI inflation — are lower for safer EMEs. In other words, safer EMEs experience larger currency appreciation. When EME monetary policy does not aim to stabilize exchange rate, this larger appreciation translates into larger downward pressure on CPI inflation.

For safer EMEs (e.g., given $\gamma_b^* = 0.01$), the stochastic steady state real interest rate is lower under strict peg than strict inflation targeting. This is mainly due to the different implications for stochastic steady state CPI inflation under the two different monetary policies. Under peg, the lower real interest rate is a result of higher CPI inflation, driven by the higher PPI inflation. In addition, CPI inflation is slightly lower than PPI inflation because imported goods become cheaper as EME currency appreciates. Under inflation targeting, the uncertainty correction to $\pi_c$ is close to zero. Overall, these results are consistent with the previous finding that consumption is higher for safer EMEs, especially when under strict peg.

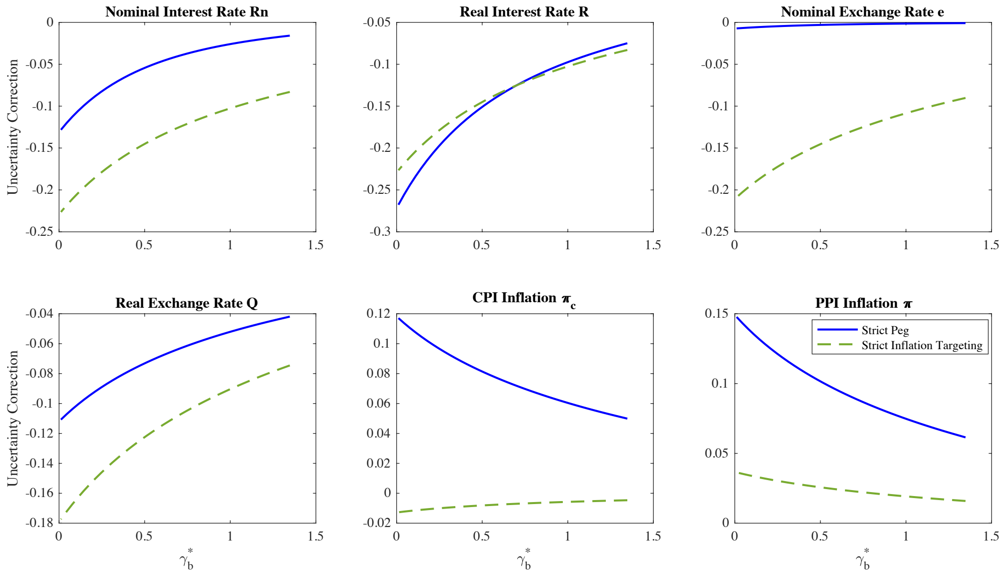


**Figure 3**: Uncertainty correction of key macroeconomic variables for EME of different riskiness levels $\gamma_b^*$. Notes: $y$ axis: uncertainty correction; $x$ axis: EME riskiness $\gamma_b^*$. Smaller $\gamma_b^*$ denotes safer EMEs; larger $\gamma_b^*$ denotes riskier EMEs.

### *5.3 Stochastic Steady State Asset Price and Capital Inflow*

As for the EME financial market (see Figure **4**), stochastic steady state value of home asset price $q$ is higher for safer EMEs than riskier EMEs. Correspondingly, home capital return $R_k$ is higher and premium $\mu$ is lower for safer EMEs. One may thus wonder why higher levels of $R_k$ is associated with lower $\mu$, since by definition $\mu_t = \mathbb{E}_t[\Lambda_{t,t+1}\Omega_{t+1}(R_{kt+1} - R_{t+1})]$. In fact, higher capital return $R_k$ has two off-setting effects on premium $\mu$: First, the most straight-forward effect is that higher stochastic steady state level of capital return pushes up the stochastic steady state level of premium $\mu$ (see Figure **6** (b)). The second effect, which is less direct, is that the uncertainty correction to expected future period capital return, $R_{kt+1}$ is actually lower due to higher stochastic steady state $q$ (see Figure **6** (a)). When the second effect is dominant, premium $\mu$ will be rendered lower[24]. Finally, stochastic steady state cross-border asset price $q_b^*$, cross-border asset return $R_b^*$ and capital inflow $D^{be*}$ are all higher for safer EMEs than riskier EMEs.

[24] In log-linearized form, $\widetilde{\mu_t} = \widetilde{\Lambda_{t,t+1}} + \widetilde{\Omega_{t+1}} + \frac{1}{R_k - R}\left(R_k\widetilde{R_{kt+1}} - R\widetilde{R_t}\right)$. $\frac{\partial\widetilde{\mu_t}}{\partial\widetilde{R_{kt+1}}} = \frac{R_k}{R_k - R}$, which is very small in magnitude. That is why the absolute value of uncertainty correction to $\mu$, and the $y$-axis scale in Figure **6** are quite large.

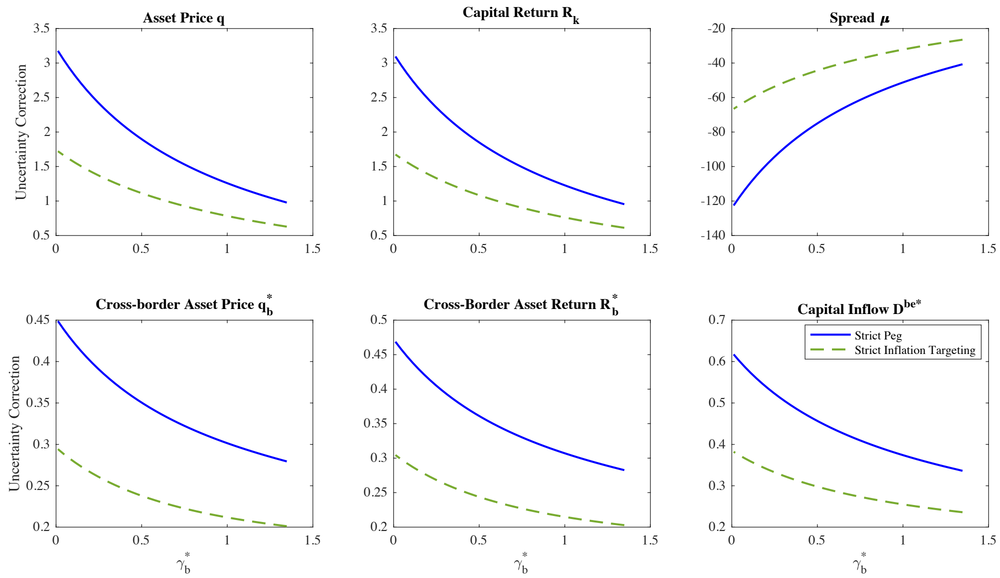


**Figure 4**: Uncertainty correction of key financial variables for EME of different riskiness levels $\gamma_b^*$. Notes: $y$ axis: uncertainty correction; $x$ axis: EME riskiness $\gamma_b^*$. Smaller $\gamma_b^*$ denotes safer EMEs; larger $\gamma_b^*$ denotes riskier EMEs.

