Risky Banks and Macroprudential Policy for Emerging Economies[*]

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Abstract

We develop a two-country DSGE model with global banks to analyze the transmission mechanism of cross-border banking flows from the United States to emerging market economies (EMEs). We study EMEs' macro-prudential policy that aims at moderating the financial instability that the volatility of cross-border banking flows cause. Banks face a moral hazard problem on borrowing from households. EME's banks might also be constrained on how much they can borrow from U.S. banks (because EME's banks are risky). A negative shock to the value of the capital in the United States generates a decline in asset prices, banks' net worth, consumption, and investment in both countries. Cross-border banking flows transmits the domestic shock prompting outflows for the EME and a global financial crisis. Macro-prudential policy that targets non-core liabilities carried out by the EME helps to resilience the domestic economy to the volatility of cross-border capital flows and makes EME households better off.

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1 Introduction

Financial liberalization and progress in communication and information technologies have triggered a significant increase in the degree of interconnectedness among financial institutions, investors, and markets at an international level. In principle, these developments have allowed a more efficient allocation of resources and risk across countries and economic agents. However, the higher interdependence has also led to a faster transmission of financial shocks across economies. In particular, it has increased the exposure of emerging market economies (EMEs) to financial shocks originated in advanced economies (AEs). For example, the financial crisis of 2007-2009 originated in the U.S. housing sector and spread to a number of economies, such as EMEs.

In the last couple of years, scholars and EMEs' policy makers have expressed their concern regarding the negative spillovers of the AEs' monetary policy through cross-border flows (see Powell, 2013, Rajan, 2014, Sánchez, 2013) and in particular international banking flows (see Takáts and Vela, 2014).[1] Supporting this view, Cetorelli and Goldberg (2011) look at EMEs and find that the main channel of transmission of the financial crisis was the reduction in cross-border lending by foreign banks. Moreover, Morais, Peydró, and Ruiz (2014) use Mexican data to show that a loosening in U.S. monetary policy generates a reduction of credit of domestic global banks to non-financial Mexican firms with consequences on the real economy. From the theoretical point of view, several papers have tried to explain the transmission mechanism by modeling international economies with financial frictions, but so far none has presented a stylized two-country model with cross-border banking flows.[2] Moreover, we do not know of any theoretical paper that looks at the different impact's magnitude of the negative spillovers in EMEs due to prudential banking regulation already in place or the structure of the financial system.

In this paper, we study the effects of cross-border banking flows' volatility in EMEs' credit and how macro-prudential measures carried out by an EME can reduce the financial instability that comes from these non-core liabilities. In particular, we look at a shock that resembles the recent financial crisis and then, we analyze the response of EMEs in terms of macro-prudential policy. We evaluate how the transmission changes when the EME has prudential regulation already in placed once the financial crisis hits. We focus on asset prices and flows managed by the AEs' banks. We are not aware of developments of these

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[1] Angelini, Neri, and Panetta (2014), Beau, Clerc, and Mojon (2012), Hanson, Kashyap, and Stein (2011), Quint and Rabanal (2014), among others, develop models to study the role of macro-prudential policy and its interaction with monetary policy. Mohanty (2014) expresses the policy makers' general agreement: macro-prudential policy in EMEs help to reduce the volatility that international spillovers generate.

[2] Unsal (2013) presents a two-country model but non-financial firms are the ones that borrow from abroad. Macro-prudential policy is effective on improving welfare only when there are financial shocks. Brzoza-Brzezina, Kolasa, and Makarski (2013), also in a two-country setup, model banks that borrow from abroad, however they have a very complete model and a currency union framework; they find that macro-prudential policy is a good complement to monetary policy.

channels in the literature and they play an important role on the transmission from the financial to the real side of EMEs.

We propose a two-country (advanced and emerging economies) model with global banks and financial frictions. The EME is a relatively small country with a small banking sector, such as Mexico or Turkey, while the AE is a relatively big economy with a big banking sector, such as the United States. The model builds on the closed economy models of Gertler and Kiyotaki (2010) and Gertler and Karadi (2011) and the open economy framework of Nuguer (2015). There are advanced and emerging banks. They use their net worth and local deposits to finance domestic non-financial businesses. Although banks can finance local businesses by buying their securities without frictions, they face a financing constraint in raising deposits from local households because banks are subject to a moral hazard problem. AE banks (U.S. banks) have a longer average lifetime and a larger net worth (relative to the size of the economy) than EME banks; as a consequence, AE banks lend to EME banks using cross-country debt agreements and effectively participate in risky finance in the EME market; cross-border banking flows are non-core liabilities for EME banks.

We simulate the response of the model to a negative shock to the value of capital, the so-called quality of capital shock. When there is a reduction in the value of capital and securities in the AE, both AE and EME banks lose some of their net worth. Because banks are constrained in raising deposits, they have to reduce lending to businesses, which further depresses the value of securities and the banks' net worth. EME banks are affected because AE banks have to reduce how much they lend to the EME. EME banks' net worth falls. Then, EME banks' liability side shrinks, banks are more financially constrained and they reduce lending to domestic firms. Therefore, the adverse shock in the larger economy leads to a decline in the asset price, investment, and domestic demand in both economies through cross-border banking debt. When we allow EME banks to only repay a fraction of the debt with AE banks before running away (what we call risky EME banks) the negative spillover of the shock is larger.

First, we examine how a country-specific quality of capital shock is transmitted internationally. When EME banks are allowed to borrow from AE banks, the international asset insures the AE against the shock because cross-border banking flows prompt risk sharing. We study two cases. One in which there are no financial frictions for EME banks to borrow from AE banks and one in which there are (risky banks). When there are no financial frictions on borrowing from AE banks, EME banks are considered safe and there is perfect integration of the domestic assets markets. The response of the model to a quality of capital shock in the AE shows similar characteristics to the VAR evidence estimated in Section 2: there is asset price co-movement across countries, AE banks decrease how much they lend to EME banks, and the AE experiences a decrease in the final domestic demand. When there are financial frictions on borrowing from AE banks, there are risky EME banks and there is imperfect integration of the domestic assets markets. The transmission of the financial crisis to the EME is qualitatively similar to the case of safe EME banks, however there is an extra source of friction and the crisis in the EME is deeper in the latest case.

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Macro-prudential regulation targets cross-border banking flows through a levy on non-core bank liabilities.

Second, we focus on macro-prudential regulation in the EME. The main purpose of the regulation is to smooth the effect of the volatility of non-core liabilities in the EME's financial system. Because the transmission mechanism works through the cross-border banking flows, we target the volatility that comes from them. The intensity of the policy moves with the ratio of bank credit growth over bank deposits growth. EME banks pay a tax on non-core liabilities when bank credit is growing faster than bank deposits. The macro-prudential policy goes in line with the tax that the Central Bank of Korea put on non-core liabilities in October 2010. This bounds the risk of widespread disruptions from AE to the EME, limiting the negative consequences for the small economy. Whenever there is a shock, the international asset reacts less and the transmission of the shock is mitigated. Banks experience a smoother reaction of their net worth with capital, investment, and asset price falling less. EME households cut less their consumption and labor is smoother; EME households are better off. The policy manages to control the dynamics of the spread too. The AE is slightly affected by the EME's macro-prudential regulation. From a welfare point of view, EME consumers are better off with the policy than without it. This policy is not a capital control because domestic banks, i.e. residents, pay the tax and not AE banks, i.e. foreigners. Moreover, this is a macro-prudential tool because it aims at financial stability, rather than a tool for capital controls or one to manage exchange rate, see Shin (2011) for this discussion.

Third, we take the net charge-off of all loans and leases of U.S. banks as an approximation to the quality of capital shock in the AE and we simulate the response of the different models to this path of shocks for the Great Recession period, 2007Q1-2011Q1. We find that the models with safe and risky EME banks do a very good job in replicating the collapse of the domestic bank credit to private non-financial firms for Mexico and Turkey, respectively; specially when compare it to a model without global banks.

What is new in this framework is the study of the cross-border banking flows channel in a DSGE setup with constrained financial intermediaries and the introduction of macro-prudential regulation and the interaction with prudential regulation already in place. The international debt in the model prompts a high level of co-movement between the EME and the AE, with similarities to the VAR shown in the next Section. These co-movements are exacerbated by the introduction of a financial friction for EME banks to borrow from AE banks, what we call risky banks. There is international co-movement of asset prices, the banks' net worth, and total final demands. Moreover, the macro-prudential regulation protects the EME from shocks propagated by the banks' non-core liabilities.

The rest of the paper is organized as follows. In the next section, we show empirical evidence that explains why EMEs should look closely at banks' non-core liabilities in general, and cross-border banking flows in particular. In Section 3, we describe in detail the two-country model with cross-border banking flows. In Section 4, we incorporate into our framework the macro-prudential policy in the EME, as a levy on non-core liabilities. In

Section 5, we study the role of cross-border banking flows on the propagation of an AE quality of capital shock (that resembles the global financial crisis). We examine the model with and without policy response from the EME and its welfare implications. Finally, in Section 6 we discuss the main results of the paper and we conclude.

2   Empirical Evidence

In this section, we document the empirical facts. First, we briefly explain the main steps that brought macro-prudential policy to the front of the stage. Second, we show how U.S. reporting banks' cross-border flows to EMEs have changed over time and we explain the role of these flows on the increase in EMEs' credit. Third, we estimate a VAR for two EMEs: one that put prudential banking regulation in the mid-nineties, Mexico, and one that has not, Turkey. From the VAR we learn that foreign claims of U.S. banks play a key role on the transmission of a shock to the value of capital in the U.S. to EMEs. We also learn the difference between a country that has had prudential policy for more than a decade, such as Mexico, versus one that has only put it into place after the latest financial crisis, such as Turkey.

The international financial crisis revealed the role that global banks can play in spreading financial shocks across economies. In 2007, the problems in the U.S. housing sector hit financial institutions and many banks found themselves in distress. This, in addition to the failure of Lehman Brothers in September 2008, triggered a severe liquidity crisis in the interbank market. The spread between the interest rate on interbank loans and the U.S. T-bills increased 350bps. Assets in the United States started to lose value. U.S. banks decreased their loans, including their foreign claims on EMEs counterparties. EMEs banks saw an outflow of capital from global banks; their liability side was shrinking. Therefore, EMEs' banks decided to decrease loans domestically, and the crisis transmitted from the United States to EMEs. As a results of the loss of the value of U.S. assets and the fall in credit in the United States, U.S. banks started to lend less to EMEs. At the end of 2008, the total foreign claims of U.S. banks with developing economies counterparties had fallen by almost 19% of the level of the end of 2007, almost $100 billion U.S. dollar.

As a result of the financial crisis, the Federal Reserve and other central banks introduced a set of so-called "unconventional" monetary policies. In particular, the Fed started to intervene directly in the credit market, lending to non-financial institutions and reducing the restrictions to access the discount window, among other policies. This helped to recover confidence in financial markets and capital started to move back to EMEs.

In this setting, loose monetary conditions in major AEs, such as the United States, contributed to an episode of large capital flows to EMEs. The magnitude and speed at which these financial flows move raised some financial stability concerns in the recipient economies, see Sánchez (2013), Powell (2013), and Rajan (2014). Overall, capital flows can be allocated to different markets and assets, with different implications for the development of financial imbalances. For example, capital flows may be directly allocated

to public or corporate debt markets and/or intermediated through the domestic banking system. In the case of EMEs, Mendoza and Terrones (2008), Avdjiev, McCauley, and McGuire (2012), and Magud, Reinhart, and Vesperoni (2014) find that episodes of large capital inflows increase the probability of credit booms. Gourinchas and Obstfeld (2012) show that for EMEs and AEs domestic credit expansion and real exchange appreciation are good predictors of financial crisis. There are different channels through which capital inflows may contribute to a credit expansion. There is a direct link between these inflows and credit boom in those cases when financial inflows take the form of bank loans and are intermediated through domestic banks, see Lane and McQuade (2014). Hence, some countries experienced growing financial imbalances.

On June 2013, the Federal Reserve announced that they would start the tapering of some of the unconventional policies (in particular quantitative easing) contingent on positive economic data. This news prompted a decrease in U.S. stock markets. Capital started to fly back to AEs, creating financial instability in EMEs. In this context, an important concern is the risk of reversals in financial flows, with a negative impact on the banking credit granted to the private sector in EMEs. This risk is latent due to the uncertainty about the normalization of monetary conditions in the United States. This situation has already contributed to some periods of high volatility in international financial markets, which affected EMEs. These economies are vulnerable to external shocks. In particular, shocks in the United States or the Federal Reserve's policy decisions might prompt capital to move around the globe. BIS (2010b) points that their main concerns are debt (portfolio) flows and cross-border bank lending because they might cause financial instability in EMEs.

The consequences of the financial crisis brought back the discussion regarding macro-prudential regulation. The financial crisis reminded policymakers around the globe about the costs of a systemic disruption in financial markets. Macro-prudential regulation aims to reduce the systemic risk of the financial system. The International Monetary Fund (2011) considers two types of macro-prudential tools: (1) instruments designed to control the systemic risk across time and across individual institutions and (2) instruments that can be re-calibrated according to specific objectives and with the purpose of reducing systemic risk. Additionally, the BIS (2010a) defines a macro-prudential tool as the one whose main objective is to promote the stability of the financial system as a whole.

Many EMEs implemented prudential regulation at the end of the 90s due to several EMEs crisis. The tools that EMEs have been using are mainly of flexible instruments that vary according to the different systemic risks (see Castillo, Quispe, Contreras, and Rojas, 2011). EMEs have strengthened the regulatory framework with respect to maturity mismatches on the balance sheets of financial institutions, limited short-term foreign borrowing, and strengthened the supervision of foreign currency exposures. These measures have ensured a resilient financial system (BIS, 2010b).

