Risky Banks and Macro-Prudential Policy for Emerging Economies

Online Appendix

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A Empirical Evidence

A.1 Foreign Claims of US Banks

Figure A.1 documents the foreign claims of U.S. banks on EMEs from 2001Q4 until 2015Q3. Developing economies correspond to 25% of the total of foreign claims as an average of the sample. Mexico is the non-advanced economy that receives the most foreign claims from U.S. reporting banks; in terms of Mexican GDP they are on average almost 9% and they are 4% of the total foreign claims of U.S. banks. The sum of foreign U.S. claims on Mexico, Turkey, and Korea is on average 6% of the total GDP of those countries. Foreign claims show a positive trend for the sample. There is a clear fall in September 2008, when Lehman Brothers failed and a sharp recovery afterwards, as a consequence of unconventional monetary policy. However, the last year of data do not present a clear trend of where the claims of U.S. banks are going, but Mexico, Turkey, and Korea show some degree of slowdown.[1]

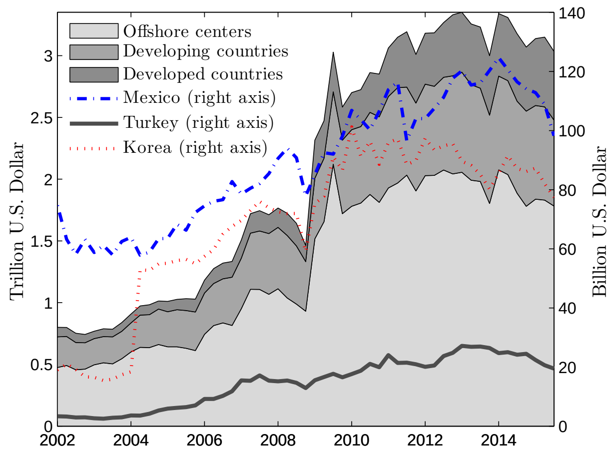

Fig. A.1. Foreign Claims of U.S. Reporting Banks on Individual Countries, 2001Q4-2015Q3

Source: BIS Consolidated Banking Statistics, Immediate Borrower Basis

A.2 Funding of Commercial Banks, for Mexico and Turkey

Here we document how Mexican and Turkish commercial banks fund their activities. In particular, commercial banks in EME are mainly financed with domestic deposits from households. Foreign assets play an important role in transmitting shocks from abroad, but they represent a small share of total liabilities. Moreover, as we explain in the paper, Mexican banks are subject to prudential regulation that restricts how much they can borrow from abroad; then, we expect Mexican banks' liabilities from foreign banks to be smaller than for Turkish banks. We show these characteristics in Figure A.2.

The left hand side plot in Figure A.2 corresponds to Turkish data, while the right hand side plot corresponds to Mexican data. The ratio of de-

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[1] The time series for Korea do not show a clear trend after 2010, and if there is any, it is negative; we interpret this as a consequence of the different measures of macro-prudential policy carried out after 2010 by the Central Bank of Korea.

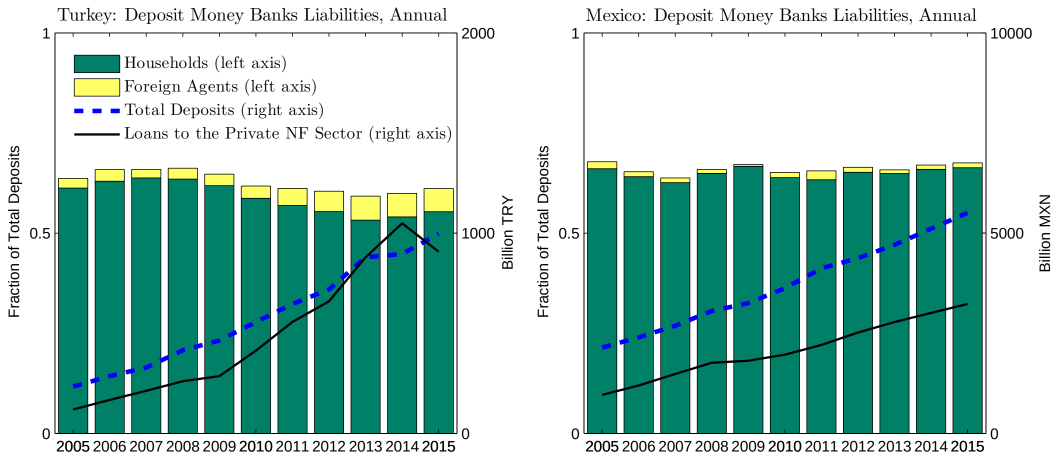

Fig. A.2. Mexico and Turkey: Deposit Money Banks Liabilities, 2005-2015
Source: Turkish Central Bank and Bank of Mexico

posits from households to total liabilities is the green area, while the ratio of borrowing from foreign agents to total liabilities is the yellow area, both variables refer to the left axis. Total deposits and total loans to the private non-financial sector for each country are in billions of domestic currency and refer to the right axis. As we show in Figure A.4 for Turkey, the ratio between credit and deposits has been increasing over time and, by the end of the sample, loans are larger than core liabilities. This also corresponds to an increase in foreign assets. On the other hand, deposits in Mexico have been larger than total loans for the whole sample.

A.3 Funding of Private Non-Financial Firms, for Mexico

In this part we document how Mexican private non-financial firms get their funding. We want to show that these firms get funding mainly from the domestic banking system. In Figure A.3 we show the total loans (right axis, blue dotted thick line), the fraction of direct foreign lending with respect to total loans (left axis, yellow area), the fraction of bank domestic loans with respect to total loans (left axis, light green area), and the fraction of other domestic loans with respect to total loans (left axis, dark green area). As the Figure documents, bank domestic loans have been the main source of funding of non-financial firms, with more than 50% of the total funding for most of the sample. Direct foreign credit increased before the latest financial crisis, but decreased afterwards as a portion of total loans.