### *5.4 Stochastic Steady State Real Exchange Rate*

Before we move on to US financial sector variables, it might be of some interest to look at the factors influencing the stochastic steady state value of real exchange rate for EMEs of different riskiness levels. In equilibrium, $\mathbb{E}_t\left[\Lambda_{t,t+1}\Omega_{t+1}\left(R_{t+1}-\frac{R^*_{bt+1}Q_{t+1}}{Q_t}\right)\right]=\mu_t^b$. We therefore can decompose the factors affecting the uncertainty correction to $Q_t$ into (1) cross-border borrowing rate $R^*_{bt+1}$; (2) EME premium $\mu_t$ and (3) expected future real exchange rate $Q_{t+1}$. First, it's easy to see that higher stochastic steady state level of $R_b^*$ will depreciate EME real exchange rate, all else equal (see Figure 5 (a)). However, the uncertainty correction to expected future period cross-border borrowing rate $R_{bt+1}$ is actually negative due to higher stochastic steady state cross-border asset price $q_b^*$ (see Figure 5 (b)), which leads to a negative uncertainty correction to real exchange rate $Q_t$. Combined, the second effect is dominating the first, appreciating stochastic steady state EME real exchange rate $Q$. Second, higher stochastic steady state $\mu^b$ will depreciate stochastic steady state EME real exchange rate, all else equal. By construction, $\mu^b$ is correlated with EME premium $\mu$ (see equation (34)). As $\mu$ is lower for safer EMEs (recall from Figure 4), real exchange rate appreciates by more for safer EMEs (see Figure 5(c)). Third, lower stochastic steady state real interest rate $R$ depreciates EME currency, all else equal. As real interest rate is lower for safer EMEs (see Figure 3), it exerts more downward pressure on safer EME currency value (see Figure 5 (d)). Finally, uncertainty correction due to expected future period real exchange rate is negative, appreciating stochastic steady state $Q$ (See Figure 5 (e)). Overall, we can say that safer EMEs enjoy lower expected future foreign borrowing rate $R_b^*$ and lower lending spread $\mu$, therefore their currencies appreciate by more in the stochastic steady state.

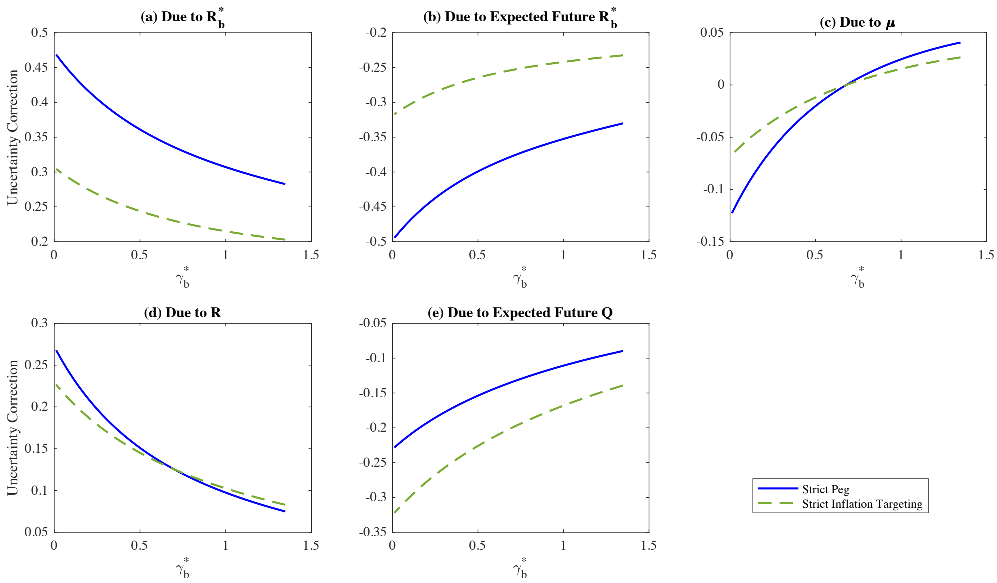


**Figure 5**: Factors influencing uncertainty correction to real exchange rate $Q$. Notes: $y$ axis: uncertainty correction; $x$ axis: EME riskiness $\gamma_b^*$. Smaller $\gamma_b^*$ denotes safer EMEs; larger $\gamma_b^*$ denotes riskier EMEs.

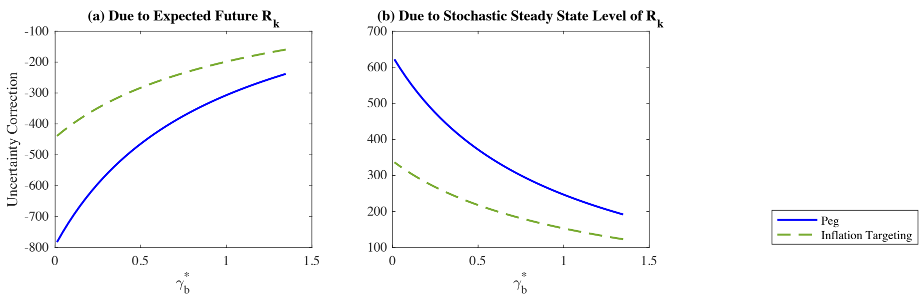


**Figure 6**: Uncertainty correction to $\mu$ due to $R_{kt+1}$. Notes: $y$ axis: uncertainty correction; $x$ axis: EME riskiness $\gamma_b^*$. Smaller $\gamma_b^*$ denotes safer EMEs; larger $\gamma_b^*$ denotes riskier EMEs.

*5.5 Portfolio Adjustment by US Banks in Stochastic Steady State*

We now look at some of the key US financial variables with EMEs of different riskiness levels (see Figure 7). While with safer EMEs, in stochastic steady state cross-border asset price $q_b^*$, cross-border asset return $R_b^*$ and US investment in EME are higher, US investment in domestic asset $S^*$ and US domestic asset price $q^*$ are lower. There seem to be some portfolio adjustment: Note that uncertainty correction of leverage ratio for US investment in EME $\phi_b^*$ is positive and the uncertainty correction of total leverage ratio (i.e., home assets plus investment in EME) $\phi^*$ is negative. This means that compared to deterministic steady state, after US banks take into account future monetary policy uncertainty, they invest more in EME (especially safer EME) and less in domestic assets. We interpret this to be US banks diversifying away risks by investing more in the EME.

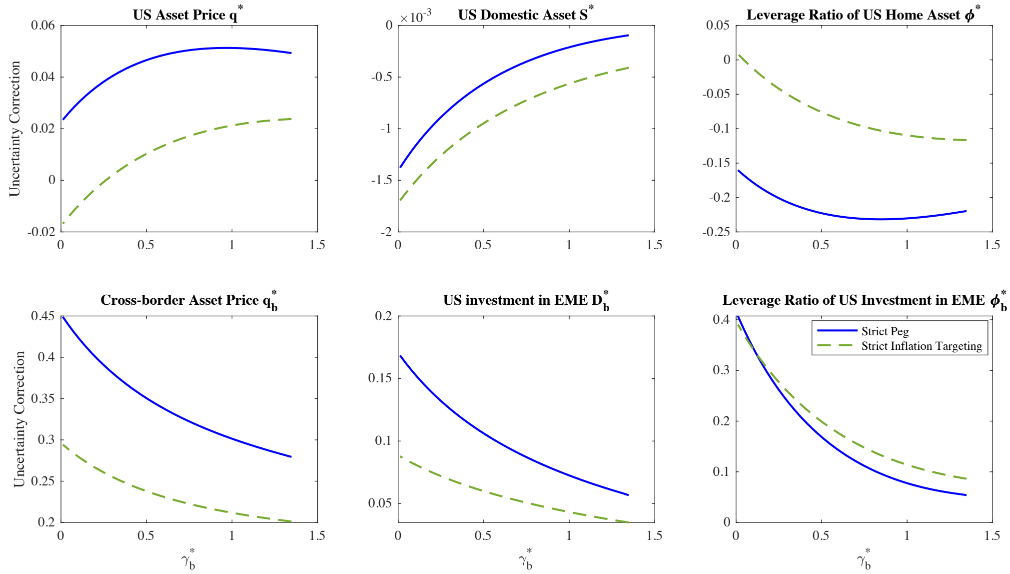


**Figure 7**: Uncertainty correction of key US financial variables with EMEs of different riskiness levels $\gamma_b^*$. Notes: $y$ axis: uncertainty correction; $x$ axis: EME riskiness $\gamma_b^*$. Smaller $\gamma_b^*$ denotes safer EMEs; larger $\gamma_b^*$ denotes riskier EMEs.