In Mexico, after the so called Tequila Crisis in 1995, the Bank of Mexico started to implement prudential regulation. One of the main changes in the regulation was to require
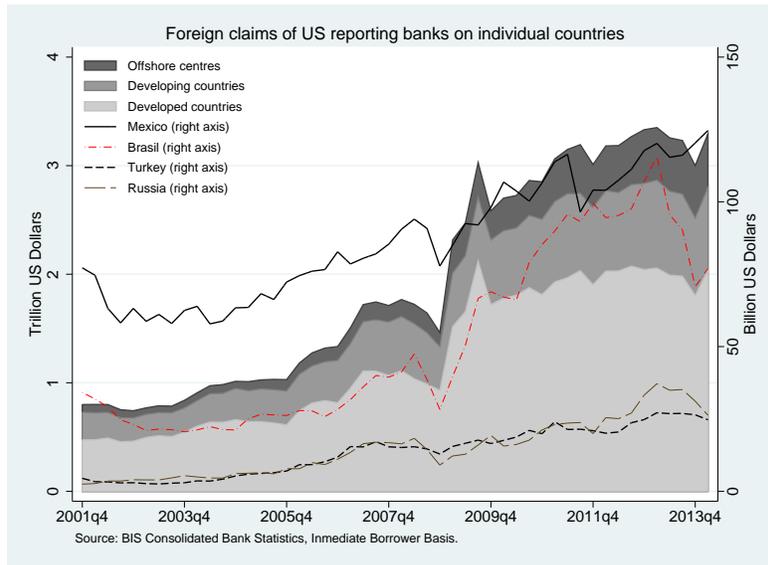
Fig. 1. Foreign Claims of U.S. Reporting Banks on Individual Countries, 1999Q4-2014Q1

global banks offering banking services in Mexico to do it through subsidiaries, instead of branches. Subsidiaries are separate entities from their parent bank with their own capital. By doing this, Citibank, Santander, BBVA, HSBC, and Scotiabank arrived to a very regulated market where foreign and domestic banks have the same rules and supervisor processes.

Among the prudential regulation measures that the Mexican financial system implemented in the 90s are: regulation for banks' foreign currency operations (maturity and currency); a cap on exposure to related counterparties; caps on interbank exposures and higher limits on value at risk for pension fund portfolios at times of high volatility; among others. (Guzmán Calafell, 2013). The prudential measures implemented in the 90s helped Mexican banks to be resilient during the global financial crisis. With the financial crisis and the Basel III Agreement, some new measures were implemented and there is still room for working more on targeting the sources of instability of the financial system.

Figure 1 documents the foreign claims of U.S. banks by EMEs from 2001Q4 until 2014Q1. Developing economies correspond to 26% 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% points and they are 5% of the total foreign claims of U.S. banks. The sum of foreign U.S. claims on Brazil, Mexico, Turkey, and Russia is on average 5% 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. For the last year of data there is not a
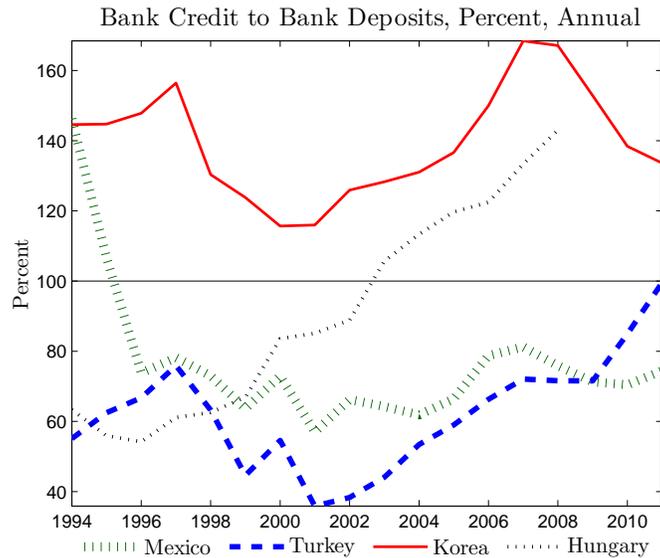
Fig. 2. Bank Credit to Bank Deposits for EMEs, 1994-2011
Source: Federal Reserve Bank of St. Louis (FRED).

clear tendency of where the claims of U.S. banks are going, but Mexico, Brazil, Russia, and Turkey show some level of slowdown.

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 2 shows the ratio between credit and deposits for several EMEs, from the year 1994 until 2011. Except for Mexico after the prudential regulation was entailed, all the other EMEs show an increasing trend in the ratio with values higher than the equality between credit and deposits. 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. In Appendix A we document that commercial banks in Turkey and Mexico fund their activities mainly with domestic households deposits. Moreover, the fraction of borrowing from foreign agents with respect to total liabilities is larger for Turkish than for Mexican banks.

It is important to remark that the crisis to EMEs was not only transmitted by global banks. The trade effect also played a very important role in the transmission mainly because the EMEs' banks did not hold U.S. mortgage backed securities and in general the financial deepness is low in comparison with AEs. Chudik and Fratzscher (2011) find that, different from AEs, for EMEs, the key transmission channel of the financial crisis was the real side. Furthermore, the magnitude of the effects prompted by the financial crisis was different across EMEs because of country specific characteristics. In this paper, we look

at Mexico, an EME that started to improve financial regulation and supervision after the 1995 crisis, and Turkey, a stylized EME that had not implemented macro-prudential policies until the 2008 financial crisis (see Central Bank of the Republic of Turkey, 2014).

To understand better the transmission through cross-border banking flows of the financial crisis from the United States to EMEs, we estimate a VAR. Figure 3 shows the orthogonalized impulse responses functions from a VAR with one lag with U.S. and two EMEs data: Mexico (blue dashed lines) and Turkey (gray solid area). The core VAR consists of six variables: real net charge-offs on all loans and leases of U.S. banks, the S&P500 index, real foreign U.S. banks' claims with EME counterparties, real EME GDP, real EME banks' credit to the private non-financial sector, exchange rate of EME domestic currency per U.S. dollar, and the EME stock market index. For Mexico, the data goes from 2002Q1 to 2013Q4. And for Turkey the data goes from 2001Q3 to 2013Q3.[3] All data are in log and detrended using the Hodrick-Prescott filter. The starting point corresponds to the availability of the EMEs data. The Cholesky ordering corresponds to the order of the listed variables.[4]

In choosing the structure of the VAR, we are making several assumptions. First, we do not have an exogeneity block because we want the VAR to be as close as possible to our model which is a two-country one. Second, the ordering of the country variables implies that EME's variables do not influence U.S. variables on the same period, and only with one lag; nevertheless, the estimated parameters of U.S. variables to changes in EME variables are smaller than the reaction of EME variables to domestic ones. In the same sense, a variable ordered before other has an impact on the latter on the same period. In particular, we first put the variable that has the shock; then, we order the rest of U.S. variables. Foreign claims of U.S. banks is the variable that in our model, by construction, works as the channel of transmission of the shocks in the AE and that is why it follows. To order the rest of the variables we follow the literature on first including the real variables (as GDP and domestic banks credit) and then the more volatile ones (exchange rate and stock market index). However, we have try with different orderings, especially for the variables that are new, such as foreign claims of U.S. banks and domestic bank credit, and the main results do not change. We normalize the U.S. net charge-off increase to be the same in the initial period for both estimations. This corresponds to one standard deviation of U.S. net charge-off used in the Mexican sample.

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[3] See Appendix C for the definition and the sources of the data. we use Mexican banks' credit to the private non-financial sector and not the new loans of Mexican banks because the former starts before. Moreover this data is comparable to the one for Turkish banks. In Appendix B, we show that non-financial firms for these countries are mainly financed with domestic bank loans.

[4] The Akaike information criterion (AIC) suggests the use of one lag. Given the comments of Kilian (2011), we performed different robustness checks. Changing the order for the Cholesky decomposition of the Mexican variables does not alter the behavior of the IRF. Including the difference between the Mexican interest rate on new loans and the interest rate on deposit before the Mexican stock market index prompts a similar reaction of the VAR with the spread increasing after a positive shock to the net charge-offs of U.S. banks.
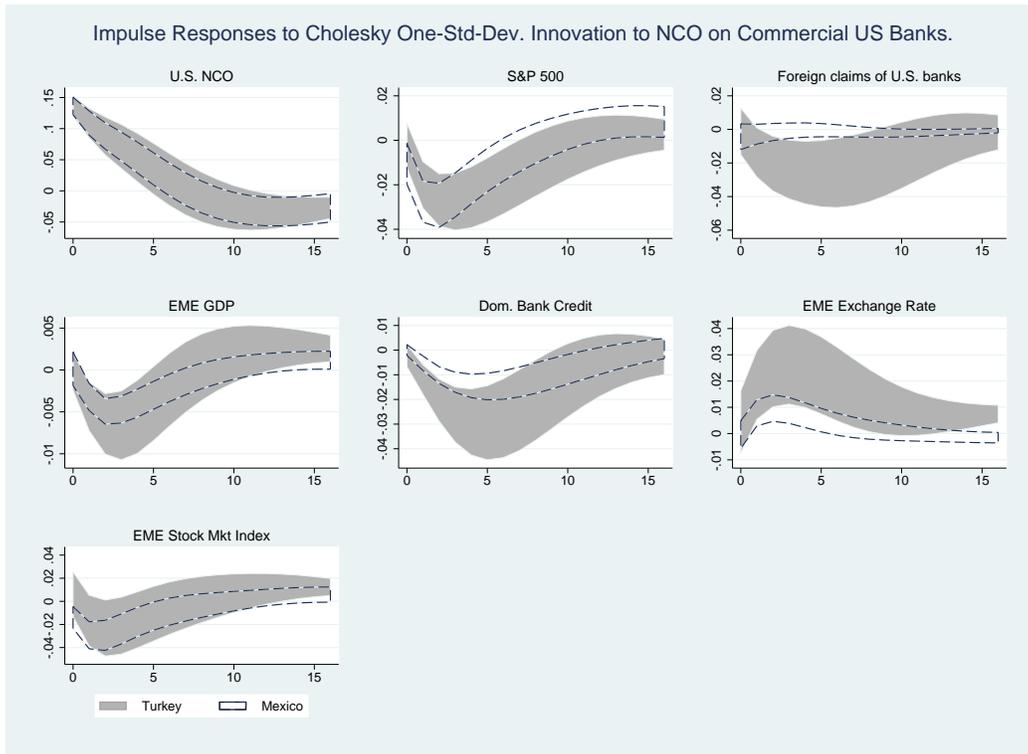
Fig. 3. VAR Evidence

Note: Mexican VAR estimated for 2002Q1 to 2013Q4. The Cholesky ordering is U.S. net charge-offs, S&P500, 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 estimated for 2001Q3 to 2013Q3. The Cholesky ordering of the variables is similar to the Mexican case. The vertical axis shows the percent deviation from the baseline.[a]

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[a] Country VAR estimated with 1 standard deviations confident intervals.

Figure 3 exposes the response to a one-standard deviation innovation to the net charge-offs on all loans and leases in bank credit for all U.S. commercial banks. The shock captures one of the initial characteristics of the financial crisis: the decrease in the value of the U.S. banks' loans. The shock suggests a decrease in the S&P 500 index and a decrease in the loans that U.S. banks make to the EME. Then, the crisis is transmitted to the EME, where the GDP, the total loans to the private non-financial sector and the stock market index fall. The exchange rate between EME domestic currency and U.S. dollar increase suggesting a deterioration of the domestic currency because of the loans flying away from the country. The VAR highlights a significant and negative reaction of the EME (real and financial) economy to a decrease in the U.S. banks' net charge-off on all loans and leases.

Furthermore, the co-movement of the stock indexes suggests a strong cross-country relation of the asset prices. While U.S. loans go down because of the shock, the decrease on the loans of U.S. banks to the EME emphasizes the co-movement across countries prompting financial instability in the EME. The two EMEs show similar response to the initial shock. However, the estimated VAR results on a larger impact on the Turkish economy. This highlights how the Turkish economy, one without prudential regulation, is hit harder by a foreign shock than the Mexican economy, an economy that started to improve financial regulation and supervision in the mid-nineties. We can also see this on the reaction of the foreign claims of U.S. banks, in the case for Mexico this movement is not significant. In this paper, we build a DSGE that explains these interactions. We describe the model in the next section.

3 The Model

The model builds on the work of Gertler and Kiyotaki (2010) and Nuguer (2015). Our focus, as in Nuguer (2015), is on the international transmission of a simulated financial crisis. However, in this paper we look at countries that are net borrowers from the United States and face a premium for borrowing from an AE, such as an EME. In particular, we introduce banks non-core liabilities in the form of foreign debt and imperfect global integration of the capital markets; they both contribute to the international spillover of the crisis. Then, we look at macro-prudential policy in the EME.

We keep the framework as simple as possible to analyze the effects of cross-border banking debt. In line with the previous literature, we focus on a real economy, abstracting from nominal frictions. First, we present the physical setup, a two country real business cycle model with trade in goods. Second, we add financial frictions. We introduce banks that intermediate funds between households and non-financial firms. Financial frictions constrain the flow of funds from households to banks. A new feature of this model is that AE banks can invest in the EME by lending to EME banks. Moreover, we assume that EME banks are constrained on how much they can borrow from AE banks. EME banks also face a premium on the interest rate payed to AE banks. Households and non-financial firms are standard and we describe them briefly, while we explain in more detail the financial firms. In what follows, we describe the AE; otherwise specified, the EME is symmetric. EME variables are expressed with an *. We present all the equations in Appendix D.

3.1 Physical Setup

There are two countries in the world: the advanced economy (AE) and the emerging market economy (EME). Each country has a continuum of infinitely lived households. In the global economy, there is also a continuum of firms of unit mass. A fraction m corresponds to the AE, while a fraction $1 - m$ to the EME. Using an identical Cobb-Douglas production

function, each of the firms produces output with domestic capital and labor. Aggregate AE capital, K_t, and aggregate AE labor hours, L_t, are combined to produce an intermediate good X_t in the following way:

$$X_t \;=\; A_t K_t^{\alpha} L_t^{1-\alpha}, \quad \text{with } 0 < \alpha < 1, \tag{1}$$

where A_t is the productivity shock. This is the domestic production of the AE.

With K_t as the capital stock at the end of period t and S_t as the aggregate capital stock "in process" for period $t+1$, we define

$$S_t \;=\; I_t + (1-\delta)K_t \tag{2}$$

as the sum of investment, I_t, and the undepreciated capital, $(1-\delta)K_t$. Capital in process, S_t, is transformed into final capital, K_{t+1}, after receiving the quality of capital shock, Ψ_{t+1},[5]

$$K_{t+1} = S_t \Psi_{t+1}. \tag{3}$$

Following the previous literature, the quality of capital shock introduces an exogenous variation in the value of capital. The shock affects asset price dynamics, because the latter is endogenous. The disruption refers to economic obsolesce, in contrast with physical depreciation. The shocks Ψ_t and Ψ_t^* are mutually independent and i.i.d. The AE quality of capital shock serves as a trigger for the financial crisis.[6]

As in Heathcote and Perri (2002), there are local perfectly competitive distributor firms that combine domestic, X_t^H, and imported, X_t^F, goods to produce the final good, Y_t. These are used for consumption and investment, and are produced using a constant elasticity of substitution technology

$$Y_t \;=\; \left[\nu^{\frac{1}{\eta}} X_t^{H \frac{\eta-1}{\eta}} + (1-\nu)^{\frac{1}{\eta}} X_t^{F \frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}, \tag{4}$$

where η is the elasticity of substitution between domestic and imported goods. There is home bias in production (see Sutherland, 2005).