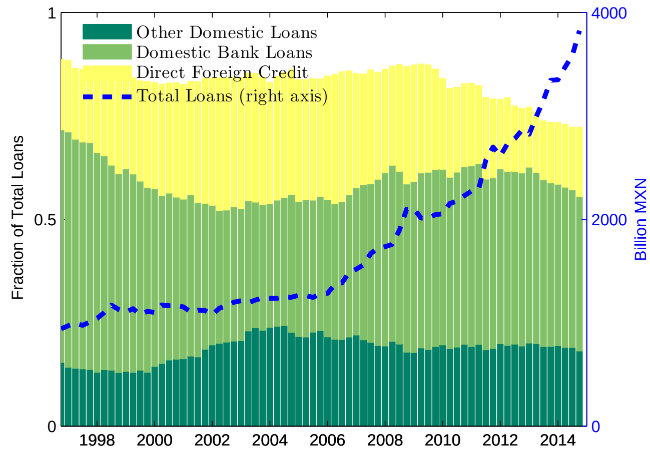

Fig. A.3. Mexico: Non-Financial Private Firms Liabilities, 1996Q4-2014Q4
Source: Bank of Mexico

A.4 Bank Credit to Bank Deposits for EMEs

Lane and McQuade (2014) highlight that behind the divergence between domestic bank deposit growth and bank credit growth, banks are using wholesale cross-border funding. Figure A.4 shows the ratio between credit and deposits for the three EMEs presented above, from 1994 to 2014. Turkey shows an increasing trend in the ratio with values higher than the equality between credit and deposits for the last years of the sample. This reflects that banks are funding their loans with non-core liabilities, i.e. borrowing short term on the international interbank and money markets and by issuing bonds. This goes in line with the risks that non-core liabilities can prompt in EMEs that are experiencing credit booms, as explained above. Korea shows that its credit is being financed with non-core liabilities but this trend presents a sharp slowdown after the financial crisis with the introduction of macro-prudential policy. Mexico, on the contrary, presents a credit to deposit ratio clearly below the equality after the prudential regulation was in place.

A.5 VAR Evidence and Data

In Figure A.5 we present the data that we use to run the VAR for Mexico and for Turkey. In Figure A.6 we plot an alternative VAR in which the S&P 500 impact on the U.S. net charge-offs on the same period. The results are similar to the baseline VAR.

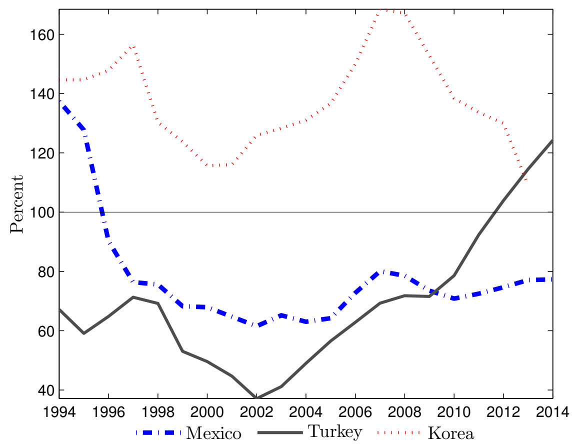

Fig. A.4. Bank Credit to Bank Deposits for EMEs, 1994-2014
Source: Federal Reserve Bank of St. Louis (FRED)

B Data and Sources

U.S. NCO Real U.S. Net charge-offs on all loans and leases, all commercial banks (in millions of dollars, not seasonally adjusted), divided by U.S. consumer price index. Source: Federal Reserve Bank of St. Louis (FRED).

S&P 500 Stock Price Index (not seasonally adjusted). Source: Federal Reserve Bank of St. Louis (FRED).

Foreign claims of U.S. Banks Real U.S. banks foreign claims on Mexican (Turkish) counterparties (in millions of U.S. dollar), divided by U.S. consumer price index. Source: BIS and Federal Reserve Bank of St. Louis (FRED).

EME GDP Real Mexican Gross Domestic Product at current prices (in millions of Mexican peso), divided by the GDP deflator. Source: Federal Reserve Bank of St. Louis (FRED). Real Turkish Gross Domestic Product at current prices (in millions of Turkish lira), divided by the GDP deflator. Source: Federal Reserve Bank of St. Louis (FRED).

Domestic Bank Credit Real Domestic Mexican banks' loans to the private non-financial sector, divided by the Mexican consumer price index. Source: BIS and Federal Reserve Bank of St. Louis (FRED). Real

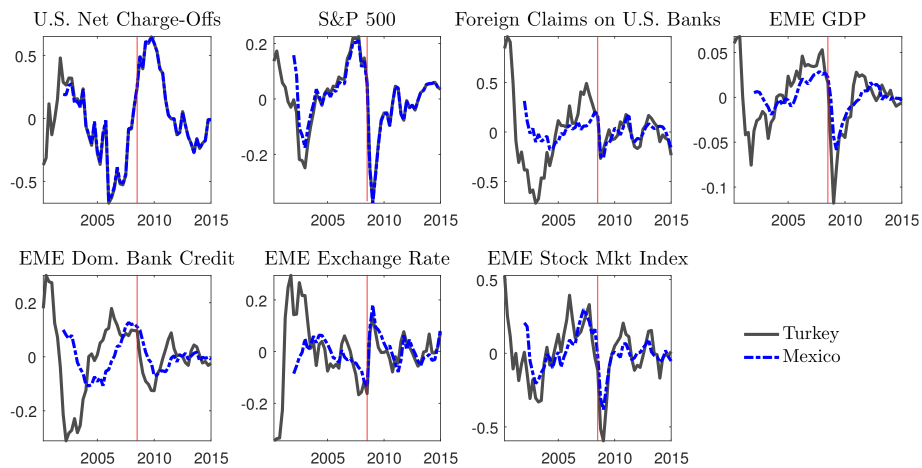

Fig. A.5. Data

Note: The data correspond to the one used to run the VAR: real, in logs, and HP filtered.