## 6. Conclusion

In this paper, we explore the consequences of US monetary spillovers into emerging countries with banks of different riskiness and the implications for optimal monetary policy making. By constructing a new banking sector risk index, we first provide empirical evidence that banking sector risk amplifies the negative impact on emerging countries' real economy and financial market due to contractionary US monetary shocks even after controlling for other risk factors. We then develop a two-country DSGE model with financial frictions in both the US and the emerging economy that can help to account for the empirical findings. We incorporate a new modelling feature that by investing in riskier EMEs, US investors face a tighter financing constraint, thus require a higher return from the EME in the deterministic steady state. We find that riskier EMEs experience larger capital outflow, steeper asset price decline and larger currency depreciation following an unexpected US monetary policy rate hike, and exchange rate stabilizing monetary policies tend to exacerbate conditional welfare losses. For safer EMEs, however, fixed exchange rate policy can outperform inflation targeting policies. The different optimal monetary policy implications for the riskier and safer EMEs are mainly driven by higher real interest rate of riskier EMEs that commit to peg compared to their safer counterparts. In stochastic steady state, cross-border asset price, cross-border asset return and capital inflow are all higher for safer EMEs than riskier EMEs. Meanwhile, as safer EMEs enjoy lower expected future foreign borrowing rate and lower domestic lending spread, which is a proxy for risk premium, their currencies also appreciate by more (depreciate by less) than riskier EMEs in the stochastic steady state. After US banks take into account future monetary policy uncertainty, they invest more in EME (especially safer EME) and less in domestic assets in the stochastic steady state. We interpret this to be US banks diversifying away risks by investing more in the EME. For future research, it might be helpful to look at how macroprudential policies can complement monetary policies for riskier EMEs.

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## Appendix

### A.1 Parameter calibration and steady states

**Table 1:** Calibration

| **Parameter** | **Symbol** | **Value** | **Source** |
|---|---|---|---|
| EME discount factor | $\beta$ | 0.9925 | Carrillo et al. (2017) |
| Depreciation rate | $\delta(\delta^*)$ | 0.025 | Conventional |
| Trade price elasticity | $\rho$ | 1.5 | Erceg et al. (2007) |
| Home bias (EME) | $\gamma$ | 0.8 | Conventional |
| Home bias (US) | $\gamma^*$ | 1-0.2/3 | Conventional |
| Habit parameter | $b$ | 0.78 | Justiano et al. (2010) |
| Wage markup | $\theta_w$ | 0.2 | Conventional |
| Price markup | $\theta_p$ | 0.2 | Conventional |
| Prob. of keeping price fixed | $\xi_p$ | 0.84 | Justiano et al. (2010) |
| Prob. of keeping wage fixed | $\xi_w$ | 0.7 | Justiano et al. (2010) |
| Price indexation | $\iota_p$ | 0.24 | Justiano et al. (2010) |
| Wage indexation | $\iota_w$ | 0.15 | Justiano et al. (2010) |
| Capital share | $\alpha$ | 0.33 | Conventional |
| IES | $\sigma_u$ | 1 | Conventional |
| Inverse Frisch elasticity of labor supply | $\chi$ | 3.79 | Justiano et al. (2010) |
| Trade adjustment cost parameter | $\psi_{FC}(\psi_{FI})$ | 10 | Erceg et. al (2005) |
| Investment adjustment cost | $\Psi_I$ | 2.85 | Justiano et al. (2010) |
| Relative EME size | $\frac{\xi}{\xi^*}$ | 1/3 | Akinci and Queralto (2019) |
| Bank survival rate (EME) | $\sigma$ | 0.95 | Average horizon of 6 years |
| EME bank riskiness | $\gamma^b$ | 0.2 or -0.1 | |
| Bank transfer rate | $\xi_b$ | 0.0756 | Target leverage ratio of 5 |
| Bank fraction divertible | $\theta$ | 0.3905 | |
| US discount factor | $\beta^*$ | 0.9950 | Akinci and Queralto (2019) |
| Bank survival rate (US) | $\sigma^*$ | 0.95 | Average horizon of 6 years |
| Inverse of additional risk bearing capacity of US banks in international market | $\gamma^{b*}$ | 0.01 or 1 | Chosen by author |
| Bank transfer rate | $\xi_b^*$ | 0.1328 | Target leverage ratio of 5 |
| Monetary policy coefficients | $\gamma_r$ | 0.82 | Justiano et al. (2010) |
| | $\varpi_\pi$ | 1.5 | Conventional |
| | $\varpi_\pi^*$ | 1.5 | Conventional |
| | $\varpi_y^*$ | 0.125 | Conventional |
| Shock processes | $\rho_r(\rho_r^*)$ | 0.25 | Akinci and Queralto (2019) |
| | $\rho_a(\rho_a^*)$ | 0.8556 | Cuadra and Nuguer (2018) |
| Shock sizes | $\sigma_a(\sigma_a^*)$ | 0.01 | |
| | $\sigma_r(\sigma_r^*)$ | 0.002 | Akinci and Queralto (2019) |

## A.2 Non-contingent Foreign Borrowing

In this section we change EME cross-border borrowing rate $R_b^*$ to be non-contingent. Figure **8** plots impulse responses of key EME macroeconomic variables following a one standard deviation unexpected US monetary policy shock; Figure **9** plots the impulse responses of key financial variables.

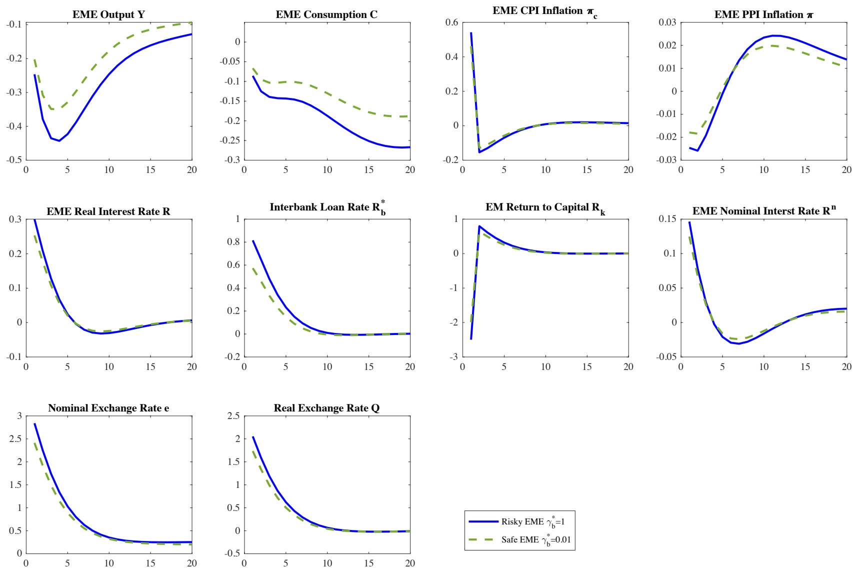


**Figure 8**:Impulse responses of key EME macroeconomic variables to a one standard deviation (20 basis points) increase in the US monetary policy rate, interbank rate $R_b^*$ is non-contingent. Notes: $y$ axis: percentage deviation from the steady state; $x$ axis: quarters from the shock.

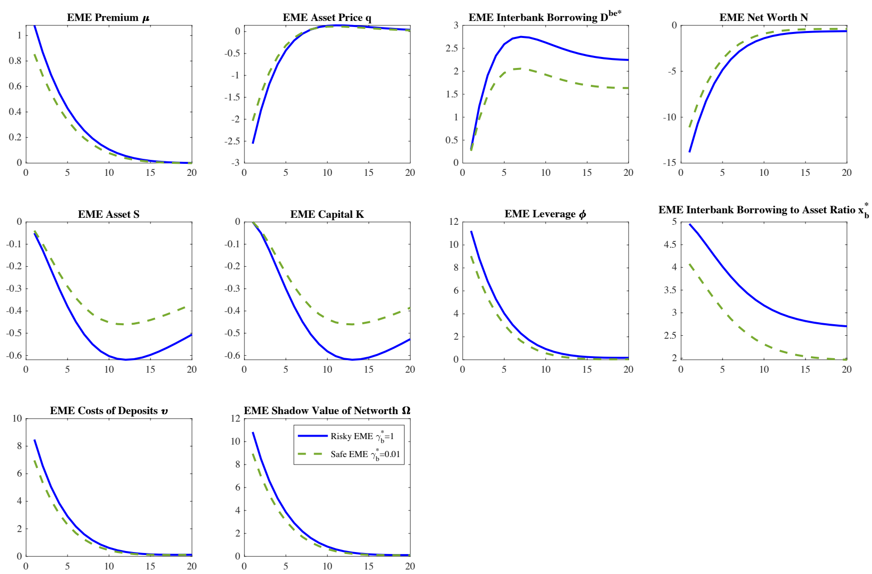


**Figure 9**: Impulse responses of key EME financial variables to a one standard deviation (20 basis points) increase in the US monetary policy rate, interbank rate $R_b^*$ is non-contingent. Notes: $y$ axis: percentage deviation from the steady state; $x$ axis: quarters from the shock.