Non-financial firms acquire new capital from capital good producers, who operate at a national level. As in Christiano, Eichenbaum, and Evans (2005), there are convex adjustment costs in the gross rate of investment for capital goods producers. Then, the final domestic output equals domestic households' consumption, C_t, domestic investment, I_t, and government consumption, G_t,

$$Y_t = C_t + I_t \left[1 + f\left(\frac{I_t}{I_{t-1}} \right) \right] + G_t. \tag{5}$$

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[5] Note that we do not include adjustment costs in investment in this equations because this comes from Gertler and Kiyotaki (2010); in their problem, $K_{t+1} = \Psi_t[I_t + \pi(1-\delta)K_t] + \Psi_t(1-\pi)(1-\delta)K_t$, where π is the probability of having an investment opportunity in that island, and Ψ_t is the quality of capital shock. We include the adjustment costs in the resource constrain, and the problem becomes standard.

[6] The process of the shock is $\log \Psi_t = \epsilon_{\Psi,t}$, where $\epsilon_{\Psi,t} \sim N(0, \sigma_\Psi)$.

Turning to preferences, households maximize their expected discounted utility

$$U(C_t, L_t) = E_0 \sum_{t=0}^{\infty} \beta^t \left[\ln C_t - \frac{\chi}{1+\gamma} L_t^{1+\gamma} \right], \tag{6}$$

where E_t is the expectation operator conditional on information available on date t, and γ is the inverse of Frisch elasticity. We abstract from many features in the conventional DSGE models, such as habit in consumption, nominal prices, wage rigidity, etc.

In Appendix E, we define the competitive equilibrium of the frictionless economy. It is a standard international real business cycle model in financial autarky with trade in goods. We show the impulse response functions of this model in Appendix G. Next, we add financial frictions.

3.2 Households

There is a representative household in each country. The household is composed of a continuum of members. A fraction f are bankers, while the rest are workers. Workers supply labor to non-financial firms, and return their wages to the households. Each of the bankers manages a financial intermediary and transfers non negative profits back to its household, subject to its flow of funds constraint. Within the family, there is perfect consumption insurance.

Households deposit funds in a bank; we assume that they cannot hold capital directly. Deposits are riskless one period securities, and they pay a return R_t, determined in period $t-1$.

Households choose consumption, deposits, and labor (C_t, D_t^h, and L_t, respectively) by maximizing expected discounted utility, Equation (6), subject to the flow of funds constraint,

$$C_t + D_{t+1}^h = W_t L_t + R_t D_t^h + \Pi_t - T_t, \tag{7}$$

where W_t is the wage rate, Π_t are the profits from ownership of banks and non-financial firms, and T_t are lump sum taxes. The first order conditions for the problem of the households are standard.

3.3 Non-financial firms

3.3.1 Goods producers

Intermediate competitive goods producers operate at a local level with constant returns to scale technology with capital and labor as inputs, given by Equation (1). The price of the final AE good is equalized to 1. The gross profits per unit of capital Z_t are

$$Z_t = \alpha P_t^H L_t^{1-\alpha} K_t^{\alpha-1} \quad \text{with } P_t^H = \nu^{\frac{1}{\eta}} Y_t^{-1} \left(X_t^H \right)^{-\frac{1}{\eta}}, \tag{8}$$

where X_t^H are the goods produced and consumed domestically, and P_t^H is the price of these goods.

To simplify, we assume that non-financial firms do not face any financial frictions when obtaining funds from intermediaries and they can commit to pay all future gross profits to the creditor bank. A good producer will issue new securities at price Q_t to obtain funds for buying new capital. Because there is no financial friction, each unit of security is a state-contingent claim to the future returns from one unit of investment. By perfect competition, the price of new capital equals the price of the security and goods producers earn zero profits state-by-state.

The production of these competitive goods is used locally and abroad,

$$X_t = X_t^H + \frac{1-m}{m} X_t^{H*} \tag{9}$$

to produce the final good Y_t following the CES technology shown in Equation (4). Then, the demands faced by the intermediate competitive goods producers are

$$X_t^H = \nu \left[\frac{P_t^H}{P_t} \right]^{-\eta} Y_t \tag{10}$$

and

$$X_t^{H*} = \nu^* \left[\frac{P_t^{H*}}{P_t^*} \right]^{-\eta} Y_t^*,$$

where P_t is the price of the AE final good, P_t^H the domestic price of AE goods, and P_t^{H*} the price of the AE good abroad. By the law of one price, $P_t^{H*} NER_t = P_t^H$ with NER_t as the nominal exchange rate. Rewriting the price of the final good yields

$$
\begin{aligned}
P_t &= \left[\nu (P_t^H)^{1-\eta} + (1-\nu)(P_t^F)^{1-\eta} \right]^{\frac{1}{1-\eta}} \\
\frac{P_t}{P_t^H} &= \left[\nu + (1-\nu)\tau_t^{1-\eta} \right]^{\frac{1}{1-\eta}},
\end{aligned}
$$

where τ_t is the terms of trade, the price of imports, relative to exports. Because of home bias in the final good production, $P_t \neq P_t^* NER_t$; the real exchange rate is defined by $\varepsilon_t = \frac{P_t^* NER_t}{P_t}$. An increase in τ_t implies a deterioration (appreciation) of the terms of trade for the AE (EME).

3.3.2 Capital producers

Capital producers use final output, Y_t, to make new capital subject to adjustment costs. They sell new capital to goods producers at price Q_t. The objective of non-financial firms is to maximize their expected discounted profits, choosing I_t

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

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

$$Q_t = 1 + f\left(\frac{I_t}{I_{t-1}}\right) + \frac{I_t}{I_{t-1}} f'\left(\frac{I_t}{I_{t-1}}\right) - E_t \Lambda_{t,t+1} \left[\frac{I_{t+1}}{I_t}\right]^2 f'\left(\frac{I_{t+1}}{I_t}\right). \tag{11}$$

Profits, which arise only out of the steady state, are redistributed lump sum to households.

3.4 Banks

To finance their lending, banks get funds from national households and use retained earnings from previous periods. Banks are constrained on how much they can borrow from households. In order to limit the banker's ability to save to overcome their financial constraints, inside the household we allow for turnovers between bankers and workers. We assume that with i.i.d. probability σ a banker continues being a banker next period, while with probability $1-\sigma$ it exits the banking business. If it exits, it transfers retained earnings back to its household, and becomes a worker. To keep the number of workers and bankers fixed, each period a fraction of workers becomes bankers. A bank needs positive funds to operate, therefore every new banker receives a start-up constant fraction ξ of total assets of the bank.

To motivate cross-border banking flows, we assume that the survival rate of the AE banks σ is higher that of the EME banks σ^*. Then, the AE banks can accumulate more net worth to operate and, in equilibrium, AE banks lend to EME banks. This interaction between AE and EME banks is what we call international or foreign debt/asset. AE banks fund their activity through a retail market (deposits from households) and EME banks fund their lending through a retail and an international wholesale market (where AE banks lend to EME banks).

At the beginning of each period, a bank raises funds from households, deposits d_t, and retains earnings from previous periods which we call net worth n_t; it decides how much to lend to non-financial firms s_t. AE banks also choose how much to lend to EME banks b_t.

Banks are constrained on how much they can borrow from households. In this sense, financial frictions affect the real economy. By assumption, there is no friction when transferring resources to non-financial firms. Firms offer banks a perfect state-contingent security, s_t. The price of the security (or loan) is Q_t, which is also the price of the assets of the bank. In other words, Q_t is the market price of the bank's claim on the future returns from one unit of present capital of non-financial firm at the end of period t, which is in process for period $t + 1$.

Next, we describe the characteristics of the AE and the EME banks.

3.4.1 Advanced Economy Banks

For an individual AE bank, the balance sheet implies that the value of the loans funded in that period, $Q_t s_t$ plus $Q_{bt} b_t$, where Q_{bt} is the price of foreign debt, has to equal the sum

of bank's net worth n_t and domestic deposits d_t,

$$Q_t s_t + Q_{bt} b_t = n_t + d_t.$$

Let R_{bt} be the cross-border banking flows rate of return from period $t-1$ to period t. The net worth of an individual AE bank at period t is the payoff from assets funded at $t-1$, net borrowing costs:

$$n_t = [Z_t + (1-\delta)Q_t]s_{t-1}\Psi_t + R_{b,t}Q_{bt-1}b_{t-1} - R_t d_{t-1},$$

where Z_t is the dividend payment at t on loans funded in the previous period, and is defined in Equation (8).

At the end of period t, the bank maximizes the present value of future dividends taking into account the probability of continuing being a banker in the next periods; the value of the bank is defined by

$$V_t = E_t \sum_{i=1}^{\infty} (1-\sigma)\sigma^{i-1}\Lambda_{t,t+i} n_{t+i}.$$

Following the previous literature, we introduce a simple agency problem to motivate the limit ability of the bank on obtaining funds. After the bank obtains funds, it may transfer a fraction θ of assets back to its own household. Households limit the funds lent to banks.

If a bank diverts assets, it defaults on its debt and shuts down. Its creditors can reclaim the remained $1-\theta$ fraction of assets. 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 individual bank to ensure that the bank does not divert funds:

$$V_t(s_t, b_t, d_t) \geq \theta(Q_t s_t + Q_{bt} b_t). \tag{12}$$

The borrowing constraint establishes that for households to be willing to supply funds to a bank, the value of the bank must be at least as large as the benefits from diverting funds.

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

$$V(s_{t-1}, b_{t-1}, d_{t-1}) = E_{t-1}\Lambda_{t-1,t} \left\{ (1-\sigma)n_t + \sigma \left[\max_{s_t, b_t, d_t} V(s_t, b_t, d_t) \right] \right\}. \tag{13}$$

The problem of the bank is to maximize Equation (13) subject to the borrowing constraint, Equation (12).

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

$$V(s_t, b_t, d_t) = \nu_{st} s_t + \nu_{bt} b_t - \nu_t d_t, \tag{14}$$

where ν_{st} is the marginal value of assets at the end of period t, ν_{bt}, the marginal value of global lending, and ν_t, the marginal cost of deposits.

We maximize the objective function (13) subject to (12), with λ_t as the constraint multiplier. Rearranging the first order conditions yields,

$$(\nu_{bt} - \nu_t)(1 + \lambda_t) = \lambda_t \theta Q_{bt} \tag{15}$$

$$\left(\frac{\nu_{st}}{Q_t} - \frac{\nu_{bt}}{Q_{bt}}\right)(1 + \lambda_t) = 0 \tag{16}$$

$$\left[\theta - \left(\frac{\nu_{st}}{Q_t} - \nu_t\right)\right] Q_t s_t + \left[\theta - \left(\frac{\nu_{bt}}{Q_{bt}} - \nu_t\right)\right] Q_{bt} b_t = \nu_t n_t. \tag{17}$$

From Equation (16), we verify that the marginal value of lending in the international market is equal to the marginal value of assets in terms of AE final good. Let μ_t be the excess value of a unit of assets relative to deposits, Equations (15) and (16) yield:

$$\mu_t = \frac{\nu_{st}}{Q_t} - \nu_t.$$

Rewriting the incentive constraint (17), we define the leverage ratio net of international borrowing as

$$\phi_t = \frac{\nu_t}{\theta - \mu_t}. \tag{18}$$

Therefore, the balance sheet of the individual bank is written as

$$Q_t s_t + Q_{bt} b_t = \phi_t n_t. \tag{19}$$

The last equation establishes how tightly the constraint is binding. The leverage has negative co-movement with the fraction that banks can divert, θ, and positive with the excess value of bank assets, μ. These interactions imply that when banks can divert a higher fraction of their assets (they are more borrowing constrained), the ratio between assets and net worth falls, mainly because there are less assets. When the value of an extra unit of assets increases relative to the cost of holding deposits, the leverage falls, due to the acumulation of assets.

We verify the conjecture regarding the form of the value function using the Bellman equation (13) and the guess (14). For the conjecture to be correct, the cost of deposits and the excess value of bank assets have to satisfy:

$$\nu_t = E_t \Lambda_{t,t+1} \Omega_{t+1} R_{t+1} \tag{20}$$

$$\mu_t = E_t \Lambda_{t,t+1} \Omega_{t+1} [R_{kt+1} - R_{t+1}], \tag{21}$$

where $\Lambda_{t,t+1}$ is the households' stochastic discount factor and the shadow value of net worth at $t + 1$ is

$$\Omega_{t+1} = (1 - \sigma) + \sigma(\nu_{t+1} + \phi_{t+1}\mu_{t+1}) \tag{22}$$

and holds state by state. The gross rate of return on bank assets is

$$R_{kt+1} = \Psi_{t+1} \frac{Z_{t+1} + Q_{t+1}(1 - \delta)}{Q_t}. \tag{23}$$

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Regarding the shadow value of net worth, the first term corresponds to the probability of exiting the banking business; the second term represents the marginal value of an extra unit of net worth given the probability of survival. For a survivor banker, the marginal value of net worth corresponds to the sum of the benefit of an extra unit of deposits ν_{t+1} plus the payoff of holding assets, the leverage ratio times the excess value of loans, $\phi_{t+1}\mu_{t+1}$. Because the leverage ratio and the excess return varies counter-cyclically, the shadow value of net worth varies counter-cyclically, too. In other words, because the banks' incentive constraint is more binding during recessions, an extra unit of net worth is more valuable in bad times than in good times.

Then, from Equation (20), the marginal value of deposits is equal to the expected augmented stochastic discount factor (the household discount factor times the shadow value of net worth) times the risk free interest rate, R_{t+1}. According to Equation (21), the excess value of a unit of assets relative to deposits is the expected value of the product of the augmented stochastic discount factor and the difference between the risky and the risk free rate of return, $R_{kt+1} - R_{t+1}$. The spread is also counter-cyclical.