Domestic Turkish banks' loans to the private non-financial sector, divided by the Turkish consumer price index. Source: BIS and Federal Reserve Bank of St. Louis (FRED).

EME Exchange Rate Mexican peso - U.S. dollar Exchange Rate (not seasonally adjusted). Source: Federal Reserve Bank of St. Louis (FRED). Turkish lira - U.S. dollar Exchange Rate (not seasonally adjusted). Source: Federal Reserve Bank of St. Louis (FRED).

EME Stock Mkt Index Mexican stock market index (not seasonally adjusted). Source: Bank of Mexico. Turkish stock market index (not seasonally adjusted). Source: Turkish Central Bank.

C Equations of the Model

C.1 Households

Households maximize their expected discounted utility subject to their budget constraint:

$$U(C_t, L_t) = E_t \sum_{t=0}^{\infty} \beta^t \left(\ln C_t - \frac{\chi}{1+\gamma} L_t^{1+\gamma} \right)$$

$$\text{s.t} \quad C_t + D_{t+1} = W_t L_t + R_t D_t + \Pi_t - T_t,$$

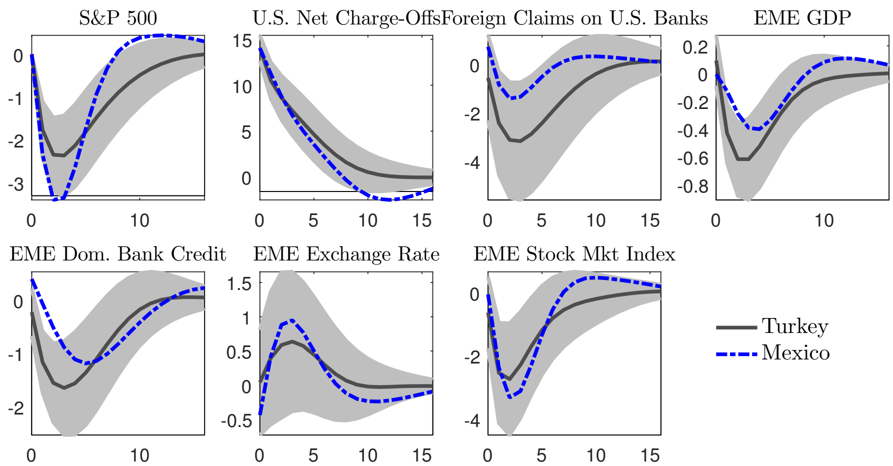

Fig. A.6. VAR Evidence. Impulse Responses to Cholesky One Standard Deviation Innovation to U.S. Commercial Banks Net Charge-Offs

Note: Mexican VAR (blue-dashed-dotted lines represent the mean) estimated from 2002Q1 to 2015Q1. The Cholesky ordering is S&P500, U.S. net charge-offs, U.S. banks' foreign claims on Mexican banks, Mexican GDP, Mexican banks credit to the private non-financial sector, exchange rate of Mexican pesos per U.S. dollar and the Mexican stock market index. Turkish VAR (gray-solid lines represent the mean and shaded areas represent one standard deviation confidence interval) estimated from 2000Q2 to 2015Q1. The Cholesky ordering of the variables is the same to the Mexican VAR. The vertical axis shows the percent deviation from the trend, while the horizontal axis corresponds to quarters.

The first order conditions are

$$L_t : \quad \frac{W_t}{C_t} = \chi L_t^{\gamma} \tag{C.1}$$

$$D_{t+1} : \quad E_t R_{t+1} \beta \frac{C_t}{C_{t+1}} = E_t R_{t+1} \Lambda_{t,t+1} = 1. \tag{C.2}$$

Similarly for the EME,

$$L_t^* : \quad \frac{W_t^*}{C_t^*} = \chi L_t^{*\gamma} \tag{C.3}$$

$$D_{t+1}^* : \quad E_t R_{t+1}^* \beta \frac{C_t^*}{C_{t+1}^*} = E_t R_{t+1}^* \Lambda_{t,t+1}^* = 1 \tag{C.4}$$

C.2 Intermediate Goods Producers

Intermediate goods producers maximize their expected discounted dividends,

$$\begin{aligned}
&\max_{K_{t+1},L_t} E_t q_t + d_t = d_t + E_t \sum_{s=t+1}^{\infty} \frac{d_s}{\Pi_{v=t+1}^{s} R_v} \\
&\text{s.t. } \; d_t = X_t P_t^A - W_t L_t - Q_t \left[\frac{K_{t+1}}{\Psi_{t+1}} + (1-\delta) K_t \right] \\
&\text{and } \; X_t = K_t^{\alpha} L_t^{1-\alpha}. \qquad \text{(C.5)}
\end{aligned}$$

Then, the first order conditions are

$$L_t: \quad W_t = (1-\alpha) K_t^{\alpha} P_t^A L_t^{-\alpha} \qquad \text{(C.6)}$$

$$K_{t+1}: \quad R_{t+1} = \Psi_{t+1} \tfrac{[Q_{t+1}(1-\delta) + Z_{t+1}]}{Q_t}, \qquad \text{(C.7)}$$

where we define the capital gross return

$$Z_t = \alpha P_t^A {L_t}^{1-\alpha} {K_t}^{\alpha-1}. \qquad \text{(C.8)}$$

To finance their capital, intermediate producers need to borrow from financial intermediaries. Total borrowing for the AE is S_t and is defined by

$$S_t = I_t + (1-\delta) K_t \qquad \text{(C.9)}$$

$$K_{t+1} = S_t \Psi_{t+1}. \qquad \text{(C.10)}$$

While the corresponding conditions for the EME are defined by

$$X_t^* = K_t^{*\alpha} L_t^{*(1-\alpha)} \qquad \text{(C.11)}$$

$$W_t^* = (1-\alpha) P_t^{E*} K_t^{*\alpha} {L_t}^{*-\alpha} \qquad \text{(C.12)}$$

$$Z_t^* = \alpha P_t^{E*} L_t^{*1-\alpha} {K_t}^{*\alpha-1} \qquad \text{(C.13)}$$