Figure **10** plots the conditional welfare of the risky and safe EME across different policy parameter values when cross-border borrowing rate is non-contingent. Figure **11** plots the uncertainty correction to welfare and its key components under two monetary policies—strict peg ($\varpi_e = 0.99$) and strict inflation targeting ($\varpi_e = 0.01$)—across different EME riskiness levels $\gamma_b^*$ when cross-border borrowing rate is non-contingent.

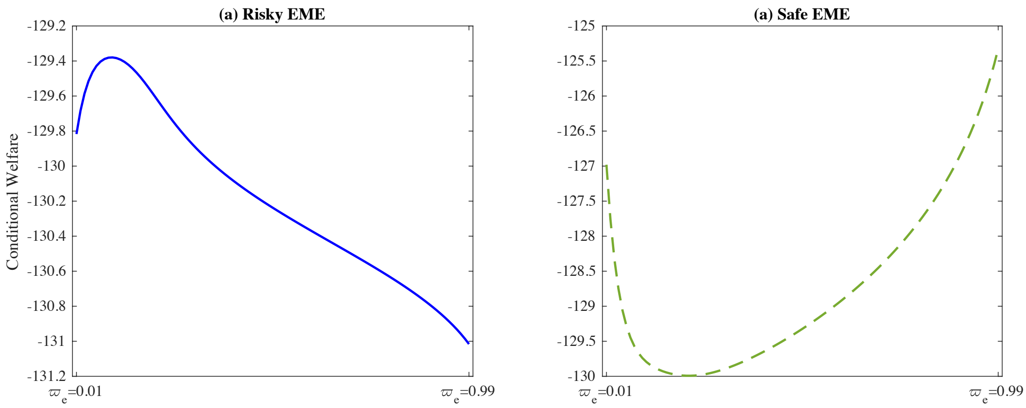


**Figure 10**: Conditional welfare measures for the (a) risky and (b) safe EME, interbank rate $R_b^*$ is non-contingent. Notes: $y$ axis: conditional welfare measure; $x$ axis: policy parameter $\varpi_e$. $\varpi_e = 0.01$ denotes strict inflation targeting; $\varpi_e = 0.99$ denotes strict peg.

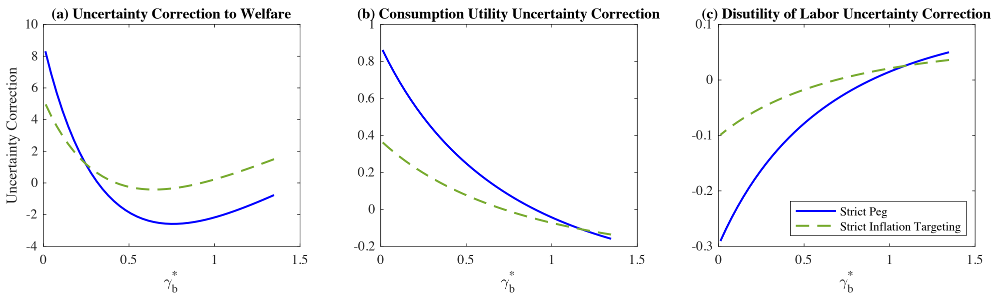


**Figure 11**: Components of conditional welfare measures across EME riskiness levels $\gamma_b^*$. Notes: $y$ axis: uncertainty correction; $x$ axis: EME riskiness $\gamma_b^*$. Smaller $\gamma_b^*$ denotes safer EMEs; larger $\gamma_b^*$ denotes riskier EMEs.

Overall the key impulse responses and welfare implications across different parameter values are similar to the baseline case. Further, it still holds that exchange rate stabilizing policies may benefit safer EMEs while worsening welfare losses for riskier EMEs.

## A.3 Banking Sector Risk

**Table 2:** Mapping of credit ratings to credit quality steps (CQS)

| Credit Quality Steps (CQS) | Moody's | Fitch | S&P |
|---|---|---|---|
| 1 | P-1 | F1+ | A-1+ |
| 2 | P-2 | F1 | A-1 |
| 3 | P-3 | F2/F3 | A-2/A-3 |
| 4 | NP | B/C/RD/D | B/C/R/SD/D |

**Notes:** Moody's short-term ratings are opinions of the ability of issuers to honor short-term financial obligations which generally have an original maturity not exceeding 13 months. Fitch's issuer default ratings describe short-term vulnerability to default of the rated entity and relates to the capacity to meet financial obligations in accordance with the documentation governing the relevant obligation. S&P's issuer credit rating is a forward-looking opinion about an obligor's overall creditworthiness. This opinion focuses on the obligor's capacity and willingness to meet its financial commitments as they come due.

**Table 3:** Details of banking sector risk index construction

| Country | Banks | Rating & Initial Date | Average CQS |
|---|---|---|---|
| Argentina | Banco de la Nacion Argentina, Banco Santander Rio, Banco Macro SA | Banco de la Nacion Argentina: Moody's (1995q4)<br>Banco Santander Rio: Moody's (1990q2), S&P (1994q3)<br>Banco Macro SA: Moody's (1995q4), Fitch (2006q3) | 3.99 |
| Botswana | First Capital Bank Limited, First National Bank of Botswana Limited | N.A. | |
| Brazil | Itau Unibanco Holding S.A., Banco do Brasil S.A., Banco Bradesco S.A. | Itau Unibanco Holding S.A.: Moody's (2010q1), Fitch (1996 q3), S&P (2002q1)<br>Banco do Brasil S.A.: Fitch (1996q1), S&P (2003q2)<br>Banco Bradesco S.A.: Fitch (1996q1), S&P (2006q2) | 3.46 |
| Chile | Banco de Credito e Inversiones,<br>Banco del Estado de Chile, Banco BICE | Banco de Credito e Inversiones: Moody's (1995q4), Fitch (2010q1), S&P (2010q1)<br>Banco del Estado de Chile: Moody's (2000q2), Fitch (2012q2), S&P (2004q4)<br>Banco BICE: Moody's (1995q4 – 2007q2), Fitch (2014q3) | 2.1 |
| China | ICBC, China Construction Bank, Agricultural Bank of China | ICBC: Moody's (1994q4), Fitch (2001q3), S&P (1994q4)<br>China Construction Bank: Moody's (1993q3), Fitch (2005q4), S&P (1998q2)<br>Agricultural Bank of China: Moody's (1995q2), Fitch (2013q2), S&P (2012q4) | 2.21 |
| Colombia | Grupo Aval Acciones y Valores S.A., Bancolombia S.A., Banco de Bogota | Grupo Aval Acciones y Valores S.A.: Moody's (2012q1), Fitch (2012q1)<br>Bancolombia S.A.: Moody's (1996q2), Fitch (2004q4), S&P (2012q4)<br>Banco de Bogota: Moody's (1996q2), Fitch (2011q4), S&P (2011q4). | 3.28 |
| Ecuador | Banco Pichincha C.A. y Subsidiarias | Banco Pichincha C.A. y Subsidiarias: Moody's (1997q4), Fitch (2005q3) | 4 |
| El Salvador | Banco Agricola S.A. | Banco Agricola S.A.: Moody's (2015q2), Fitch (2000q2), S&P (2002q1) | 3.97 |