From Equation (15):

$$\frac{\nu_{st}}{Q_t} = \frac{\nu_{bt}}{Q_{bt}},$$

which implies that the discounted rate of return on AE assets has to be equal to the discounted rate of return on global loans

$$E_t \Lambda_{t,t+1} \Omega_{t+1} R_{kt+1} = E_t \Lambda_{t,t+1} \Omega_{t+1} R_{bt+1}, \tag{24}$$

where R_{bt} will be defined in the next section and is related to the return on non-financial EME firms expressed in terms of AE final goods. AE Banks are indifferent between providing funds to non-financial AE firms and to EME banks because the expected return on both assets is equalized. Next, we turn to the EME banks problem.

3.4.2 Emerging Market Economy Banks

The problem of the EME banks is similar to the one from the AE banks, except for two features. The first feature is that the international asset, b_t^*, is a liability. So we can write the balance sheet of the bank as

$$Q_t^* s_t^* = n_t^* + d_t^* + Q_{bt}^* b_t^*.$$

or we can think of the net worth as the payoff from assets funded at $t-1$, net of borrowing costs which include the international loans,

$$n_t^* = [Z_t^* + (1-\delta)Q_t^*]s_{t-1}^*\Psi_t^* - R_t^* d_{t-1}^* - R_{bt}^* Q_{bt-1}^* b_{t-1}^*.$$

The second difference with the problem of AE banks is that EME banks might face two constraints on obtaining funds, instead of one. First, as in the problem of AE banks, EME

banks faced a moral hazard problem on borrowing from domestic households, where θ^* is the parameter that measures this friction. Second, we allow EME banks to be risky for AE banks; this means that EME banks can default a fraction $\theta^*(1 - \omega)$ of the funds borrowed from the AE. If $\omega = 1$, the EME bank pays back its debt with AE banks before running away with households' deposits (the EME bank can run away with a fraction θ^* of total assets minus cross-border banking flows). If $0 < \omega < 1$, the EME bank pays back only a fraction ω of the cross-border banking flows before running away. Then, $V_t^*(s_t^*, b_t^*, d_t^*)$ is 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 individual bank to ensure that a bank does not divert funds,

$$V_t^*(s_t^*, b_t^*, d_t^*) \geq \theta^*(Q_t^* s_t^* - \omega Q_{bt}^* b_t^*) \text{ with } 0 < \omega \leq 1. \tag{25}$$

In Appendix F we explain the problem of the EME bank with more detail. From the first order conditions it can be shown that the shadow value of domestic assets is equal to the shadow cost of international borrowing minus a term that depends on the friction (ω); that is

$$\frac{\nu_{st}^*}{Q_t^*} = \left[\frac{\nu_{bt}^*}{Q_{bt}^*} - (1 - \omega)\nu_t^* \right] \frac{1}{\omega}. \tag{26}$$

On the one hand, if $\omega = 1$, EME banks cannot run away with cross-border banking debt and the second term in brackets in the RHS is zero, therefore there is perfect asset market integration. In terms of returns:

$$E_t \Lambda_{t,t+1}^* \Omega_{t+1}^* R_{kt+1}^* = E_t \Lambda_{t,t+1}^* \Omega_{t+1}^* R_{bt+1}^*. \tag{27}$$

On the other hand, if $0 < \omega < 1$, the second term inside the brackets in the RHS of Equation (26) is positive, which implies a higher marginal value of holding assets with respect to the cost of holding international debt. This means that the interest rate on foreign debt is lower than the rate of return on domestic capital, but higher than the deposit interest rate. In Appendix F, we show that $\mu_t^* = \frac{\nu_{st}^*}{Q_t^*} - \nu_t^*$ and $\mu_{bt}^* = \frac{\nu_{bt}^*}{Q_{bt}^*} - \nu_t^*$. In terms of excess return on capital and international debt, we can write:

$$\mu_{bt}^* = \omega \mu_t^* \text{ or } \mu_{bt}^* < \mu_t^*. \tag{28}$$

After verifying the conjecture of the value function, we define the following variables

$$\nu_t^* = E_t \Lambda_{t,t+1}^* \Omega_{t+1}^* R_{t+1}^*, \tag{29}$$

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

$$\mu_{bt}^* = E_t \Lambda_{t,t+1}^* \Omega_{t+1}^* \left[R_{bt+1}^* - R_{t+1}^* \right] \tag{31}$$

with

$$\Omega_{t+1}^* = 1 - \sigma^* + \sigma^* \left(\nu_{t+1}^* + \phi_{t+1}^* \mu_{t+1}^* \right),$$

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where Ω_{t+1}^* is the shadow value of net worth at date $t + 1$, and R_{kt+1}^* is the gross rate of return on bank assets.

Therefore, when $\omega = 1$ ($0 < \omega < 1$) the expected discounted rate of return on international debt is equal to (less than) the expected discounted rate of return of loans to non-financial EME firms (Equation (30) transforms into Equation (31) when $\omega = 1$, but the result of Equation (30) turns out to be higher than the result in Equation (31) when $0 < \omega < 1$). Given a shock, the return on the international debt is as volatile as the return on the domestic asset, emphasizing the transmission mechanism from one country to the other. Furthermore, when $\omega = 1$ the expected discounted rate of return on the global asset equalizes to the one on loans to non-financial AE firms, see Equation (24). Then, the AE loan market and the EME loan market behave in a similar way. This is the integration of the asset markets. When $0 < \omega < 1$, the rates equalized but there is an extra term, and that is why we call this case imperfect asset market integration; EME banks face an extra friction.

When there are risky EME banks, AE banks tend to lend less to the EME banks because they might run away with a fraction of cross-border banking flows. Less funds moving into EME banks prompt that the EME currency does not appreciate as much as in the case of safe banks. Additionally, AE banks ask for a higher rate of return when $0 < \omega < 1$, because they have to compensate for the extra level of riskiness that they face.

3.4.3 Aggregate Bank Net Worth

Finally, aggregating across AE banks, from Equation (19):

$$Q_t S_t + Q_{bt} B_t = \phi_t N_t. \tag{32}$$

Capital letters indicate aggregate variables. From the previous equation, we define the households deposits

$$D_t = N_t(\phi_t - 1). \tag{33}$$

Furthermore,

$$N_t = (\sigma + \xi)\{R_{k,t}Q_{t-1}S_{t-1} + R_{b,t}Q_{b,t-1}B_{t-1}\} - \sigma R_t D_{t-1}. \tag{34}$$

The last equation specifies the law of motion of the AE banking system's net worth. The first term in the curly brackets represents the return on loans made last period. The second term in the curly brackets is the return on funds that the household invested in the EME. Both loans are scaled by the old bankers (that survived from the last period) plus the start-up fraction of loans that young bankers receive, $\sigma + \xi$. The last term in the equation is the total return on households' deposits that surviving banks need to pay back.

For EME banks, the aggregation yields

$$N_t^* = (\sigma^* + \xi^*)R_{k,t}^* Q_{t-1}^* S_{t-1}^* - \sigma^* R_t^* D_{t-1}^* - \sigma^* R_{bt}^* Q_{bt-1}^* B_{t-1}^*, \tag{35}$$

where R_{bt}^* equals R_{kt}^*, from Equation (27). The balance sheet of the aggregate EME banking system can be written as

$$Q_t^* S_t^* - \omega Q_{bt}^* B_t^* = \phi_t^* N_t^*. \tag{36}$$

EME households' deposits are given by

$$D_t^* + (1 - \omega) Q_{bt}^* B_t^* = N_t^* (\phi_t^* - 1). \tag{37}$$

3.4.4 Cross-border banking flows

At the steady state, AE banks invest in the EME because the survival rate of AE banks is higher than the survival rate of EME banks; therefore, AE banks lend to EME banks. An international asset market arises. EME banks have an incentive to borrow from AE banks because EME banks are more constrained than AE banks.

The smaller economy is an EME, therefore we assume that EME banks need to pay a premium on borrowing from AE banks. Following Schmitt-Grohé and Uribe (2003), the interest rate payed by EME banks on the international debt is debt elastic. Specifically, we assume that Equation (24) becomes

$$E_t \Lambda_{t,t+1} \Omega_{t+1} R_{kt+1} = E_t \Lambda_{t,t+1} \Omega_{t+1} R_{bt+1} + \Phi \left[\exp\left(B_t - \bar{B}\right) - 1 \right]. \tag{38}$$

The new term in Equation (38) is the risk premium associated with the EME. The parameter Φ reflects the elasticity of the difference of the international asset with respect to its steady state level, $\bar{B}$. Note that at the steady state the risk premium is zero.[7]

Regarding the interest rate, the return on loans to EME banks made by AE banks is $E_t(R_{bt+1}) = E_t(R_{bt+1}^* \frac{\varepsilon_{t+1}}{\varepsilon_t})$. The rate on international debt is equalized to the return on loans to AE firms, R_{kt}, in expected terms plus a risk premium, as in Equation (38); AE banks at the steady state are indifferent between lending to AE firms or to EME banks. EME banks might face a financial constraint on borrowing from AE banks. When there is no friction in the EME with the international debt, in other words $\omega = 1$, Equation (27) relates the rate of return on global loans to the rate of return on EME loans and there is perfect asset market integration. However, when there is an extra friction in the EME economy, $0 < \omega < 1$, there is imperfect asset market integration and there is an extra cost specified in Equation (26).

EME banks pay to AE banks the interest rate adjusted by movements in the exchange rate; then, we are ruling out currency mismatch problems for the AE, and the EME bears all the exchange rate risk. As we are going to see in Section 5, there is an exchange rate channel on the international transmission of shocks. When the EME currency depreciates, the EME's collateral expressed in foreign currency falls, then AE banks lend less to EME

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[7] Another reason for changing Equation (24) for Equation (38) is that the model without it becomes very volatile when we decrease the size of the EME by reducing m; therefore, we introduce the mechanism explained here to close the model.

banks, because the risk of running away with AE money is higher (specially when there are risky EME banks). Cesa-Bianchi, Cespedes, and Rebucci (2015) document empirically the effects of the exchange rate on the collateral for EME.

It is it important to notice that cross-border banking flows are different from the so called "outside" equity in Gertler, Kiyotaki, and Queralto (2012) in two aspects. First, EME banks prefer financing their activity with deposits rather than cross-border banking flows because at the steady state, the interest rate that they have to pay on deposits is lower than the one for cross-border flows. However, the latter is state-contingent while the former is predetermined. In contrast, outside equity is preferred to deposits because the interest rate is not only state contingent, but also lower than the one for deposits. Second, an increase in cross-border banking flows makes the borrowing constraint, Equation (25), less binding because EME banks have a lower gain from running away (the right-hand side of the Equation falls). On the contrary, an increase in outside equity prompts a tightening on the borrowing constraint. Even though cross-border banking flows and outside equity are both a debt, they have different implications on the optimal decision of the banks.

3.5 Equilibrium

To close the model the different markets need to be in equilibrium. The equilibrium in the final goods market for AE and for EME are

$$Y_t = C_t + I_t\Big[1 + f\Big(\frac{I_t}{I_{t-1}}\Big)\Big] + G_t \text{ and} \tag{39}$$

$$Y_t^* = C_t^* + I_t^*\Big[1 + f\Big(\frac{I_t^*}{I_{t-1}^*}\Big)\Big] + G_t^*. \tag{40}$$

Then for the intermediate-competitive goods market,

$$X_t = X_t^H + X_t^{*H}\frac{1-m}{m} \quad \text{and} \quad X_t^* = X_t^F\frac{m}{1-m} + X_t^{*F}. \tag{41}$$

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

$$\chi L_t^\gamma = (1-\alpha)\frac{X_t}{L_t C_t} \quad \text{and} \quad \chi L_t^{*\gamma} = (1-\alpha)\frac{X_t^*}{L_t^* C_t^*}. \tag{42}$$

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

$$CA_t = 0 = \frac{1-m}{m}X_t^{H*} - \tau_t X_t^F, \tag{43}$$

where τ_t is the terms of trade, defined by the price of imports relative to exports for the AE.

On the other hand, if there are global banks in the economy, the current account is

$$CA_t = Q_{b,t}B_t - R_{bt}Q_{b,t-1}B_{t-1} = X_t^{*H}\frac{1-m}{m}\frac{P_t^H}{P_t} - X_t^F\tau_t\frac{P_t^H}{P_t}. \tag{44}$$

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

$$B_t = B_t^*\frac{1-m}{m}. \tag{45}$$

To close the model the last conditions correspond to the riskless debt. Total household savings equal total deposits plus government debt. Government debt is perfect substitute of deposits to banks,

$$D_t^h = D_t + \mathcal{D}_{gt} \quad \text{and} \quad D_t^{h*} = D_t^* + \mathcal{D}_{gt}^*. \tag{46}$$

We formally define the equilibrium of the banking model in Appendix E.

4 Macro-prudential Policy in the Emerging Market Economy

In this section we introduce policy into the model. We allow the EME policy maker to carry out macro-prudential policy. In line with the Korean experience, we introduce a levy on non-core liabilities, in our model they correspond to cross-border banking flows.

Since October 2010, the Bank of Korea has introduced two macro-prudential measures to address the risk factors of capital inflows and outflows generated on the demand and the supply side. First, they introduced leverage caps on banks' foreign exchange derivatives positions. The aim was to curb the increase in banks' short-term external debt and the currency and maturity mismatches. Later on, they introduced the macro-prudential stability levy. The objective was to reduce the increase in banks' non-core liabilities (non-deposit liabilities). The levy rate varies according to the maturity of the liability. The effects contributed to reduce banks' foreign borrowings and improving their maturity structures. (Kim, 2014 and Shin, 2010)

Levy on non-core liabilities In the framework that we have developed in this paper, the systemic risk or the contagion across financial institutions for the EME comes from the cross-border banking flows. We consider the international asset as a non-core liability of the bank because it is not households' deposits.