$$R_{t+1}^* = \Psi_{t+1}^* \frac{\left[Q_{t+1}^*(1-\delta) + Z_{t+1}^*\right]}{Q_t^*} \qquad \text{(C.14)}$$

$$S_t^* = I_t^* + (1-\delta) K_t^* \qquad \text{(C.15)}$$

$$K_{t+1}^* = S_t^* \Psi_{t+1}^*. \qquad \text{(C.16)}$$

C.3 Final Goods Producers

They combine domestic, X_t^A, and imported, X_t^E, intermediate goods to produce the final good, Y_t. They maximize their profits,

$$\max_{X_t^A, X_t^E} P_t Y_t - P_t^A X_t^A - P_t^E X_t^E$$

$$\text{s.t. } \; Y_t = \left[\nu^{\frac{1}{\eta}} {X_t^A}^{\frac{\eta-1}{\eta}} + (1-\nu)^{\frac{1}{\eta}} {X_t^E}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \qquad \text{(C.17)}$$

for the AE producers and for the EME producers, respectively,

$$Y_t^* = \left[\nu^{*\frac{1}{\eta^*}} X_t^{A*\frac{\eta^*-1}{\eta^*}} + (1-\nu^*)^{\frac{1}{\eta^*}} X_t^{E*\frac{\eta^*-1}{\eta^*}}\right]^{\frac{\eta^*}{\eta^*-1}} \tag{C.18}$$

From the optimization problem of the final goods producers, the demand for domestic goods for domestic and foreign producers are, respectively,

$$X_t^A = \nu \left(\frac{P_t^A}{P_t}\right)^{-\eta} Y_t, \tag{C.19}$$

$$X_t^{A*} = \nu^* \left(\frac{P_t^{A*}}{P_t^*}\right)^{-\eta} Y_t^*, \tag{C.20}$$

where prices are defined by

$$P_t^A = \nu^{\frac{1}{\eta}} Y_t^{\frac{1}{\eta}} \left(X_t^A\right)^{-\frac{1}{\eta}} \tag{C.21}$$

$$P_t = 1 = \left[\nu (P_t^A)^{1-\eta} + (1-\nu)(P_t^E)^{1-\eta}\right]^{\frac{1}{1-\eta}}$$

$$\frac{P_t}{P_t^A} = \frac{1}{P_t^A} = \left[\nu + (1-\nu)\, ToT_t^{1-\eta}\right]^{\frac{1}{1-\eta}}. \tag{C.22}$$

C.4 Capital Producers

Capital producers maximize their expected discounted profits, choosing I_t,

$$\max_{I_t} E_t \sum_{j=t}^{\infty} \Lambda_{t,j} \left\{ Q_j I_j - \left[1 + f\left(\frac{I_j}{I_{j-1}}\right)\right] I_j \right\}.$$

The first order condition yields the price of capital goods, which equals the marginal cost of investment for each country

$$Q_t = 1 + f\left(\frac{I_t}{I_{t-1}}\right) + \frac{I_t}{I_{t-1}} f'\left(\frac{I_t}{I_{t-1}}\right) - E_t \Lambda_{t,t+1} \left(\frac{I_{t+1}}{I_t}\right)^2 f'\left(\frac{I_{t+1}}{I_t}\right) \tag{C.23}$$

and $$Q_t^* = 1 + f\left(\frac{I_t^*}{I_{t-1}^*}\right) + \frac{I_t^*}{I_{t-1}^*} f'\left(\frac{I_t^*}{I_{t-1}^*}\right) - E_t \Lambda_{t,t+1}^* \left(\frac{I_{t+1}^*}{I_t^*}\right)^2 f'\left(\frac{I_{t+1}^*}{I_t^*}\right) \tag{C.24}$$

C.5 Banks

C.5.1 Advanced Economy Banks

Banks maximize the value of the bank subject to the borrowing constraint

$$\max_{s_t, b_t, d_t} V(s_{t-1}, b_{t-1}, d_{t-1}) = E_{t-1} \Lambda_{t-1,t} \left\{ (1-\sigma) n_t + \sigma \left[\max_{s_t, b_t, d_t} V(s_t, b_t, d_t)\right] \right\}$$

$$\text{s.t. } V_t(s_t, b_t, d_t) \geq \theta(Q_t s_t + Q_{bt} b_t).$$

We guess and verify that the form of the value function of the Bellman equation is linear in assets and liabilities,

$$V(s_t, b_t, d_t) = \vartheta_{st} s_t + \vartheta_{bt} b_t - \vartheta_t d_t.$$

The excess return on capital is

$$\mu_t = \frac{\vartheta_{st}}{Q_t} - \vartheta_t.$$

The equations that we use in the codes and come from solving and rearranging are

$$\phi_t = \frac{\vartheta_t}{\theta - \mu_t} \tag{C.25}$$
$$\vartheta_t = E_t \Lambda_{t,t+1} \Omega_{t+1} R_{t+1} \tag{C.26}$$
$$\mu_t = E_t \Lambda_{t,t+1} \Omega_{t+1} \left[R_{kt+1} - R_{t+1}\right] \tag{C.27}$$
$$\Omega_{t+1} = (1-\sigma) + \sigma(\vartheta_{t+1} + \phi_{t+1}\mu_{t+1}) \tag{C.28}$$
$$R_{kt+1} = \Psi_{t+1} \frac{Z_{t+1} + Q_{t+1}(1-\delta)}{Q_t}. \tag{C.29}$$