| | | | |
|---|---|---|---|
| Hong Kong | Hang Seng Bank Limited, HSBC Hong Kong | Hang Seng Bank Limited: Moody's (1995q3), Fitch (2011q3), S&P (2005q2)<br>HSBC Hong Kong: Moody's (1987q1), Fitch (1988q1), S&P (1990q2) | 1.35 |
| India | State Bank of India, ICICI Bank Limited, Bank of Baroda | State Bank of India: Moody's (1988q1), Fitch (2004q4), S&P (1988q3)<br>ICIC Bank Limited: Moody's (2002q2), Fitch (2005q1), S&P (2002q2)<br>Bank of Baroda: Moody's (1995q4), Fitch (2008q2), S&P (1996q1) | 3.6 |
| Indonesia | PT Bank Rakyat Indonesia (Persero) Tbk, PT Bank Mandiri (Persero) Tbk, PT Bank Central Asia Tbk | PT Bank Rakyat Indonesia: Moody's (1996q1), Fitch (2002q3), S&P (2012q2)<br>PT Bank Mandiri: Moody's (1999q3), Fitch (2001q4), S&P (2001q4)<br>PT Bank Central Asia: Moody's (2007q3), Fitch (2002q4) | 3.89 |
| Israel | Bank Leumi Le-Israel B.M., Bank Hapoalim B.M., Mizrahi Tefahot Bank Ltd. | Bank Leumi Le-Israel: Moody's (1996q1), Fitch (2003q2), S&P (1999q1).<br>Bank Hapoalim: Moody's (1996q1), Fitch (1995q4), S&P (1997q3)<br>Mizrahi Tefahot Bank: Moody's (1996q1) | 2.26 |
| Jordan | Arab Bank Plc, Bank of Jordan Plc | Arab Bank Plc: Moody's (1998q4), Fitch (2002q2), S&P (2007q1)<br>Bank of Jordan Plc: Fitch (2005q2) | 3.46 |
| South Korea | Kookmin Bank, Shinhan Bank, KEB Hana Bank | Kookmin Bank: Moody's (1995q2), Fitch (2008q3), S&P (1996q2)<br>Shinhan Bank: Moody's (1995q1), Fitch (2003q2), S&P (1994q1)<br>KEB Hana Bank: Moody's (1994q3), Fitch (2000q2), S&P (1995q4) | 2.44 |
| Malaysia | Malayan Banking Berhad, CIMB Group Holdings Berhad, RHB Bank Berhad | MayBank: Moody's (1995q2), Fitch (2015q3), S&P (1995q1)<br>CIMB: Moody's (2014q3), S&P (2004q4)<br>RHB: Moody's (1998q2), S&P (1997q4) | 2.6 |
| Mexico | Banco Mercantil de Norte, SA, Banco Nacional de Obras y Servicios Publicos, Nacional Financiera SNC | Banco Mercantil: Fitch (2001q1), S&P (1999q2)<br>Banco Nacional: Moody's (2005q4), Fitch (2003q2), S&P (2012q3)<br>Nacional Financiera: Moody's (1992q4), Fitch (2000q2), S&P (2015q1) | 3.02 |
| Peru | Banco BBVA Peru, Banco Internacional del Peru SAA, Banco Interamericano de Finanzas SA | Banco BBVA Peru: Moody's (1997q1), Fitch (2006q4), S&P (2007q3)<br>Banco Internacional del Peru: Moody's (1997q1), Fitch (2010q1)<br>Banco Interamericano de Finanzas SA: Fitch (2013q3) | 3.26 |
| Philippines | BDO Unibank, Inc., Metropolitan Bank & Trust Company, Bank of the Philippine Islands | BDO Unibank: Moody's (2003q4), Fitch (2015q2), S&P (2003q4)<br>Metropolitan Bank: Moody's (1995q2), Fitch (2002q4), S&P (2003q4)<br>Bank of the Philippine Islands: Moody's (1995q2), Fitch (2015q2) | 3.8 |
| Singapore | DBS, OCBC, UOB | DBS: Moody's (2013q4), Fitch (2013q4)<br>OCBC: Moody's (1995q4), Fitch (2004q3), S&P (2001q2)<br>UOB: Moody's (1995q4), Fitch (2006q3), S&P (2001q3) | 1.27 |
| South Africa | The Standard Bank of South Africa Limited, FirstRand | The Standard Bank: Moody's (1996q1), Fitch (2000q3), S&P (2011q3) | 32.91 |

| | | | |
|---|---|---|---|
| | Bank Limited, Absa Bank Limited | FirstRand Bank: Moody's (1996q1), Fitch (2000q3), S&P (1999q4)<br>Absa Bank: Moody's (1996q1), Fitch (2000q4) | |
| Taiwan | CTBC Bank Co., Ltd, E.SUN Commercial Bank, Ltd., The Shanghai Commercial & Savings Bank, Ltd. | CTBC Bank: Moody's (1996q2), Fitch (2002q2), S&P (1999q1)<br>E.SUN Commercial Bank: Moody's (1996q4), S&P (2005q3)<br>The Shanghai Commercial & Savings Bank: Fitch (2013q1), S&P (2012q4) | 2.52 |
| Thailand | Bangkok Bank Public Company Limited, KASIKORNBANK Public Company Limited, Krung Thai Bank Public Company Limited. | Bangkok Bank: Moody's (1994q4), Fitch (1999q3), S&P (1995q1)<br>KASIKORNBANK: Moody's (1994q4), Fitch (1999q3), S&P (1995q1)<br>Krung Thai Bank: Moody's (1997q4), Fitch (1999q3), S&P (2003q3) | 3.11 |
| Turkey | Turkiye Cumhuriyeti Ziraat Bankasi AS, Turkiye Is Bankasi AS, Turkiye Halk Bankasi AS | Ziraat Bankasi: Moody's (1993q4), Fitch (2000q1), S&P (1996q4)<br>Is Bankasi: Moody's (1996q3), Fitch (1999q3), S&P (2000q3)<br>Halk Bankasi: Moody's (2009q4), Fitch (2000q4) | 3.86 |
| Venezuela | Banco de Venezela, Banesco Banco Universal CA, Mercantil CA Banco Universal | Banco de Venezuela: Moody's (1995q4), Fitch (1997q4)<br>Banesco Banco: Moody's (1997q4), Fitch (2011q2)<br>Mercantil Banco: Moody's (1995q4), Fitch (1997q4) | 4 |

While banks' creditworthiness is related to their risk management and prudential regulations, it could also be related to culture, business practices and rule of law that are unique to a country. Interestingly, we find that the average credit quality step (CQS) values of the sample countries are highly correlated with their corruption levels, as we plot the 2020 corruption perceptions index (CPI) retrieved from Transparency International against the average CQS values below. Countries with low bank risk (low CQS values) generally have high transparency (high CPI score).

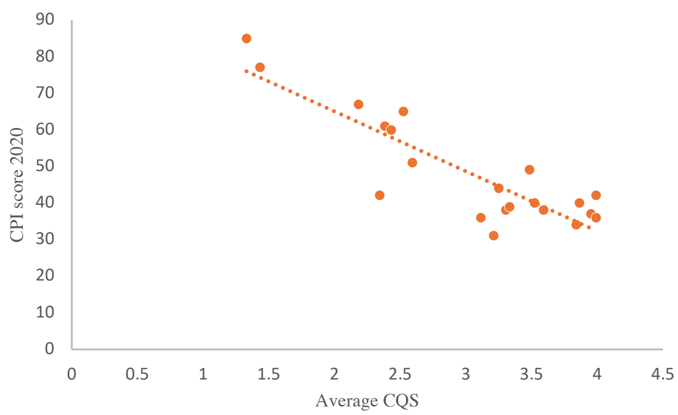


**Figure 12**:Country transparency and bank risk. Notes: $y$ axis: corruption perception index (CPI), with a high value indicate low corruption; $x$ axis: credit quality step (CQS), with a high CQS indicate high bank risk.