The policy is a tax on non-core liabilities, the magnitude of the tax is related to the ratio between the banks' credit growth and the banks' deposits growth,

$$\vartheta_{gt}^* = \left(\frac{\frac{S_{t+1}^*-S_t^*}{S_t^*}}{\frac{D_t^*-D_{t-1}^*}{D_{t-1}^*}}\right)^{\tau_g^*}. \tag{47}$$

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How big the tax is has an exogenous (arbitrary) component τ_g^* and an endogenous one that corresponds to the parenthesis. In Section 5.5 we do a welfare analysis for different levels of τ_g^*. EME banks pay the tax from their net worth, Equation (35) is now

$$N_t^* = (\sigma^* + \xi^*)R_{kt}^*Q_{t-1}^*S_{t-1}^* - \sigma^*\left[R_t^*D_{t-1}^* + \vartheta_{gt}^*R_{bt}^*Q_{b,t-1}^*B_{t-1}^*\right].$$

When the assets are growing faster than deposits, they are being financed with non-core liabilities, or cross-border banking flows. Because it is a credit boom, the tax is greater than 1 and EME's banks pay it, and smooths the quantities borrowed from abroad. On the other hand, during periods of financial crisis, the tax works as a subside.

The EME' government budget constraint becomes

$$G_t^* + R_t^*\mathcal{D}_{g,t-1}^* = T_t^* + \mathcal{D}_{gt}^* + (\vartheta_{gt}^* - 1)R_{bt}^*Q_{b,t-1}^*B_{t-1}^*.$$

In this framework, the macro-prudential policy helps to limit exposures arising from cross-border banking flows and limits adverse consequences associated with them. The policy tool is a levy on non-core liabilities, as the Korean experience. This is in line with BIS (2010b) and Shin (2011)'s suggestions regarding macro-prudential measures in EMEs.

5 Crisis experiment

In this section, we present numerical experiments to show how the model captures key aspects of the international transmission of a financial crisis. First, we present the calibration. Next, we analyze the impulse response function to a crisis experiment without response from the government and we highlight the role of banks' non-core liabilities in the transmission of the crisis and how it works as insurance for the economy that is hit by a shock. Moreover, we show the difference between risky and safe EME banks. We evaluate the model in two different ways. First, we look at a generic one time shock to the quality of capital. Second, we assume that the U.S. banks' net-charge off of all loans and leases that we used in the VAR can be thought at the quality of capital shock in the AE, we use the data as a path of the shock and we compare the different models by looking at the behavior of the credit (loans) in the EME. Finally, we look at macro-prudential policy carried out by the EME. We present more exercises in Appendix G.

5.1 Calibration

The calibration is specified in Table 1. The parameters that correspond to the non-financial part of the model, i.e. households and non-financial firms, are common in the literature. The discount factor, β is set to 0.99, resulting in a risk free interest rate of 1.01% at the steady state. The inverse of the Frisch elasticity of labor supply, γ, and the relative weight of labor in the utility faction, χ, are equal to 0.1 and 5.584, respectively. The capital share in the production of the intermediate good, α, is 0.33 and the parameter in the adjustment

		AE	EME
β	discount factor	0.9900	0.9900
γ	inverse elasticity of labor supply	0.1000	0.1000
χ	relative utility weight of labor	5.5840	5.5840
α	effective capital share	0.3330	0.3330
κ	adj cost parameter	1.0000	1.0000
δ	depreciation	0.0250	0.0250
ν	home bias	0.8500	0.9625
η	elasticity of substitution	1.5000	1.5000
m	size of the countries	0.9600	0.0400
ξ	start-up	0.0018	0.0018
θ	fraction of div assets	0.4067	0.4074
σ	survival rate	0.9720	0.9710
ω	friction on EME banks		0.6000
$\bar{g}$	steady state gov expenditure	0.1240	0.2000
τ_{1S}^*	cost of issuing loans		0.00125
τ_{2S}^*	cost of issuing loans		0.0120

Tab. 1. Calibration

cost in investment, κ, equals 3. The depreciation rate of capital is 2.5% quarterly.

With respect to the parameters that enter into the CES aggregator, we choose η and we calibrate ν (and λ) to match the Mexican data. The elasticity of substitution between the AE and the EME goods in the production of the final good, η, is set to be greater than one. This implies substitutability between domestic and foreign goods. The home bias, ν, is defined by the size of the AE and the degree of openness, λ: $\nu = 1 - (1 - m)\lambda$. We calibrate them to match the ratio of U.S. exports to Mexico with Mexican final domestic demand as an average between 1999Q4 and 2013Q4. The size of the AE is set to be clearly bigger than the EME, 0.96 and 0.04, respectively.

The parameters of the banking sector are such that the average credit spread is 110 basis points per year for the AE and 115 for the EME. For the AE is a rough approximation of the different spreads for the pre-2007 period. For the EME is higher than in the AE because it is riskier to invest there. How tightly the constraint is binding, explained by the parameter θ, matches the target credit spread. The start-up fraction that the new banks receive, ξ, is 0.18% of the last period's assets, which corresponds to the value used by Gertler and Kiyotaki (2010) and is equal for both economies. AE banks lend to EME banks because the survival rate is different across countries, 0.972 for AE and 0.971 for EME banks. On average, AE banks survive 8 years, while EME banks around 7 years. At the steady state, the holding of global asset represents 1.4% of the total assets of the AE banks, which matches the data for total lending by U.S. banks to Mexican counterparties from the year 1999Q4 until 2013Q4, and constitutes 7.8% of Mexican banks' total assets.

We assume a negative i.i.d. shock that occurs in the AE.

5.2   IRF: No policy response. Safe and Risky EME Banks.

Figure 4 shows the impulse responses to a one time decline in the AE quality of capital of 5% in period t comparing three models. The first model is one with financial frictions and in financial autarky (no cross-border assets) and is the red dashed line. The second model has financial frictions and an international debt market (financial openness) with no further EME frictions ($\omega = 1$) and is the blue solid line. The third model is similar to the second one, but it includes risky EME banks, $0 < \omega < 1$; it is the dotted green line. The comparison of these models shows how the transmission mechanism across countries changes given the different assumptions. In the first models, there is only international spillover due to the trade of intermediate goods. In the second and third models, we add the international financial mechanism and a new friction with risky EME banks. In Appendix G, we show the complete set of impulse responses functions: AE and EME variables are in Figure G.3. We also present a new model comparison where we include a framework without financial frictions, Figures G.1 and G.2 in Appendix G.

When there is a decrease in the AE quality of capital, and there are financial frictions but no global banks, the reaction of the AE results in a similar one to the closed economy model of Gertler and Kiyotaki (2010). Banks are financially constrained; when their asset (capital) goes down, banks face a decrease in their net worth. Because banks are more constrained on how much they can borrow, there is a firesale of asset that prompts its price, Q_t, to go down.

The spread between the AE rate of return on capital and the risk free rate, $E(R_k) - R$, widens. The behavior of the spread is a characteristic of the crisis period. The expected rate of return on capital increases because of the fall in capital.

The AE production and consumption shrink. So, there are less advanced goods and they are relatively more expensive, the terms of trade slightly improve for the AE. EME goods are cheaper and its production increases. However, the depreciation of the EME currency makes the EME households to cut down on consumption which will prompt a decrease in the EME capital, net worth of the banks, and the asset price. Asset prices and production co-move across countries. The international transmission is negligible.

When we allow for foreign debt, AE banks lend to EME banks. EME banks borrow internationally; AE banks diversify their assets and pool a country specific shock. These asset market characteristics have been discussed by Cole and Obstfeld (1991) and Cole (1993).

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 without global banks and is shown by the solid-blue and the dashed-red line in Figure 4. The mechanism that takes place for the AE variables is the same in both models with financial frictions. However, final domestic demand is less affected by the shock when there are global banks because
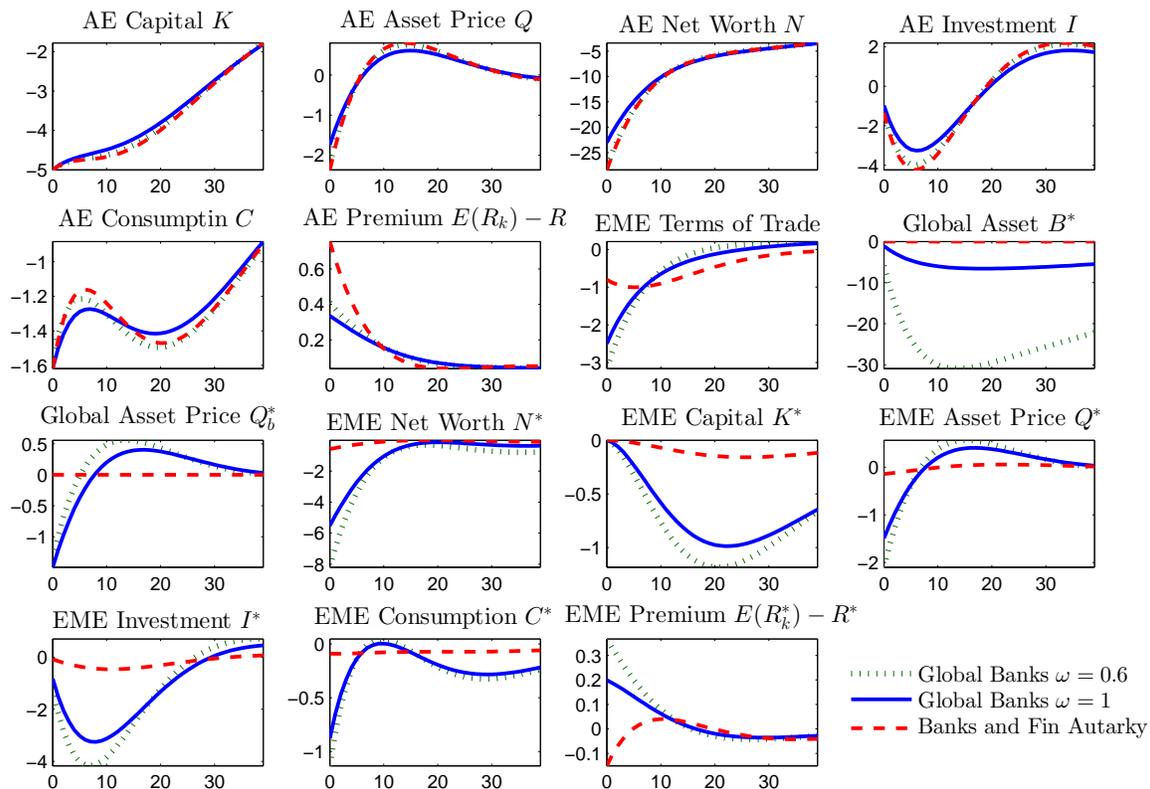
Fig. 4. Impulse Responses to a 5% Decrease in Ψ_t, Model Comparison with Global Banks
y axis: percentage deviation from steady state; x axis: quarters

the AE can partially pool the country specific shock.

In the model with $\omega = 1$, the return on EME assets equalizes the return on EME debt. EME banks face a reduction in their net worth because of a country specific shock in the AE. The collateral of EME banks in foreign currency falls due to the depreciation of the exchange rate; AE banks lend less to the EME. EME financial intermediaries are more financially constrained and reduce lending to domestic businesses. Investment and the price of capital shrink. Global banks transmit the crisis from the AE to the EME.

Two types of spillovers disturb the EME: the demand and the international debt effects. The demand effect prompts an increase in production because the exchange rate is depreciating for the EME. The international debt effect generates a tightening of the EME borrowing constraint because there is a decrease in the value of international lending. The international debt effect predominates and the net worth of EME banks falls and households cut down on consumption. The effect on production vanishes after 3 periods. The current account is now defined in Equation (44) because of financial openness.

In the model with global banks and financial frictions, the AE and EME consumption,

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asset price, and total demand co-move, while production does not (on impact). The asset markets across countries are integrated when $\omega = 1$ because of the equalization of returns of the asset market in the AE and the EME. The AE banks' lending to EME banks does not imply a risk for the AE.

When we allow risky EME banks, $0 < \omega < 1$, the shock hits harder the EME. EME banks are restricted on borrowing from AE banks. This difference in the possibility of running away with money from AE banks prompts a difference in the perception of risk of the EME banks that is also reflected on how the spread on the interest rates of the EME reacts to the shock. The macro-prudential regulation analyzed in the next section targets the cross-border banking flows and we analyze it for risky banks.

The AE variables also show a deeper crisis when EME banks are riskier. This is the case because even if the AE does not lend much to the EME, the perception of being riskier hurts the AE. The gain that the AE had on pooling the shock by introducing global banks is partially offset by the introduction of risky EME banks.

The qualitative behavior of the model matches the VAR evidence shown in Figure 3. In the data, a decrease in the U.S. loans prompts a decrease in the international debt that is then transmitted to the EME. Total final demand, foreign U.S. dollars denominated loans, credit in the EME, and asset prices fall.

The EME has a larger co-movement with the AE in a framework with financial openness than without it. The EME experiences a crisis because of the quality of capital shock abroad, as shown by the VAR evidence and the model. Moreover, through the international debt market, the AE manages to partially insure itself against the shock. The EME experiences a deeper financial crisis when domestic banks can run away with resources from the AE banks. We can understand the difference between risky and safe EME banks, as a country that did not had prudential regulation in place before the crisis and a country that had, Turkey and Mexico, respectively.

5.3 The Great Recession

Another way of evaluating the model is to fit in the path of the quality of capital shock in the AE and see if the model manages to replica some empirical facts. Here, we focus on credit in the EME because is the most important variable when generating financial instability in the small economy.

To do this exercise, we assume that the real net charge-offs on all loans and leases of U.S. banks, that we have used previously in the VAR exercise, are a good approximation to the quality of capital shock in the AE. We take the path of the filtered data as the path of the shock and we compare the same three models as above with the data. The first model is one with financial frictions and in financial autarky (no cross-border assets) and is the red dashed line. The second model has financial frictions and an international debt market (financial openness) with no further EME frictions ($\omega = 1$) and is the blue solid line. The third model is similar to the second one, but it includes risky EME banks, $0 < \omega < 1$; it is
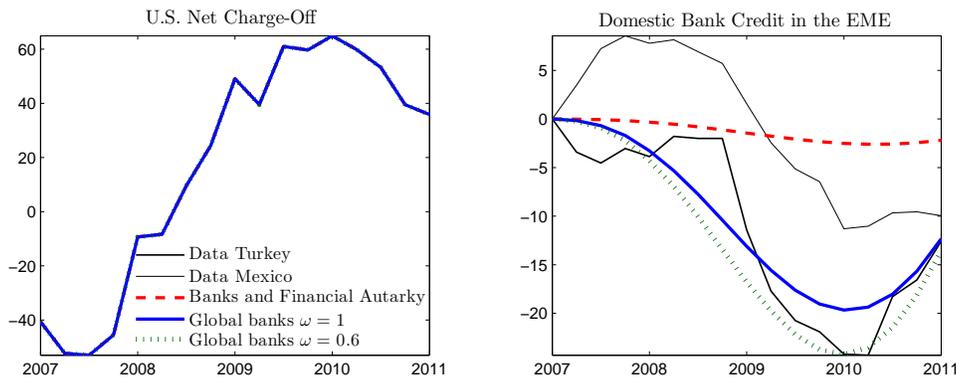
28

Fig. 5. The Great Recession and EME banks' credit

the dotted green line. We use real EME banks' credit to the private non-financial sector for Turkey, solid thick black line, and for Mexico, solid thin black line. The results are in Figure 5. The data are in log and HP filtered, and credit has been normalized to be zero in 2007q1.