C.5.2 Emerging Market Economy Banks

We present with more details the optimization problem of EME banks in Appendix E. Here we just stick to the equations that we use for coding:

$$\vartheta_t^* = E_t \Lambda_{t,t+1}^* \Omega_{t+1}^* R_{t+1}^* \tag{C.30}$$
$$\mu_t^* = E_t \Lambda_{t,t+1}^* \Omega_{t+1}^* \left[R_{kt+1}^* - R_{t+1}^*\right] \tag{C.31}$$

$$\Omega_{t+1}^* = 1 - \sigma^* + \sigma^* \left(\vartheta_{t+1}^* + \phi_{t+1}^* \mu_{t+1}^*\right) \tag{C.32}$$
$$R_{kt+1}^* = \Psi_{t+1}^* \frac{Z_{t+1}^* + Q_{t+1}^*(1-\delta)}{Q_t^*}. \tag{C.33}$$
$$\phi_t^* = \frac{\vartheta_t^*}{\theta^* - \mu_t^*} \tag{C.34}$$

$$\mu_{bt}^* = E_t \Lambda_{t,t+1}^* \Omega_{t+1}^* \left[R_{bt+1}^* - R_{t+1}^*\right] \tag{C.35}$$
$$\phi_{bt}^* = \frac{\vartheta_t^*}{\theta^* \omega - \mu_{bt}^*} \tag{C.36}$$
$$\mu_{bt}^* = \mu_t^* \omega \tag{C.37}$$

C.5.3 Aggregate Bank Net Worth

$$\phi_t N_t = Q_t S_t + Q_{bt} B_t \tag{C.38}$$

$$D_t = N_t(\phi_t - 1) \tag{C.39}$$

$$N_t = (\sigma + \xi)\left(R_{k,t} Q_{t-1} S_{t-1} + R_{b,t} Q_{b,t-1} B_{t-1}\right) - \sigma R_t D_{t-1} \tag{C.40}$$

$$N_t^* = (\sigma^* + \xi^*) R_{k,t}^* Q_{t-1}^* S_{t-1}^* - \sigma^* R_t^* D_{t-1}^* - \sigma^* R_{bt}^* Q_{bt-1}^* B_{t-1}^*, \tag{C.41}$$

$$\phi_t^* N_t^* = Q_t^* S_t^* - \omega Q_{bt}^* B_t^* \tag{C.42}$$

$$N_t^*(\phi_t^* - 1) = D_t^* + (1 - \omega) Q_{bt}^* B_t^* \tag{C.43}$$

C.5.4 Global Interbank Market

$$R_{b,t+1}^* = \Psi_{t+1}^* \frac{Z_{t+1}^* + Q_{b,t+1}^*(1-\delta)}{Q_{bt}^*}. \tag{C.44}$$

$$E_t \Lambda_{t,t+1} \Omega_{t+1} R_{kt+1} = E_t \Lambda_{t,t+1} \Omega_{t+1} R_{bt+1} + \Phi\left[\exp\left(B_t - \bar{B}\right) - 1\right]. \tag{C.45}$$

C.6 Market Clearing and Equilibrium

To close the model, the different markets need to be in equilibrium. The equilibrium in the final goods market for home and for foreign

$$Y_t = C_t + I_t\left[1 + f\left(\frac{I_t}{I_{t-1}}\right)\right] + G_t \quad \text{and} \tag{C.46}$$

$$Y_t^* = C_t^* + I_t^*\left[1 + f\left(\frac{I_t^*}{I_{t-1}^*}\right)\right] + G_t^*. \tag{C.47}$$

Then, for the intermediate-competitive goods market

$$X_t = X_t^A + X_t^{*A}\frac{1-m}{m} \quad \text{and} \tag{C.48}$$

$$X_t^* = X_t^E \frac{m}{1-m} + X_t^{E*}. \tag{C.49}$$

The markets for securities are in equilibrium when

$$S_t = I_t + (1-\delta)K_t = \frac{K_{t+1}}{\Psi_{t+1}} \quad \text{and} \quad S_t^* = I_t^* + (1-\delta)K_t^* = \frac{K_{t+1}^*}{\Psi_{t+1}^*}.$$

The conditions for the labor market are

$$\chi L_t^\gamma = (1-\alpha)\frac{X_t}{L_t C_t} \quad \text{and} \quad \chi L_t^{*\gamma} = (1-\alpha)\frac{X_t^*}{L_t^* C_t^*}.$$

If the economies are in financial autarky, the net exports for home are zero in every period; the current account results in

$$CA_t = 0 = \frac{1-m}{m} X_t^{A*} - ToT_t X_t^E, \tag{C.50}$$

with ToT_t as the terms of trade, defined by the price of imports relative to exports for the home economy.

On the other hand, if there are cross-border bank flows in the economy, the current account is

$$CA_t = Q_{b,t} B_t - R_{bt} Q_{b,t-1} B_{t-1} = X_t^{*A} \frac{1-m}{m} \frac{P_t^A}{P_t} - X_t^E ToT_t \frac{P_t^A}{P_t}. \tag{C.51}$$

The global asset is in zero net supply, as a result

$$B_t = B_t^* \frac{1-m}{m}. \tag{C.52}$$

D Definition of Equilibria

Frictionless Economy In a model without financial frictions, the competitive equilibrium is defined as a solution to the problem that involves choosing twenty two quantities (Y_t, X_t, L_t, C_t, I_t, X_t^A, X_t^{A*}, K_{t+1}, W_t, Z_t, S_t, Y_t^*, X_t^*, L_t^*, C_t^*, I_t^*, K_{t+1}^*, X_t^E, X_t^{E*}, W_t^*, Z_t^*, S_t^*), two interest rates (R_t, R_t^*), and five prices (Q_t, P_t^A, Q_t^*, P_t^{E*}, ToT_t) as a function of the aggregate state (I_{t-1}, K_t, A_t, Ψ_t, I_{t-1}^*, K_t^*, A_t^*, Ψ_t^*). There are twenty nine variables and twenty nine equations: Eq. (C.1)-(C.24), and (C.46) - (C.50).