## A.4 Stock Market Price Data

**Table 4:** Stock Market Index Data

| Country | Begin Date | End Date | Data Source and Notes |
|---|---|---|---|
| Argentina | 1986q2 | 2016q3 | Equity Market Index: Month End: BCBA: Merval, converted to 2010=100, retrieved from CEIC. |
| Botswana | 1995q2 | 2016q3 | BW: (DC)Index: Share Price (End of Period), IFS, 2010=100, retrieved from CEIC. |
| Brazil | 1991q2 | 2016q3 | BR: Index: Share Price (End of Period), IFS, 2010=100, retrieved from CEIC. |
| Chile | 1990q1 | 2016q3 | CL: Index: Share Price: Santiago Stock Exchange: IPSA, 2010=100, retrieved from CEIC. |
| China | 1990q4 | 2016q3 | CN: Index: Share Price, 2010=100, IFS, retrieved from CEIC. |
| Colombia | 2001q3 | 2016q3 | CO: Index: Share Price (End of Period), IFS, retrieved from CEIC |
| Ecuador | 2000q1 | 2016q3 | Compiled 2 series: (1) Equity Market Index: Month End: Quito Stock Exchange: ECUINDEX and (2) (DC)Quito Stock Exchange: Index: Old: ECUINDEX, retrieved from CEIC, adjusted to 2010=100. |
| EI Salvador | N.A. | N.A. | N.A. |
| Hong Kong | 1964q3 | 2016q3 | Equity Market Index: Month End: Hang Seng, adjusted to 2010=100, retrieved from CEIC. |
| India | 1960q1 | 2016q3 | IN: Index: Share Price, IFS, 2010=100, retrieved from CEIC. |
| Indonesia | 1983q2 | 2016q3 | Equity Market Index: Month End: Jakarta Composite, retrieved from CEIC, converted to quarterly data and 2010=100. |
| Israel | 1960q1 | 2016q3 | IL: (DC)Index: Share Price (End of Period), 2010=100, retrieved from CEIC. |
| Jordan | 1999q4 | 2016q3 | Equity Market Index: Month End: General Free Float Weighted, adjusted to quarterly frequency and 2010=100, retrieved from CEIC. |
| South Korea | 1976q1 | 2016q3 | Equity Market Index: Month End: KOSPI, adjusted to quarterly frequency and 2010=100, retrieved from CEIC. |
| Malaysia | 1974q1 | 2016q3 | Equity Market Index: Month End: FTSE Bursa Malaysia: Composite, adjusted to quarterly frequency and 2010=100, retrieved from CEIC. |
| Mexico | 1978q4 | 2016q3 | MX: Index: Share Price (End of Period), IFS, 2010=100, retrieved from CEIC. |
| Peru | 1989q1 | 2016q3 | PE: Index: Share Price (End of Period), IFS, 2010=100, retrieved from CEIC. |
| Philippines | 1987q1 | 2016q3 | Equity Market Index: Month End: PSEi, converted to quarterly series, 2010=100, retrieved from CEIC. |
| Singapore | 1985q1 | 2016q3 | SG: Index: Share Price (End of Period), IFS, 2010=100, retrieved from CEIC. |
| Taiwan | 1967q1 | 2016q3 | TWSE: Equity Market Index: TAIEX Capitalization Weighted: Month End, adjusted to quarterly frequency, 2010=100, retrieved from CEIC. |
| Thailand | 1975q2 | 2016q3 | Equity Market Index: Month End: SET, adjusted to quarterly frequency, 2010=100, retrieved from CEIC. |
| Turkey | 1986q1 | 2016q3 | TR: Index: Share Price, IFS, 2010=100, retrieved from CEIC. |
| Venezuela | 1971q1 | 2016q3 | Combined series of VE: Index: Share Price (End of Period) and VE: (DC)Index: Share Price, all at 2010=100, IFS, retrieved from CEIC. |

## A.5 Full Model Description for the Non-Banking Sector

### *A.5.1 Households and Labor Market*

Other parts of the model build on influential work such as Christiano, Eichenbaum, and Evans (2005). The model features Calvo-type wage setting as in Erceg, Henderson, and Levin (2000). 'Labor contractors' produce homogeneous factor of production $L_t$ by combining differentiated labor inputs $L_{it}$ according to a linear homogeneous technology:

$$L_t = [\int_0^1 L_{it}^{\frac{1}{\theta_w+1}} di]^{1+\theta_w} \tag{58}$$

Labor contractors are perfectly competitive and take the wage rate $W_t$ as well as specialized labor input's wage rate $W_{it}$ of the $i$-th differentiated type of labor as given. They choose $L_t$ and $L_{it}$ to maximize profit. It can thus be shown that the demand for $L_{it}$ is given by:

$$L_{it} = L_t(\frac{W_{it}}{W_t})^{-\frac{1+\theta_W}{\theta_w}} , \tag{59}$$

and aggregate wage index is:

$$W_t = [\int_0^1 W_{it}^{-\frac{1}{\theta_w}} di]^{-\theta_w} \tag{60}$$

Household $i$ maximizes its life-time utility:

$$\max_{C_t,D_t,B_t,L_t} \mathbb{E}_t\{\sum_{j=0}^{\infty} \beta^j [\frac{\sigma_u}{\sigma_u-1}(C_{t+j} - bC_{t+j-1})^{\frac{\sigma_u-1}{\sigma_u}} - \frac{\chi_0}{1+\chi} L_{it+j}^{1+\chi}]\}$$

subject to budget constraint:

$$P_tC_t + P_tD_t + B_t \leq W_{it}L_{it} + P_tR_tD_{t-1} + R_t^nB_{t-1} + \mathcal{W}_{it} + \pi_t ,$$

where $R_t^n$ is nominal interest rate, $B_t$ is households' holdings of nominal one-period riskless bonds. $\mathcal{W}_{it}$ is cash flow from household $i$'s portfolio of state-contingent securities and $\pi_t$ is firm and bank profits. Parameter $b$ captures households' habit formation. When $b > 0$, household's marginal utility of current consumption is an increasing function of the household's consumption in the previous period.

Solving the maximization problem, we arrive at the following first-order equations:

$$U_{ct} \equiv (C_t - bC_{t-1})^{-\frac{1}{\sigma_u}} - b\beta(C_{t+1} - bC_t)^{-\frac{1}{\sigma_u}} \tag{61}$$

$$\beta \frac{U_{ct+1}}{U_{ct}} = \Lambda_{t,t+1} \tag{62}$$

$$\Lambda_{t,t+1} R_{t+1} = 1 \tag{63}$$

$$\frac{\Lambda_{t,t+1}}{\pi_{c,t+1}} R_{t+1}^{n} = 1 \tag{64}$$

Aggregate consumption index $C_t$ is produced according to a CES technology:

$$C_t = \left[ \gamma^{\frac{1}{\rho}} C_{H,t}^{\frac{\rho-1}{\rho}} + (1-\gamma)^{\frac{1}{\rho}} \left( \psi_{ct} C_{F,t} \right)^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}} \tag{65}$$

and consumer price index (CPI) is given by:

$$P_t = \left( \gamma P_{H,t}^{1-\rho} + (1-\gamma) P_{F,t}^{1-\rho} \right)^{\frac{1}{1-\rho}} \tag{66}$$

where $\gamma$ is the degree of home bias in household consumption expenditure, $\rho$ is the intertemporal elasticity of substitution between home-produced goods $C_{H,t}$ and imported goods $C_{F,t}$, and $\pi_{ct}$ is CPI inflation. $\psi_{ct}$ reflects costs of adjusting consumption share of imports given by:

$$\psi_{ct} = 1 - \frac{\psi_{FC}}{2} \left( \frac{C_{F,t}/C_{H,t}}{C_{F,t-1}/C_{H,t-1}} - 1 \right)^2 \tag{67}$$