By fitting the net charge-offs, we give a much bigger shock that the one in the previous Section 5.2. The model in financial autarky does not generate a reaction similar to the data. On the contrary, when the model has global banks, it fits better the data. For the case of safe global banks, $\omega = 1$, the model overestimates the behavior of credit in Mexico, but still captures the deepest part of the financial crisis. For the case of risky global banks, $\omega = 0.6$, the model does a very good job on capturing the larger decrease in the Turkish economy. The simulated series manages to capture the inverse hump shape of the data.

Nevertheless the good performance in terms of credit in the EME, the model over-predicts the reaction of the real variables in the EME (remember that there are no nominal frictions). Not only the model has a deeper decrease in investment and consumption, but also in the data we see it after few periods, while in the model they react on impact. Moreover, the model prompts a larger fall in banking loans from the U.S. to the EME.

5.4 Policy response

5.4.1 IRF: Macro-prudential Policy in the Emerging Market Economy

In this part, we analyze the effects of the EME macro-prudential policy on the one time shock set-up. In particular, we look at two models. Figure 6 shows a small set of variable. The green dotted line is the same model without policy with risky banks shown in previous figures. The black solid line is a model with the quality of capital shock in the AE and macro-prudential policy in the EME. In Appendix G, Figure G.4, we show the rest of the
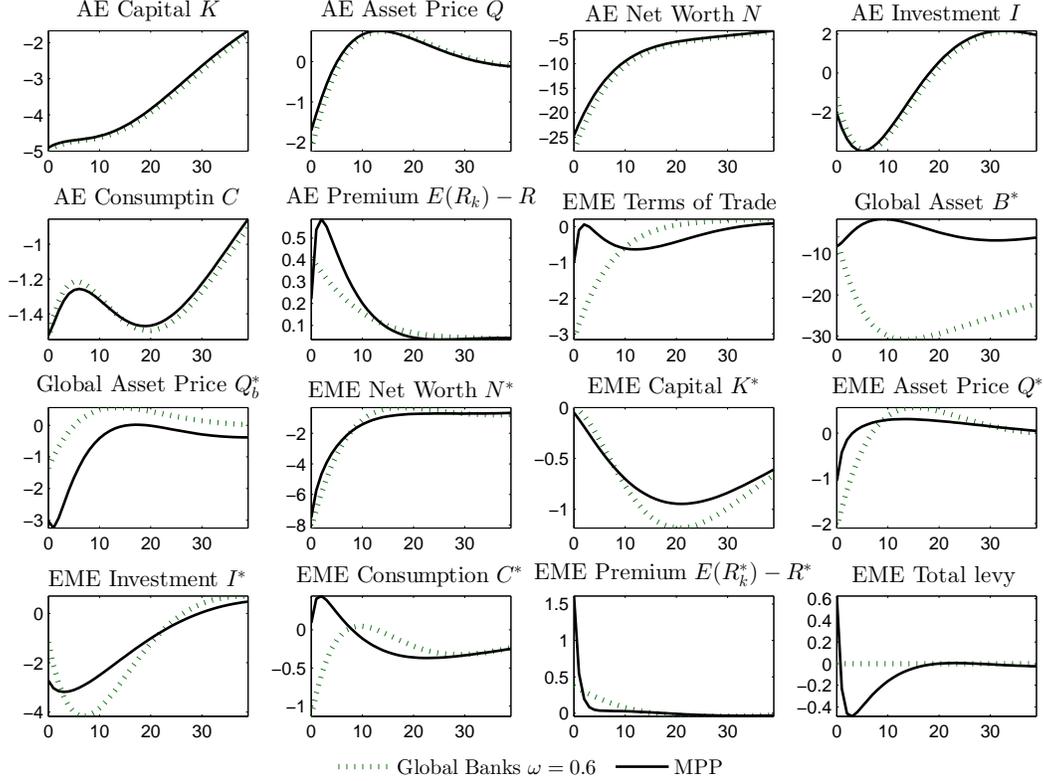
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Fig. 6. Impulse Responses to a 5% Decrease in Ψ_t, Macro-prudential Policy by the EME Central Bank

y axis: percentage deviation from steady state; x axis: quarters

variables.[8]

The macro-prudential intervention targets the ratio between the growth rate of credit and deposits of EME banks. When credit is growing faster than deposits, the assets are funded using non-core liabilities, and so EME banks pay a tax on them; the opposite is valid when deposits are growing faster than credit. When there is a financial crisis, the deposits will be growing faster than credit and so the tax will be a subsidy and EME bank will not adjust the non-core liabilities as much as they would without the levy.

The net worth of the domestic banks falls less, which prompts loans and capital to be cut by less. The price of the capital does not fall as much and so investment moves in a smoother way. Even the household's consumption shows a smaller reaction. The interest rate premium after the first period also presents a better scenario. Note that the effect on the AE of having the levy is small.

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[8] For the macro-prudential policy, the calibrated parameter is set to 5 to exemplify the mechanism through which the policy works.

So far, we have studied the first order approximation of the model. This is useful when studying the impact of unexpected shocks to the economy, however, it is not an adequate setup to study welfare. In the next subsection we evaluate the welfare implications of the macro-prudential policy and the EME friction on international debt by looking at the second order approximation of the model.

5.5 Welfare analysis

In this part, we introduce consumers' welfare. We want to look at the advanced and emerging consumers' welfare given the different level of riskiness of EME banks, i.e. ω, and the level of intervention of the EME macro-prudential policy through the policy parameter τ_g^*.

The welfare criterion considered here is the one used by Gertler and Karadi (2011) and developed by Faia and Monacelli (2007). The household's welfare function is given by

$$Welf_t = U(C_t, L_t) + \beta E_t Welf_{t+1}, \tag{48}$$

where the utility function comes from Equation (6). Welfare is defined as the lifetime utility of the consumers. We compare the different calibrations using the consumption equivalent, i.e. the fraction of household consumption that would be needed to equate the welfare of the no policy steady state to the welfare under policy, in the case of the macro-prudential intervention; and under the deterministic steady state and the stochastic steady state, in the case of the riskiness level.

The stochastic steady state is defined as the place where the model stands after 2000 periods given the deterministic steady state as starting point. The approximation of the model is of the second order (see Kim and Kim, 2003, Schmitt-Grohé and Uribe, 2004). We do not give shocks in the process of going through the deterministic to the stochastic steady state but the variance of the perturbations are taken into account in the solution of the model. We follow Carrillo, Peersman, and Wauters (2013) on the way to calculate the stochastic steady state and Schmitt-Grohé and Uribe (2007) for the definition of consumption equivalent.

The consumption equivalent for the different levels of risky EME banks are in the left panel of Figure 7. We plot the consumption equivalent for the AE and the EME when there are quality of capital, government expenditure, and productivity shocks in both economies; the red dashed line is the AE and the black solid line is the EME. The distribution of technology and government shocks follow Schmitt-Grohé and Uribe (2005). Technology shocks have an autoregressive coefficient of 0.8556 and a standard deviation of 0.0064; the autoregressive coefficient of government expenditure shocks and the standard deviation are 0.87 and 0.016, respectively.

In comparison to the deterministic steady state, EME and AE households are worse off in the stochastic steady state. However, EME consumers are less worse off when the level of riskiness of EME banks is lower (higher ω); this implies that a better regulation in
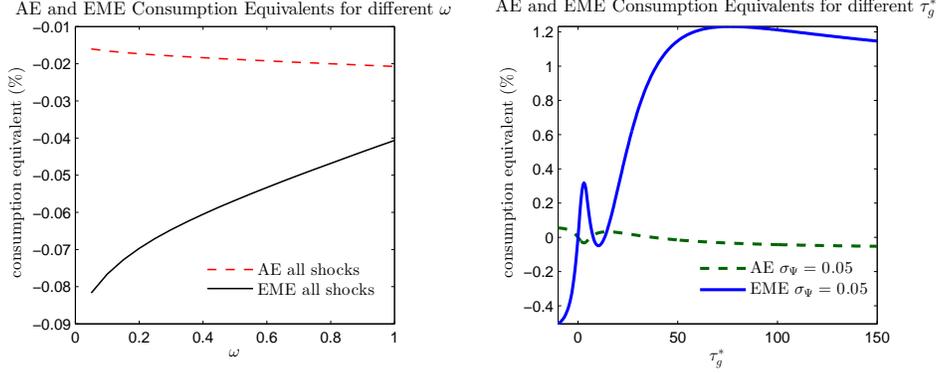
Fig. 7. Consumption Equivalent for different level of risky EME banks, ω -left panel- and different intensity of macro-prudential intervention for $\omega = 0.6$ -right panel-

the EME (or less risky banks in EME) prompts domestic households an improvement in their welfare. A lower ω (riskier banks in the EME) allows AE banks to share the risk of a domestic shock more prompting AE consumers to be less worse off. When ω increases AE welfare decreases a bit (much less than the increase in EME households' welfare because the impact of the EME in the AE is smaller).

The right hand side panel of Figure 7 shows the consumption equivalent of the AE and the EME for different intensity of macro-prudential intervention by the EME. It turns out that for τ_g^* between -10 and 500, the EME can be better or worse off depending on the policy parameter. The gains for the EME consumers are approximately 100 times larger than the looses of the AE households; this highlights the fact that the policy does not have much impact on the AE. Furthermore, there is a maximum for the EME households' consumption equivalent when $\tau_g^* = 80.5$. The results show that the macro-prudential intervention is not always better off for EME consumers; if the authority does not intervene under certain range of τ_g^*, it might prompt welfare looses for its consumers. We only plot the results for shocks in the AE because the model turns out to be very sensitive to the size and the quantity of the shocks.

The macro-prudential policy carried out by the EME policy maker turns out to prompt consumers in the EME to be better off.

6   Conclusion

We have presented a two-country DSGE model with financial intermediaries that captures part of the challenges that non-core liabilities, in particular cross-border banking flows, prompt for EMEs. In the model, banks in the AE and in the EME are constrained in obtaining funds from households. The AE can invest in the EME through banks using a global asset (or cross-border banking flows). EME banks might also be constrained on how

much they borrow from AE banks. The return of the international asset is related to the return on capital of the AE.

Comparing a model with financial frictions and in financial autarky with one with a global banks suggests that the latter generates a higher co-movement of shocks generated in the AE. This matches qualitatively the behavior seen in the data, as shown in the VAR analysis. When a quality of capital shock hits the AE, AE and EME experience a crisis both in real and financial variables. The global asset prompts the international transmission. The net worth of EME banks drops because the price of the international asset falls and so do the quantities. EME banks face a reduction in their liabilities and they are more constrained to lend to domestic non-financial firms. The price of EME domestic assets drops prompting a fall in investment, consumption, and total demand. When EME are also constrained on how much they can borrow from AE banks (risky EME banks), the crisis is deeper in the EME, in comparison to the case in which there is no such friction. In the welfare analysis we have shown that a better *ex ante* regulation for EME banks makes EME' households better off.

Banks that intermediate funds across borders and in different currencies entail relevant challenges in terms of policy and regulation. For open EMEs the non-core liabilities, such as cross-border banking flows, entail relevant challenges for their financial stability. We study the introduction of a macro-prudential policy by the central bank of the EME with the objective of reducing the financial and real volatility that banks' non-core liabilities might prompt. The policy is effective in smoothing the impact of external shocks; the levy is related to the ratio between the credit growth and the deposits growth. Moreover, the policy makes EME consumers better off.

The paper focuses on one type of non-core liabilities: the cross-border banking flows. One tool that EMEs have to create a resilience financial system is macro-prudential policy. In future research, we plan to extend the model to agency problems when banks lend to non-financial firms, with particular interest on EMEs. Moreover, the macro-prudential policy has many possible instruments that have not been studied in this paper and that are of relevance for policy makers.

In the model, the AE can only invest in the EME through the banks. We only look at the cross-border bank capital. In reality, non-financial firms issue dollar denominated debt that for the case of Mexico is of extreme relevance. This makes the cross-country relation much more complicated. We believe that this model captures one aspect of the cross-country relations that helps to understand the risks of external shocks for EMEs.

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A   Appendix: Funding of Commercial Banks, for Mexico and Turkey

In this section we document how Mexican and Turkish commercial banks fund their activities. In particular, commercial banks in emerging economies are mainly financed with domestic deposits from households. Foreign assets play an important role on transmitting shocks from abroad, but they represent a small share of the 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.1.

The left plot in Figure A.1 corresponds to Turkish data, while the right plot corresponds to Mexican data. The ratio of deposits from households with respect to total liabilities is the green area, while the borrowing from foreign agents 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 billion of domestic currency and refer to the left axis. As we show in Figure 2 in the main text, 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.

B   Appendix: Funding of Private Non-Financial Firms, for Mexico

In this part we document how Mexican non-financial private firms get their funding. We want to show that these firms get funding mainly from the domestic banking system.
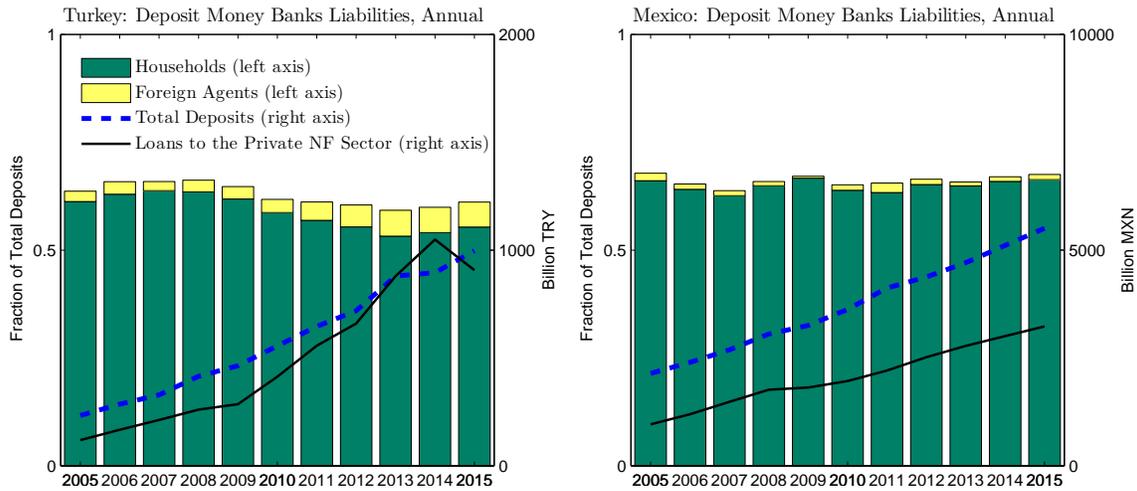
Fig. A.1. Mexico and Turkey: Deposits Money Banks Liabilities, 2005-2015
Source: Bank of Mexico and Turkish Central Bank.