Economy with Financial Frictions The competitive banking equilibrium without government intervention is defined as a solution to the problem that involves choosing the same twenty two quantities as in the frictionless economy (Y_t, X_t, L_t, C_t, I_t, X_t^A, X_t^{A*}, K_{t+1}, W_t, Z_t, S_t, Y_t^*, X_t^*, L_t^*, C_t^*, I_t^*, K_{t+1}^*, X_t^E, X_t^{E*}, W_t^*, Z_t^*, S_t^*), plus the sixteen variables related with banks (N_t, D_t, B_t, Ω_t, μ_t, ϑ_t, ϕ_t, N_t^*, D_t^*, B_t^*, Ω_t^*, μ_t^*, ϑ_t^*, ϕ_t^*, μ_{bt}^*, ϕ_{bt}^*), five interest rates (R_t, R_t^*, R_{kt}, R_{kt}^*, R_{bt}^*), and six prices (Q_t, P_t^A, Q_t^*, Q_{bt}^*, P_t^{E*}, ToT_t) as a function of the aggregate state (I_{t-1}, K_t, A_t, Ψ_t, I_{t-1}^*, K_t^*, A_t^*, Ψ_t^*). There are forty nine variables and forty nine equations. Eq. (C.1)-(C.6), (C.8)-(C.13), (C.15)- (C.49), (C.51), and (C.52).

E EME Banks' Optimization Problem

Let $V_t^*(s_t^*, b_t^*, d_t^*)$ be the maximized value of V_t^*, given an asset and liability configuration at the end of period t. The following incentive constraint must hold for each bank individually to ensure that a bank does not divert funds,

$$V_t^*(s_t^*, b_t^*, d_t^*) \geq \theta^*(Q_t^* s_t^* - \omega Q_{bt}^* b_t^*), \tag{E.53}$$

where the RHS shows the funds that a bank can run away with, which are the total value of assets minus the borrowing from AE banks.

At the end of period $t-1$, the value of the bank satisfies the following Bellman equation

$$V_t^*(s_{t-1}^*, b_{t-1}^*, d_{t-1}^*) = E_{t-1}\Lambda_{t-1,t}^* \left\{ (1-\sigma^*)n_t^* + \sigma^* \left[\max_{s_t^*, b_t^*, d_t^*} V^*\left(s_t^*, b_t^*, d_t^*\right) \right] \right\}. \tag{E.54}$$

The problem of the bank is to maximize Equation (E.54) subject to the borrowing constraint, Equation (E.53).

We guess and verify that the form of the value function of the Bellman equation is linear in assets and liabilities,

$$V\left(s_t^*, b_t^*, d_t^*\right) = \vartheta_{st}^* s_t^* - \vartheta_{bt}^* b_t^* - \vartheta_t^* d_t^*, \tag{E.55}$$

where ϑ_{st}^* is the marginal value of assets at the end of period t, ϑ_{bt}^*, the marginal cost of holding foreign debt, and ϑ_t^*, the marginal cost of deposits.

Maximizing the objective function (E.54) with respect to (E.53), with λ_t^* as the constraint multiplier, yields similar first-order conditions to the ones from the AE bank; those are

$$\begin{aligned}
s_t^* &: & \vartheta_{st}^* - \lambda_t^*\left(\vartheta_{st}^* - \theta^* Q_t^*\right) &= 0 \\
b_t^* &: & \vartheta_{bt}^* - \lambda_t^*\left(\vartheta_{bt}^* - \theta^* \omega Q_{bt}^*\right) &= 0 \\
d_t^* &: & \vartheta_t^* - \lambda_t^* \vartheta_t^* &= 0 \\
\lambda_t^* &: & \theta^*\left(Q_t^* s_t^* - \omega Q_{bt}^* b_t\right) - \left(\vartheta_{st}^* s_t^* - \vartheta_{bt}^* b_t^* - \vartheta_t^* d_t^*\right) &= 0.
\end{aligned}$$

Rearranging terms yields:

$$\left(\frac{\vartheta_{bt}^*}{Q_{bt}^*} - \vartheta_t^*\right)(1+\lambda_t^*) = \lambda_t^* \theta^* \omega \tag{E.56}$$

$$\left(\frac{\vartheta_{st}^*}{Q_t^*} - \frac{\vartheta_{bt}^*}{Q_{bt}^*}\right)(1+\lambda_t^*) = \lambda_t^* \theta^* (1-\omega) \tag{E.57}$$

$$\left[\theta^* - \left(\frac{\vartheta_{st}^*}{Q_t^*} - \vartheta_t^*\right)\right] Q_t^* s_t^* - \left[\theta^* \omega - \left(\frac{\vartheta_{bt}^*}{Q_{bt}^*} - \vartheta_t^*\right)\right] Q_{bt}^* b_t^* = \vartheta_t^* n_t^* \tag{E.58}$$

Combining Equation (E.56) with Equation (E.57) results in

$$\begin{aligned}\left(\frac{\vartheta^*_{bt}}{Q^*_{bt}} - \vartheta^*_t\right)\frac{1}{\omega} &= \left(\frac{\vartheta^*_{st}}{Q^*_t} - \frac{\vartheta^*_{bt}}{Q^*_{bt}}\right)\frac{1}{1-\omega} \\ \mu^*_{bt} &= \left(\mu^*_t - \mu^*_{bt}\right)\frac{\omega}{1-\omega} \\ \mu^*_{bt} &= \mu^*_t\omega, \end{aligned} \tag{E.59}$$

where from the first to the second step we are using the definition of μ^*_{bt} and μ^*_t given in the text.

Rewriting Equation (E.58) and defining $\phi^*_t = \frac{\vartheta^*_t}{\theta^* - \mu^*_t}$ and $\phi^*_{bt} = \frac{\vartheta^*_t}{\theta^*\omega - \mu^*_{bt}}$ yields

$$n^*_t = \frac{1}{\phi^*_t}Q^*_t s^*_t - \frac{1}{\phi^*_{bt}}Q^*_{bt}b^*_t. \tag{E.60}$$

Now expressing the guess of the value function, Equation (E.55), in terms of the net worth and international debt,

$$\begin{aligned} V(s^*_t, b^*_t, d^*_t) &= \frac{\vartheta^*_{st}}{Q^*_t}Q^*_t s^*_t - \frac{\vartheta^*_{bt}}{Q^*_{bt}}Q^*_{bt}b^*_t - \vartheta^*_t d^*_t \\ &= \left(\phi^*_t\mu^*_t + \vartheta^*_t\right)n^*_t + \left(\frac{\phi^*_t\mu^*_t}{\phi^*_{bt}} - \mu^*_{bt}\right)Q^*_{bt}b^*_t. \end{aligned} \tag{E.61}$$

With this information we can verify the value function that corresponds to Equations (C.30), (C.31), and (C.35).