Given a fixed budget, the aggregate consumption index producer chooses inputs $C_{H,t}$ and $C_{F,t}$ to minimize its discounted expected costs of producing the aggregate consumption good subject to its production function:

$$\min_{C_{H,t+j}, C_{F,t+j}} \mathcal{L} = \mathbb{E}_t \sum_{j=0}^{\infty} \Lambda_{\mathrm{t,t+j}} \{ \left( P_{H,t+j} C_{H,t+j} + P_{F,t+j} C_{F,t+j} \right) + P_{t+j} \left[ C_{t+j} - \left( \gamma^{\frac{1}{\rho}} C_{H,t}^{\frac{\rho-1}{\rho}} + (1-\gamma)^{\frac{1}{\rho}} \left( \psi_{ct} C_{F,t} \right)^{\frac{\rho-1}{\rho}} \right)^{\frac{\rho}{\rho-1}} \right] \}$$

The first-order conditions are:

$$p_{H,t} = \gamma^{\frac{1}{\rho}} \left(\frac{C_t}{C_{H,t}}\right)^{\frac{1}{\rho}} + (1-\gamma)^{\frac{1}{\rho}} \left(\frac{C_t}{C_{F,t}\psi_{ct}}\right)^{\frac{1}{\rho}} \psi_{FC} x_{FC,t} \left(\frac{x_{FC,t}}{x_{FC,t-1}} - 1\right) \frac{x_{FC,t}}{x_{FC,t-1}}$$
$$-\mathbb{E}_t\{\Lambda_{t,t+1}\pi_{ct+1}(1-\gamma)^{\frac{1}{\rho}} \left(\frac{C_{t+1}}{C_{F,t+1}\psi_{ct+1}}\right)^{\frac{1}{\rho}} \frac{C_{H,t+1}}{C_{H,t}} \psi_{FC} x_{FC,t+1} \left(\frac{x_{FC,t+1}}{x_{FC,t}} - 1\right) \frac{x_{FC,t+1}}{x_{FC,t}}\} \quad (68)$$

$$p_{F,t} = (1-\gamma)^{\frac{1}{\rho}} \left(\frac{C_t}{C_{F,t}\psi_{ct}}\right)^{\frac{1}{\rho}} \left[\psi_{ct} - \psi_{FC} \left(\frac{x_{FC,t}}{x_{FC,t-1}} - 1\right) \frac{x_{FC,t}}{x_{FC,t-1}}\right]$$
$$+\mathbb{E}_t\{\Lambda_{t,t+1}\pi_{ct+1}(1-\gamma)^{\frac{1}{\rho}} \left(\frac{C_{t+1}}{C_{F,t+1}\psi_{ct+1}}\right)^{\frac{1}{\rho}} \frac{C_{F,t+1}}{C_{F,t}} \psi_{FC} \left(\frac{x_{FC,t+1}}{x_{FC,t}} - 1\right) \frac{x_{FC,t+1}}{x_{FC,t}}\} \quad (69)$$

where $p_{H,t} \equiv \frac{P_{H,t}}{P_t}$, $p_{F,t} \equiv \frac{P_{F,t}}{P_t}$, and

$$x_{FC,t} = \frac{C_{F,t}}{C_{H,t}} \quad (70)$$

Note that in the case where $\psi_{FC} = 0, \psi_{ct} = 1$, equation (48) reduces to the familiar form of $C_{H,t} = \gamma \left(\frac{P_{H,t}}{P_t}\right)^{-\rho} C_t$ and equation (49) reduces to $C_{F,t} = (1-\gamma) \left(\frac{P_{F,t}}{P_t}\right)^{-\rho} C_t$. Terms of trade is given by:

$$\mathcal{T}_t = \frac{p_{F,t}}{p_{H,t}} \quad (71)$$

Each period, a fraction $(1 - \xi_w)$ of households are allowed to set wages optimally, while the remaining households index their wages according to:

$$W_{it} = W_{it-1}\pi_{wt-1}^{\iota_w}, \quad (72)$$

where

$$\pi_{wt} = \frac{W_t}{W_{t-1}} \quad (73)$$

We can then write households' wage-setting problem (with only the relevant parts of utility function and budget constraint) to be:

$$\max_{W_{it}} \mathbb{E}_t \sum_{j=0}^{\infty} (\beta\xi_w)^j \{-\frac{\chi_0}{1+\chi} L_{it+j|t}^{1+\chi} + \lambda_{t+j} W_{it+j|t} L_{it+j|t}\}$$

subject to

$$L_{it+j|t} = \left(\frac{W_{it+j|t}}{W_{it+j}}\right)^{-\frac{1+\theta_w}{\theta_w}} L_{t+j}$$

where $L_{it+j|t}$ is demand for type-$i$ labor given last time setting its optimal wage at period $t$ and $W_{it+j|t}$ is the nominal wage rate of type-$i$ labor given last time setting its optimal wage at period $t$.

Solving the optimization problem, the equilibrium conditions can be shown to be:

$$f_{wt}^1 = \frac{\omega_t^o}{1+\theta_w} U_{ct} L_t^o + \beta\xi_w \mathbb{E}_t\{\left(\frac{\omega_{t+1}^o}{\omega_t^o}\right)^{\frac{1}{\theta_w}} \left(\frac{\pi_{wt}^{\iota_w}}{\pi_{ct+1}}\right)^{-\frac{1}{\theta_w}} f_{wt+1}^1 \tag{74}$$

$$f_{wt}^2 = U_{ct} MRS_t L_t^o + \beta\xi_w \mathbb{E}_t\{\left(\frac{\pi_{wt}^{\iota_w}}{\pi_{ct+1}}\right)^{-\left(\frac{1+\theta_w}{\theta_w}\right)(1+\chi)} \left(\frac{\omega_{t+1}^o}{\omega_t^o}\right)^{\left(\frac{1+\theta_w}{\theta_w}\right)(1+\chi)} f_{wt+1}^2\} \tag{75}$$

$$f_{wt}^1 = f_{wt}^2 \tag{76}$$

where

$$L_t^o = \left(\frac{\omega_t}{\omega_t^o}\right)^{\frac{1+\theta_w}{\theta_w}} L_t \tag{77}$$

$$MRS_t = \frac{\chi_0 (L_t^o)^\chi}{U_{ct}} \tag{78}$$

and $\omega_t$ is the real wage index, $\omega_t^o$ is the optimally set real wage rate. Since all households are symmetric, they set the same optimal wage and therefore we omitted index $i$ in the above equilibrium equations. Given aggregate wage index equation (60), under Calvo-type wage setting, real wage index can be shown to evolve according to:

$$\omega_t = \left[\xi_w\left(\omega_{t-1}\pi_{wt-1}^{\iota_w}\pi_{ct}^{-1}\right)^{-\frac{1}{\theta_w}} + (1-\xi_w)(\omega_t^o)^{-\frac{1}{\theta_w}}\right]^{-\theta_w} \quad (79)$$

Real wage is defined to be

$$\pi_{wt} = \frac{\omega_t}{\omega_{t-1}}\pi_{ct} \quad (80)$$

*A.5.2 Home (EME) Firms and Price Setting*

*A.5.2.1 Final Goods Producers*

Home country final goods producers (retail firms) produce aggregate domestic output $Y_t$ using intermediate goods $Y_{it}$ as inputs according to a CES technology:

$$Y_t = [\int_0^1 Y_{it}^{\frac{1}{\theta_p+1}} di]^{1+\theta_p}, \quad (81)$$

and the aggregate price level of domestic final goods is given by $P_{H,t} = [\int_0^1 P_{Hit}^{-\frac{1}{\theta_p}} di]^{-\theta_p}$. Taken aggregate domestic goods price level $P_{H,t}$ and intermediate goods price $P_{Hit}$ as given, final goods producers choose level of input $Y_{it}$ to minimize cost subject to its production function. The demand for intermediate good $i$ can be shown to be

$$Y_{it} = Y_t(\frac{P_{Hit}}{P_{H,t}})^{-\frac{1+\theta_p}{\theta_p}} \quad (82)$$