For the case of Mexican non-financial firms, 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 domestic bank loans with respect to total loans (left axis, light green area), and the fraction of bank domestic loans with respect to total loans (left axis, dark green area) in Figure B.1. 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.

C   Appendix: 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 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 with 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: INEGI and Federal Reserve Bank of
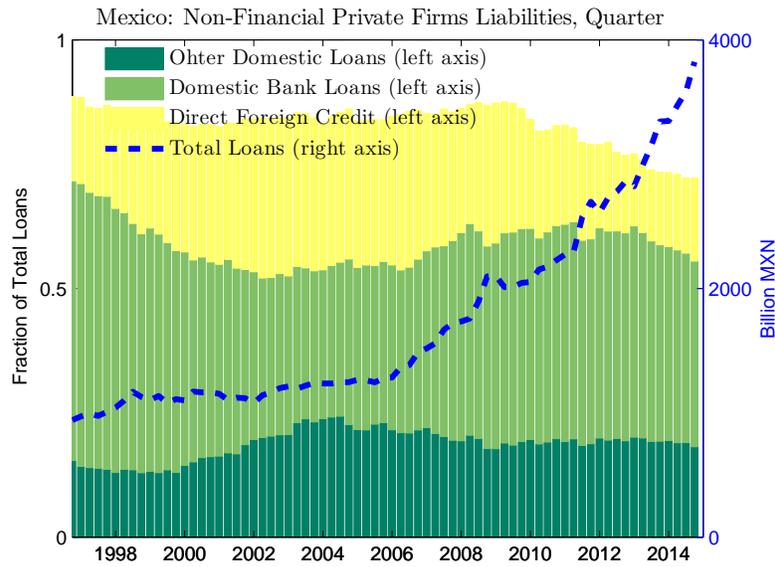
Fig. B.1. Mexico: Non-Financial Private Firms Liabilities, 1996q4-2014q4

Source: Bank of Mexico.

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 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: Banco de México. Turkish stock market index (not seasonally adjusted). Source: Turkish Central Bank.

D Appendix: Equations of the model

D.1 Physical Setup

Production functions, law of motion of capital and the total domestic demands are

$$X_t = A_t K_t^{\alpha} L_t^{1-\alpha}, \quad \text{with } 0 < \alpha < 1, \tag{D.1}$$

$$X_t^* = A_t^* K_t^{*\alpha} L_t^{*(1-\alpha)} \tag{D.2}$$

$$S_t = I_t + (1-\delta)K_t \tag{D.3}$$

$$K_{t+1} = S_t \Psi_{t+1} \tag{D.4}$$

$$S_t^* = I_t^* + (1-\delta)K_t^* \tag{D.5}$$

$$K_{t+1}^* = S_t^* \Psi_{t+1}^* \tag{D.6}$$

$$Y_t = \left[\nu^{\frac{1}{\eta}} X_t^{H\frac{\eta-1}{\eta}} + (1-\nu)^{\frac{1}{\eta}} X_t^{F\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \tag{D.7}$$

$$Y_t^* = \left[\nu^{*\frac{1}{\eta^*}} X_t^{F\frac{\eta^*-1}{\eta^*}} + (1-\nu^*)^{\frac{1}{\eta^*}} X_t^{F*\frac{\eta^*-1}{\eta^*}} \right]^{\frac{\eta^*}{\eta^*-1}} \tag{D.8}$$

Households maximize their expected discounted utility

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

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

The first order conditions are

$$L_t: \qquad \frac{W_t}{C_t} = \chi L_t^{\gamma} \tag{D.9}$$

$$D_{t+1}^h: \quad E_t R_{t+1} \beta \frac{C_t}{C_{t+1}} = E_t R_{t+1} \Lambda_{t,t+1} = 1. \tag{D.10}$$

Similarly for the EME

$$L_t^*: \qquad \frac{W_t^*}{C_t^*} = \chi L_t^{*\gamma} \tag{D.11}$$

$$D_{t+1}^{h*}: \quad E_t R_{t+1}^* \beta \frac{C_t^*}{C_{t+1}^*} = E_t R_{t+1}^* \Lambda_{t,t+1}^* = 1 \tag{D.12}$$

D.2 Non-financial firms

D.2.1 Goods producers

Wages and profits per unit of capital are

$$
\begin{align}
W_t &= (1-\alpha)P_t^H K_t^\alpha L_t^{-\alpha} \tag{D.13}\\
Z_t &= \alpha P_t^H L_t^{1-\alpha} K_t^{\alpha-1} \tag{D.14}\\
W_t^* &= (1-\alpha)P_t^{*F} K_t^{*\alpha} L_t^{*-\alpha} \tag{D.15}\\
Z_t^* &= \alpha P_t^{*F} L_t^{*1-\alpha} K_t^{*\alpha-1}. \tag{D.16}
\end{align}
$$

The demands faced by the intermediate competitive good producers are

$$
X_t^H = \nu \left[\frac{P_t^H}{P_t}\right]^{-\eta} Y_t \tag{D.17}
$$

$$
X_t^{H*} = \nu^* \left[\frac{P_t^{H*}}{P_t^*}\right]^{-\eta} Y_t^*, \tag{D.18}
$$

where prices are defined by

$$
P_t^H = \nu^{\frac{1}{\eta}} Y_t^{-1} \left(X_t^H\right)^{-\frac{1}{\eta}} \tag{D.19}
$$

$$
P_t = 1 = \left[\nu(P_t^H)^{1-\eta} + (1-\nu)(P_t^F)^{1-\eta}\right]^{\frac{1}{1-\eta}} \tag{D.20}
$$

$$
\frac{P_t}{P_t^H} = \frac{1}{P_t^H} = [\nu + (1-\nu)\tau_t^{1-\eta}]^{\frac{1}{1-\eta}} \tag{D.21}
$$

D.2.2 Capital producers

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

$$
Q_t = 1 + f\left(\frac{I_t}{I_{t-1}}\right) + \frac{I_t}{I_{t-1}} f'\left(\frac{I_t}{I_{t-1}}\right) - E_t \Lambda_{t,t+1} \left[\frac{I_{t+1}}{I_t}\right]^2 f'\left(\frac{I_{t+1}}{I_t}\right). \tag{D.22}
$$

and

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

D.3 Banks

D.3.1 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,

$$V(s_t, b_t, d_t) = \nu_{st} s_t + \nu_{bt} b_t - \nu_t d_t$$

The first order conditions are

$$s_t : \qquad \nu_{st} - \lambda_t(\nu_{st} - \theta Q_t) = 0$$
$$b_t : \qquad \nu_{bt} - \lambda_t(\nu_{bt} - \theta Q_{bt}) = 0$$
$$d_t : \qquad \nu_t - \lambda_t \nu_t = 0$$
$$\lambda_t : \quad \theta(Q_t s_t + Q_{bt} b_t) - \{\nu_{st} s_t + \nu_{bt} b_t - \nu_t d_t\} = 0.$$

Rearranging terms yields:

$$(\nu_{bt} - \nu_t)(1 + \lambda_t) = \lambda_t \theta Q_{bt}$$
$$\left(\frac{\nu_{st}}{Q_t} - \frac{\nu_{bt}}{Q_{bt}}\right)(1 + \lambda_t) = 0$$
$$\left[\theta - \left(\frac{\nu_{st}}{Q_t} - \nu_t\right)\right] Q_t s_t + \left[\theta - \left(\frac{\nu_{bt}}{Q_{bt}} - \nu_t\right)\right] Q_{bt} b_t = \nu_t n_t.$$

The excess return on capital is

$$\mu_t = \frac{\nu_{st}}{Q_t} - \nu_t.$$

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

$$\phi_t = \frac{\nu_t}{\theta - \mu_t} \qquad (D.24)$$
$$\nu_t = E_t \Lambda_{t,t+1}\Omega_{t+1} R_{t+1} \qquad (D.25)$$
$$\mu_t = E_t \Lambda_{t,t+1}\Omega_{t+1}\left[R_{kt+1} - R_{t+1}\right] \qquad (D.26)$$
$$\Omega_{t+1} = (1-\sigma) + \sigma(\nu_{t+1} + \phi_{t+1}\mu_{t+1}) \qquad (D.27)$$
$$R_{kt+1} = \Psi_{t+1}\frac{Z_{t+1} + Q_{t+1}(1-\delta)}{Q_t}. \qquad (D.28)$$

D.3.2 Emerging Market Economy Banks

We present with more details the optimization problem of EME's banks in Appendix F. Therefore, here we just stick to the equations that we use for coding:

$$\nu_t^* = E_t \Lambda_{t,t+1}^* \Omega_{t+1}^* R_{t+1}^*$$

$$\mu_t^* = E_t \Lambda_{t,t+1}^* \Omega_{t+1}^* \left[R_{kt+1}^* - R_{t+1}^* \right] \tag{D.29}$$

$$\Omega_{t+1}^* = 1 - \sigma^* + \sigma^* \left(\nu_{t+1}^* + \phi_{t+1}^* \mu_{t+1}^* \right) \tag{D.30}$$

$$R_{kt+1}^* = \Psi_{t+1}^* \frac{Z_{t+1}^* + Q_{t+1}^*(1-\delta)}{Q_t^*}. \tag{D.31}$$

$$\phi_t^* = \frac{\nu_t^*}{\theta^* - \mu_t^*} \tag{D.32}$$

$$\mu_{bt}^* = E_t \Lambda_{t,t+1}^* \Omega_{t+1}^* \left[R_{bt+1}^* - R_{t+1}^* \right] \tag{D.33}$$

$$\phi_{bt}^* = \frac{\nu_t^*}{\theta^* \omega - \mu_{bt}^*} \tag{D.34}$$

$$\mu_{bt}^* = \mu_t \omega \tag{D.35}$$

D.3.3 Aggregate Bank Net Worth

$$\phi_t N_t = Q_t S_t + Q_{bt} B_t \tag{D.36}$$

$$D_t = N_t(1 - \phi_t) \tag{D.37}$$

$$N_t = (\sigma + \xi) \left\{ R_{k,t} Q_{t-1} S_{t-1} + R_{b,t} Q_{b,t-1} B_{t-1} \right\} - \sigma R_t D_{t-1}. \tag{D.38}$$

$$N_t^* = (\sigma^* + \xi^*) R_{k,t}^* Q_{t-1}^* S_{t-1}^* - \sigma^* R_t^* D_{t-1}^* - \sigma^* R_{bt}^* Q_{bt-1}^* B_{t-1}^*, \tag{D.39}$$

$$\phi_t^* N_t^* = Q_t^* S_t^* - \omega Q_{bt}^* B_t^* \tag{D.40}$$

$$N_t^*(\phi_t^* - 1) = D_t^* + (1-\omega) Q_{bt}^* B_t^* \tag{D.41}$$

D.3.4 Global interbank market

$$R_{b,t+1}^* = \Psi_{t+1}^* \frac{Z_{t+1}^* + Q_{b,t+1}^*(1-\delta)}{Q_{bt}^*}. \tag{D.42}$$

$$E_t \Lambda_{t,t+1} \Omega_{t+1} R_{kt+1} = E_t \Lambda_{t,t+1} \Omega_{t+1} R_{bt+1} + \Phi \left[\exp \left(B_t - \bar{B} \right) - 1 \right]. \tag{D.43}$$

D.4 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 are

$$Y_t = C_t + I_t \left[1 + f\left(\frac{I_t}{I_{t-1}}\right) \right] + G_t \quad \text{and} \tag{D.44}$$

$$Y_t^* = C_t^* + I_t^* \left[1 + f\left(\frac{I_t^*}{I_{t-1}^*}\right) \right] + G_t^*. \tag{D.45}$$

Then for the intermediate-competitive goods market,

$$X_t = X_t^H + X_t^{*H} \frac{1-m}{m} \quad \text{and} \tag{D.46}$$

$$X_t^* = X_t^F \frac{m}{1-m} + X_t^{*F}. \tag{D.47}$$

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

$$CA_t = 0 = \frac{1-m}{m} X_t^{H*} - \tau_t X_t^F, \tag{D.48}$$

with τ_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 global banks in the economy, the current account is

$$CA_t = Q_{b,t} B_t - R_{bt} Q_{b,t-1} B_{t-1} = X_t^{*H} \frac{1-m}{m} \frac{P_t^H}{P_t} - X_t^F \tau_t \frac{P_t^H}{P_t}. \tag{D.49}$$

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

$$B_t = B_t^* \frac{1-m}{m}. \tag{D.50}$$

To close the model the last conditions correspond to the riskless debt. Total household savings equal total deposits plus government debt. Government debt is perfect substitute of deposits to banks,

$$D_t^h = D_t + \mathcal{D}_{gt} \quad \text{and} \quad D_t^{h*} = D_t^* + \mathcal{D}_{gt}^*. \tag{D.51}$$

E   Appendix: 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^H, X_t^{H*}, K_{t+1}, W_t, Z_t, S_t, Y_t^*, X_t^*, L_t^*, C_t^*, I_t^*, K_{t+1}^*, X_t^F, X_t^{F*}, W_t^*, Z_t^*, S_t^*), two interest rates (R_t, R_t^*), and six prices (Q_t, P_t^H, Q_t^*, P_t^{F*}, τ_t, ϵ_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 thirty variables and thirty equations: Eq. (D.1)-(D.23), (D.31) and (D.28), and (D.44) - (D.48).