F Impulse Response Functions: IRBC vs. Financial Frictions

In this section we compare the same three models presented in the main text with a model without banks or financial frictions, similar to the international real business cycle framework. We use the baseline calibration for $\omega < 1$ presented in the main text, Section **??**, and we evaluate the changes in the spillovers up to a first order approximation.

Figure F.1 shows the impulse responses to a decline in the AE quality of capital of 5% in period t comparing four models. The first model is one without financial frictions and in financial autarky, the international real business cycle model, and is the black-dashed-dotted line. The second model has financial frictions but no trade in assets, and is the red-dashed line. The third model is one with financial frictions and cross-border bank flows (financial openness) with no further EME frictions, safe EME banks, $\omega = 1$; it is the blue-solid line. The fourth model is one with financial frictions and risky EME banks ($\omega = 0.5$) and is the green-dotted line. The

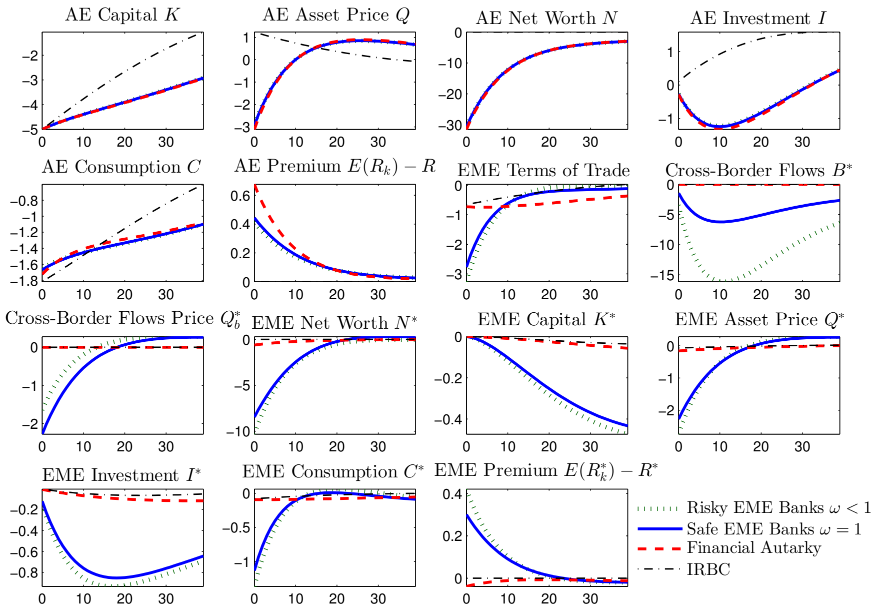

Fig. F.1. Impulse Responses to a 5% Decrease in in the the AE Quality of Capital, Ψ_t

Note: y axis: percentage deviation from the steady state; x axis: quarters from the shock

comparison of these models shows how the transmission mechanism across countries changes given the different assumptions. In the first two models, there is only international spillover due to the trade of intermediate goods. In the last two models, we add the international financial mechanism and we study safe vs. risky banks. The last three models are the same as in the main text. In Figure F.2, we show the rest of the impulse responses functions.

When there is a decrease in the AE quality of capital, and there are no financial frictions (i.e. no banks) in the economy, all resources are channeled to recovering from the initial shock. Investment and the asset price go up. On impact, households cut down on consumption because of lower labor income. Final domestic demand and production at the AE fall because of the negative shock.

The AE cuts back not only the demand for local goods, X_t^A, but also imports, X_t^E. There are fewer AE goods in the economy because of the shock. As a result, every unit of AE good is more expensive and the terms of trade slightly improve (deteriorate) for the AE (EME). The trade balance is defined by Equation (C.50), there is no international borrowing/lending.

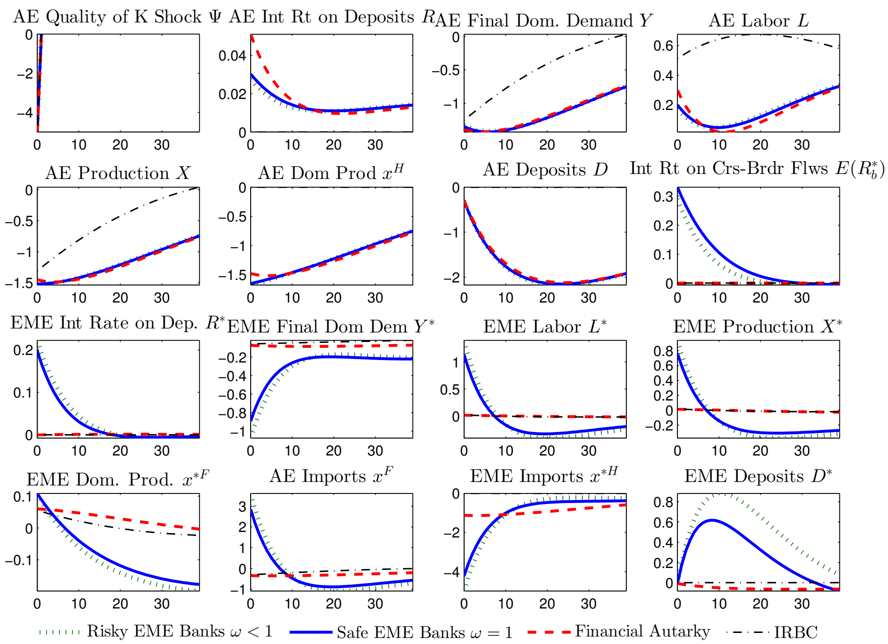

Fig. F.2. Impulse Responses to a 5% Decrease in the AE Quality of Capital Ψ_t, Large Set of Variables

Note: y axis: percentage deviation from the steady state; x axis: quarters from the shock

The AE demand for EME goods decreases but the EME starts demanding more domestic products because they are relatively cheaper. The EME increases its production, X_t^*, while substituting advanced for domestic goods. Nevertheless, consumption and investment decrease because the interest rate is higher. In the model without financial frictions and in financial autarky, there is no international co-movement either in asset prices or in production. However, there is co-movement in total demand and consumption, while the terms of trade deteriorate for the EME.