*A.5.2.2 Intermediate Goods Producers*

Home intermediate goods producer $i$ produces according to Cobb-Douglas production technology $Y_{it} = A_t K_{it}^{\alpha} L_{it}^{1-\alpha}$ where $A_t$ is the technology and follows an exogenous stochastic process. Take aggregate real wage rate $\omega_t$ and real capital rental cost $Z_t$ as given, firms choose factor inputs $L_{it}$ and $K_{it}$ in perfectly competitive factor markets to minimize real costs of production subject to its production function. In equilibrium, an optimizing firm produces according to:

$$\omega_t = \frac{1-\alpha}{\alpha}\frac{K_t}{L_t}Z_t \tag{83}$$

and the real marginal cost is given by:

$$mc_t = A_t^{-1}\left(\frac{\omega_t}{1-\alpha}\right)^{1-\alpha}\left(\frac{Z_t}{\alpha}\right)^{\alpha} \tag{84}$$

Intermediate goods producers choose the price that maximizes discounted real profits. Each period a fraction $1-\xi_p$ of firms can change their prices while the remaining firms index their price according to $P_{Hit} = P_{Hi,t-1}\pi_{t-1}^{\iota_p}$ where $\pi_t = \frac{P_{Ht}}{P_{Ht-1}}$ is domestic goods price index inflation. We can then write intermediate firms' profit maximizing problem to be:

$$\max_{P_{Hit}} \sum_{j=0}^{\infty} \xi_p^j \mathbb{E}_t\{\frac{\Lambda_{t,t+j}}{P_{t+j}}[\prod_{k=1}^{j}\pi_{t+k-1}^{\iota_p} P_{Hit}Y_{it+j|t} - MC_{t+j}Y_{it+j|t}]\} \tag{85}$$

subject to the demand faced by firm $i$:

$$Y_{it+j|t} = \left(\frac{P_{Hit+j}}{P_{H,t+j}}\right)^{-\frac{(1+\theta_p)}{\theta_p}} Y_{t+j} \tag{86}$$

where $Y_{it+j|t}$ is demand for intermediate good $i$ given firm $i$ last set its optimal price $P_{Hit}$ in period $t$.

In equilibrium, the optimal price-setting strategy equates marginal cost to marginal revenue, giving rise to the following equations:

$$f_{pt}^1 = mc_t Y_t + \xi_p(\pi_t)^{-\frac{\iota_p(1+\theta_p)}{\theta_p}}\mathbb{E}_t\{\Lambda_{t,t+1}\pi_{t+1}^{\frac{1+\theta_p}{\theta_p}} f_{pt+1}^1\} \tag{87}$$

$$f_{pt}^2 = p_{H,t}Y_t + \xi_p \pi_t^{-\frac{\iota_p}{\theta_p}}\mathbb{E}_t\{\Lambda_{t,t+1}\pi_{t+1}^{\frac{1}{\theta_p}} f_{pt+1}^2\} \tag{88}$$

and

$$\pi_t^o = (1+\theta_p)\pi_t \frac{f_{pt}^1}{f_{pt}^2} \tag{89}$$

where $\pi_t^o = \frac{P_{Hit}^o}{P_{H,t-1}}$, $\pi_t = \frac{P_{H,t}}{P_{H,t-1}}$ and $p_{H,t} = \frac{P_{H,t}}{P_t}$. Thus, CPI inflation $\pi_{ct}$ and domestic goods price inflation $\pi_t$ are related to each other via:

$$\pi_{ct} = \frac{\pi_t}{p_{H,t}/p_{H,t-1}} \tag{90}$$

Further, under Calvo pricing, the aggregate price index of domestically produced goods evolves according to:

$$\pi_t = \left[\xi_p (\pi_{t-1})^{-\frac{\iota_p}{\theta_p}} + (1-\xi_p)\,(\pi_t^o)^{-\frac{1}{\theta_p}}\right]^{-\theta_p} \tag{91}$$

*A.5.2.3 Capital Goods Producers*

Capital goods producers use final output $Y_t$ to make new capital goods subject to adjustment costs. New capital goods are sold at market price $q_t$. The objective of capital producers is to maximize their expected discounted profits by choosing input $I_t$. The representative capital goods producer solves:

$$\max_{I_{t+j}} \mathbb{E}_t\{\textstyle\sum_{j=0}^{\infty} \Lambda_{t,t+j}[q_{t+j} I_{t+j} - \left(1 + \frac{\Psi_I}{2}\left(\frac{I_{t+j}}{I_{t+j-1}} - 1\right)^2\right) I_{t+j}]\} \tag{92}$$

where $\phi_{It} = \frac{\Psi_I}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2 I_t$ is the capital adjustment costs.

In equilibrium, price of capital goods is equal to the marginal cost of investment:

$$q_t = 1 + \frac{\Psi_I}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2 + \Psi_I\left(\frac{I_t}{I_{t-1}} - 1\right)\frac{I_t}{I_{t-1}} - \mathbb{E}_t\{\Lambda_{t,t+1}\Psi_I\left(\frac{I_{t+1}}{I_t} - 1\right)\left(\frac{I_{t+1}}{I_t}\right)^2\} \tag{93}$$

Similar to consumption goods, investment goods $I_t$ is a composite of domestic ($I_{Ht}$) and imported ($I_{Ft}$) investment goods produced by an aggregator according to CES technology:

$$I_t = \left[ \gamma^{\frac{1}{\rho}} I_{H,t}^{\frac{\rho-1}{\rho}} + (1-\gamma)^{\frac{1}{\rho}} \left( \psi_{It} I_{F,t} \right)^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}} \quad (94)$$

where $\psi_{It}$ reflects costs of adjusting share of imported investment goods given by:

$$\psi_{It} = 1 - \frac{\psi_{FI}}{2} \left( \frac{I_{F,t}/I_{H,t}}{I_{F,t-1}/I_{H,t-1}} - 1 \right)^2 \quad (95)$$

Given a fixed budget, the aggregate investment goods producer chooses inputs $I_{H,t}$ and $I_{F,t}$ to minimize its discounted expected costs of producing the aggregate investment good subject to its production function. The equilibrium conditions are:

$$\begin{aligned} p_{H,t} &= \gamma^{\frac{1}{\rho}} \left( \frac{I_t}{I_{H,t}} \right)^{\frac{1}{\rho}} + (1-\gamma)^{\frac{1}{\rho}} \left( \frac{I_t}{I_{F,t}\psi_{It}} \right)^{\frac{1}{\rho}} \psi_{FI} x_{FI,t} \left( \frac{x_{FI,t}}{x_{FI,t-1}} - 1 \right) \frac{x_{FI,t}}{x_{FI,t-1}} \\ &- \mathbb{E}_t \{ \Lambda_{t,t+1} \pi_{ct+1} (1-\gamma)^{\frac{1}{\rho}} \left( \frac{I_{t+1}}{I_{F,t+1}\psi_{It+1}} \right)^{\frac{1}{\rho}} \frac{I_{H,t+1}}{I_{H,t}} \psi_{FI} x_{FI,t+1} \left( \frac{x_{FI,t+1}}{x_{FI,t}} - 1 \right) \frac{x_{FI,t+1}}{x_{FI,t}} \} \end{aligned} \quad (96)$$

$$\begin{aligned} p_{F,t} &= (1-\gamma)^{\frac{1}{\rho}} \left( \frac{I_t}{I_{F,t}\psi_{It}} \right)^{\frac{1}{\rho}} \left[ \psi_{It} - \psi_{FI} \left( \frac{x_{FI,t}}{x_{FI,t-1}} - 1 \right) \frac{x_{FI,t}}{x_{FI,t-1}} \right] \\ &+ \mathbb{E}_t \{ \Lambda_{t,t+1} \pi_{ct+1} (1-\gamma)^{\frac{1}{\rho}} \left( \frac{I_{t+1}}{I_{F,t+1}\psi_{It+1}} \right)^{\frac{1}{\rho}} \frac{I_{F,t+1}}{I_{F,t}} \psi_{FI} \left( \frac{x_{FI,t+1}}{x_{FI,t}} - 1 \right) \frac{x_{FI,t+1}}{x_{FI,t}} \} \end{aligned} \quad (97)$$

where

$$x_{FI,t} = \frac{I_{F,t}}{I_{H,t}} \quad (98)$$

*A.5.4 Foreign (US) Economy*

Except for the banking sector, US economy is symmetric to home economy with price and wage rigidity.