Adding financial frictions but no cross-border bank flows to the model results in an amplification for the AE of their domestic shock, but there is still very little transmission to the EME. The AE shows similar results to the ones in Gertler and Kiyotaki (2010), as we explain in the main text. The difference with the model without financial frictions is that the decrease in capital due to the fall in the quality of capital, brings about a fall in the net worth of AE banks. As a consequence, banks are more financially constrained, they start a fire-sale of assets that translates into a reduction in the asset price and investment. The AE production and consumption shrink more than in the model without banks. The transmission to the EME is similar to the previous case.

When we allow for cross-border bank flows, AE banks lend to EME banks. EME banks borrow internationally; AE banks diversify their assets and pool a country-specific shock. The decrease in the value of assets and securities in the AE prompts AE banks to be more financially constrained. The reaction is similar to the model in financial autarky and is shown by the solid-blue and the thick dashed-red line. The mechanism that takes place for the AE variables is the same in both setups with financial frictions.

With cross-border bank flows, EME banks face a reduction in their net worth because of a country-specific shock in the AE. EME financial intermediaries are more financially constrained and reduce lending to domestic businesses. Investment and the price of capital shrink. Credit falls and so does consumption. Cross-border bank flows transmit the crisis from the AE to the EME. This generates financial instability in the EME that is not revealed in the models without cross-border bank flows. These models replicate the VAR-based evidence. When there are riskier banks in the EME, $\omega < 1$, the crisis is deeper in the EME due to a larger fall in the lending of AE banks to EME.

G Additional Graphs

G.1 No Policy Response

G.2 Policy Response

References

LANE, P. R., AND P. MCQUADE (2014): "Domestic Credit Growth and International Capital Flows," *The Scandinavian Journal of Economics*, 116(1), 218–252.

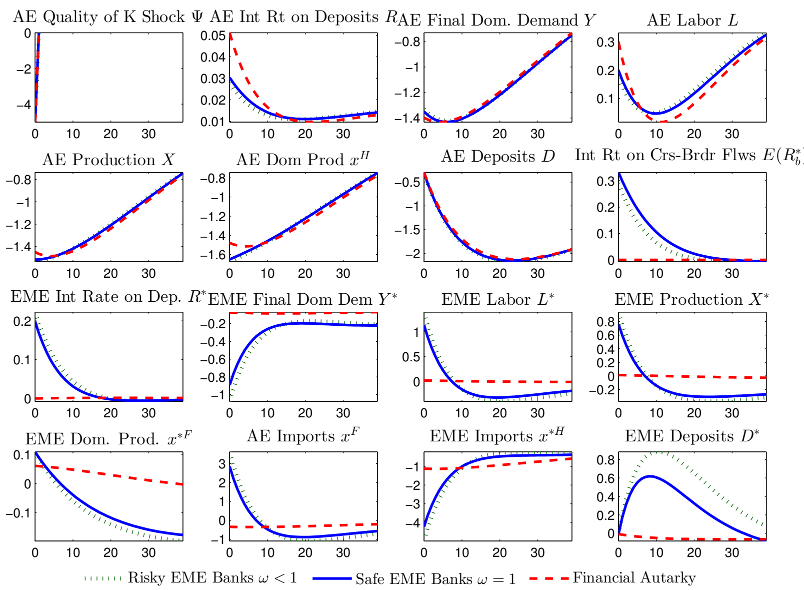

Fig. G.1. Impulse Responses to a 5% Decrease in the AE Quality of Capital Ψ_t, Large set of Variables

Note: y axis: percentage deviation from the steady state; x axis: quarters from the shock

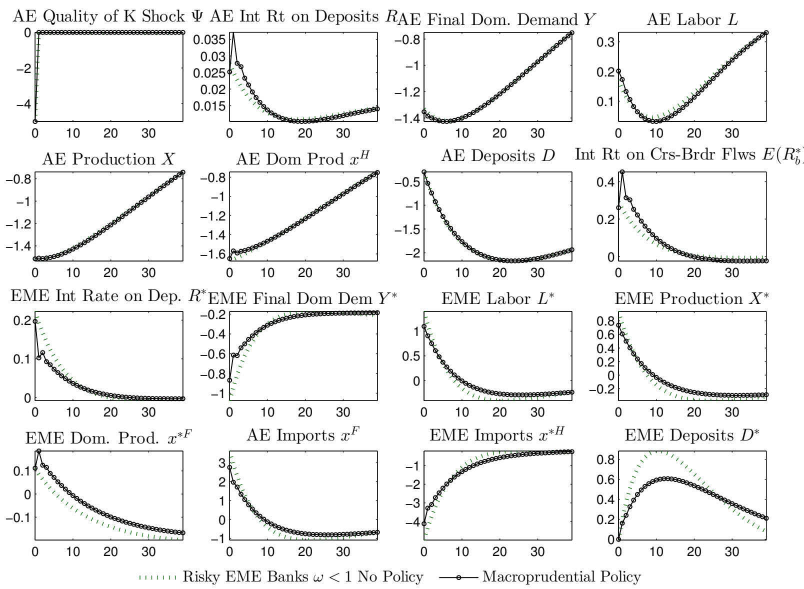

Fig. G.2. Impulse Responses to a 5% Decrease in the AE Quality of capital Ψ_t, Macro-prudential Policy by the EME Central Bank, Large set of Variables

Note: y axis: percentage deviation from the steady state; x axis: quarters from the shock