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^H, X_t^{H*}, K_{t+1}, W_t, Z_t, S_t, Y_t^*, X_t^*, L_t^*, C_t^*, I_t^*, K_{t+1}^*, X_t^F, X_t^{F*}, W_t^*, Z_t^*, S_t^*), plus the sixteen variables related with banks (N_t, D_t, B_t, Ω_t, μ_t, ν_t, ϕ_t, N_t^*, D_t^*, B_t^*, Ω_t^*, μ_t^*, ν_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, Q_{bt}^*, P_t^H, Q_t^*, P_t^{F*}, τ_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. (D.1)-(D.47), (D.49), and (D.50).

F   Appendix: 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 individual bank to ensure that a bank does not divert funds,

$$V_t^*(s_t^*, b_t^*, d_t^*) \geq \theta^*(Q_t^* s_t^* - \omega Q_{bt}^* b_t^*), \tag{F.52}$$

where the R.H.S. shows the funds that a bank can run away with, which are 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

$$V_t^*(s_{t-1}^*, b_{t-1}^*, d_{t-1}^*) = E_{t-1}\Lambda_{t-1,t}^* \left\{ (1 - \sigma^*)n_t^* + \sigma^* \left[\max_{s_t^*, b_t^*, d_t^*} V^*(s_t^*, b_t^*, d_t^*) \right] \right\}. \tag{F.53}$$

The problem of the bank is to maximize Equation (F.53) subject to the borrowing constraint, Equation (F.52).

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

$$V(s_t^*, b_t^*, d_t^*) = \nu_{st}^* s_t^* - \nu_{bt}^* b_t^* - \nu_t^* d_t^*, \tag{F.54}$$

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

Maximizing the objective function (F.53) with respect to (F.52), with λ_t^* as the constraint multiplier, yields similar first-order conditions to the ones from the AE; those are

$$s_t^* : \qquad \nu_{st}^* - \lambda_t^*(\nu_{st}^* - \theta^* Q_t^*) = 0$$
$$b_t^* : \qquad \nu_{bt}^* - \lambda_t^*(\nu_{bt}^* - \theta^* \omega Q_{bt}^*) = 0$$
$$d_t^* : \qquad \nu_t^* - \lambda_t^* \nu_t^* = 0$$
$$\lambda_t^* : \quad \theta^* \left(Q_t^* s_t^* - \omega Q_{bt}^* b_t\right) - \left(\nu_{st}^* s_t^* - \nu_{bt}^* b_t^* - \nu_t^* d_t^*\right) = 0.$$

Rearranging terms yields:

$$\left(\frac{\nu_{bt}^*}{Q_{bt}^*} - \nu_t^*\right)(1 + \lambda_t^*) = \lambda_t^* \theta^* \omega \tag{F.55}$$

$$\left(\frac{\nu_{st}^*}{Q_t^*} - \frac{\nu_{bt}^*}{Q_{bt}^*}\right)(1 + \lambda_t^*) = \lambda_t^* \theta^*(1 - \omega) \tag{F.56}$$

$$\left[\theta^* - \left(\frac{\nu_{st}^*}{Q_t^*} - \nu_t^*\right)\right]Q_t^* s_t^* - \left[\theta^* \omega - \left(\frac{\nu_{bt}^*}{Q_{bt}^*} - \nu_t^*\right)\right]Q_{bt}^* b_t^* = \nu_t^* n_t^*. \tag{F.57}$$

Combining Equation (F.55) with Equation (F.56) results in

$$\left(\frac{\nu_{bt}^*}{Q_{bt}^*} - \nu_t^*\right)\frac{1}{\omega} = \left(\frac{\nu_{st}^*}{Q_t^*} - \frac{\nu_{bt}^*}{Q_{bt}^*}\right)\frac{1}{1 - \omega}$$
$$\mu_{bt}^* = (\mu_t^* - \mu_{bt}^*)\frac{\omega}{1 - \omega}$$
$$\mu_{bt}^* = \mu_t^* \omega, \tag{F.58}$$

where from the first to the second step we am using the definition of μ_{bt}^* and μ_t^* given in the text in Equations (30) and (31), respectively.

Rewriting Equation (F.57) and defining $\phi_t^* = \frac{\theta^* - \mu_t^*}{\nu_t^*}$ and $\phi_{bt}^* = \frac{\theta^* \omega - \mu_{bt}^*}{\nu_t^*}$ yields

$$n_t^* = \frac{1}{\phi_t^*}Q_t^* s_t^* - \frac{1}{\phi_{bt}^*}Q_{bt}^* b_t^*. \tag{F.59}$$

Now expressing the guess of the value function, Equation (F.54), in terms of the net worth and international debt,

$$V(s_t^*, b_t^*, d_t^*) = \frac{\nu_{st}^*}{Q_t^*}Q_t^* s_t^* - \frac{\nu_{bt}^*}{Q_{bt}^*}Q_{bt}^* b_t^* - \nu_t^* d_t^*$$
$$= (\phi_t^* \mu_t^* + \nu_t^*) n_t^* + \left(\frac{\phi_t^* \mu_t^*}{\phi_{bt}^*} - \mu_{bt}^*\right)Q_{bt}^* b_t^*. \tag{F.60}$$

With this information I can verify the value function that corresponds to Equations (29), (30), and (31).

46

G Appendix: Additional Graphs

G.1 No policy response

Figure G.1 shows the impulse responses to a decline in the AE quality of capital of 5% in period t comparing three models. The first model is one without financial frictions and in financial autarky 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 financial frictions are à la Gertler and Kiyotaki (2010). The third model is with financial frictions and an international debt market (financial openness) with no further EME frictions ($\omega = 1$); it is the blue solid line. The 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 third model, we add the international financial mechanism. The comparison helps us understanding the insurance and the transmission role of the international debt market. In Figure G.2, we show the complete set of impulse responses functions: AE and EME variables are.

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 the resources are channeled to recovering from the initial shock. Investment and asset price go up. Households cut down on consumption on impact 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^H, but also imports, X_t^F. 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 (43) and equals zero in every period because there is no international borrowing/lending.

The AE demand of EME goods decreases but the EME starts demanding more of 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 AE.

Adding financial frictions but no global banks to the model results in a similar model to Gertler and Kiyotaki (2010). There are banks and they are financially constrained; when their asset (capital) goes down, banks face a decrease in their net worth. Because banks are more constrained on how much they can borrow, there is a firesale of asset that prompts its price, Q_t, to go down.

The spread between the AE rate of return on capital and the risk free rate, $E(R_k) - R$, widens. The behavior of the spread is a characteristic of the crisis period. The expected rate of return on capital increases because of the fall in capital.
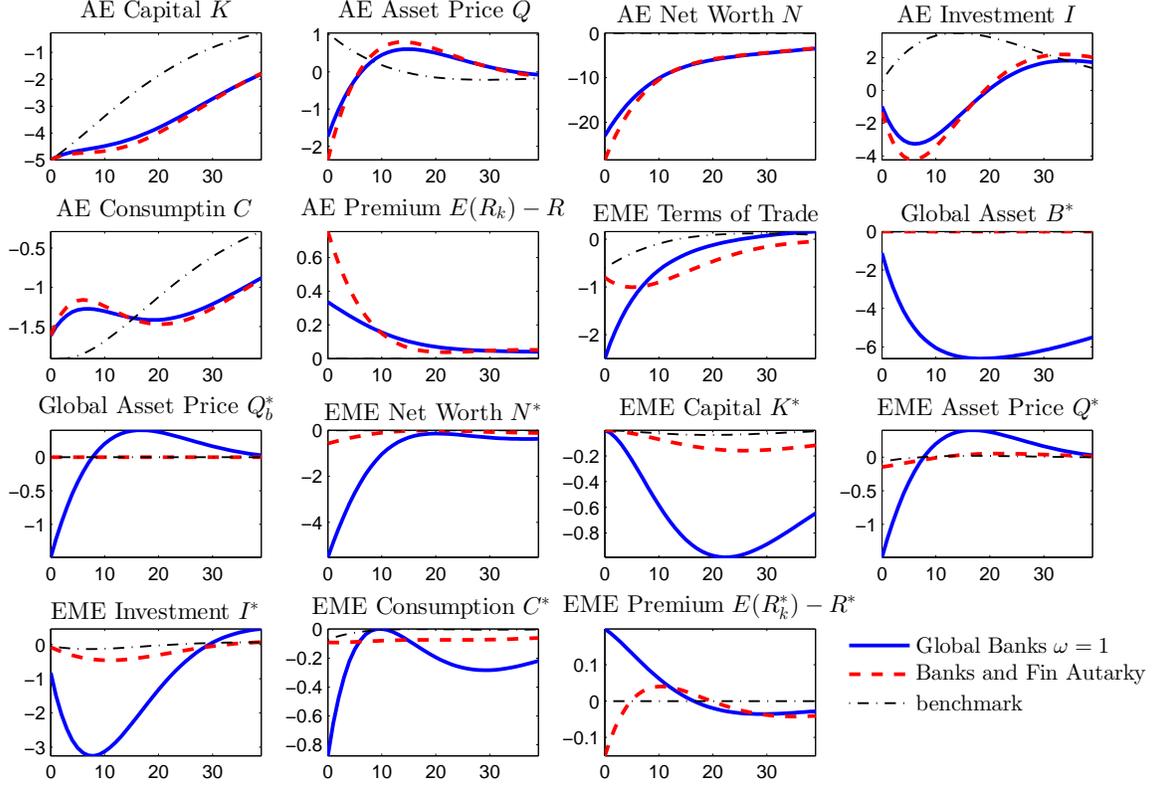
Fig. G.1. Impulse Responses to a 5% Decrease in Ψ_t, Model Comparison with Global Banks
y axis: percentage deviation from steady state; x axis: quarters

The AE production and consumption shrink. There are less advanced goods and they are relatively more expensive, similar to the model without financial frictions, the terms of trade slightly improve for the AE. EME goods are cheaper, its production increases. However, the depreciation of the EME currency makes the EME households to cut down on consumption which will prompt a decrease in the EME capital, net worth of the banks, and the asset price. Asset prices and production co-move across countries. Although there is a larger spillover to the EME economy with financial frictions than without them, the transmission is still negligible.

When we allow for foreign debt, AE banks lend to EME banks. EME banks borrow internationally; AE banks diversify their assets and pool a country specific shock. These asset market characteristics have been discussed by Cole and Obstfeld (1991) and Cole (1993).

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 without global banks and is shown by the solid-blue and the thick dashed-red line in Figure 4. The mechanism

that takes place for the AE variables is the same in both models with financial frictions. However, final domestic demand is less affected by the shock when there are global banks because the AE can partially pool the country specific shock.

In this model $\omega = 1$, the return on EME assets equalizes the return on EME debt. 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. The global banks transmit the crisis from the AE to the EME.

Two types of spillovers disturb the EME: the demand and the international debt effects. The demand effect prompts an increase in production because the exchange rate is depreciating. The international debt effect generates a tightening of the EME borrowing constraint because there is a decrease in the value of international lending. The international debt effect predominates and the net worth of EME banks falls and households cut down on consumption. The effect on production vanishes after 3 periods. Global banks imply financial openness, the current account is now defined in Equation (44).

In a model with global banks and financial frictions, the AE and EME consumption, asset price, and total demand co-move, while production does not (on impact). The asset markets across countries are integrated when $\omega = 1$ because of the equalization of returns of the asset market in the AE and the EME. For AE banks lending to EME banks only imply a country specific premium, but they do not imply a risk.
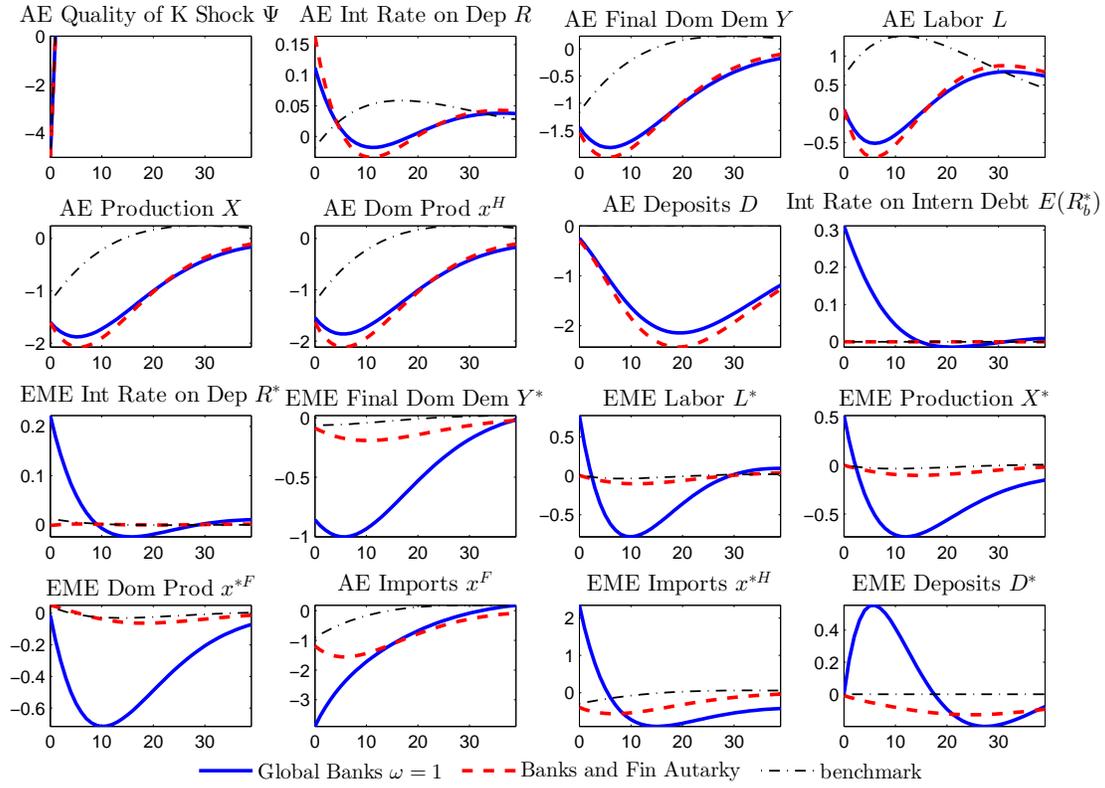
G.2 Policy Response

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Fig. G.2. Impulse Responses to a 5% Decrease in Ψ_t, Model Comparison with Global Banks, Large set of variables

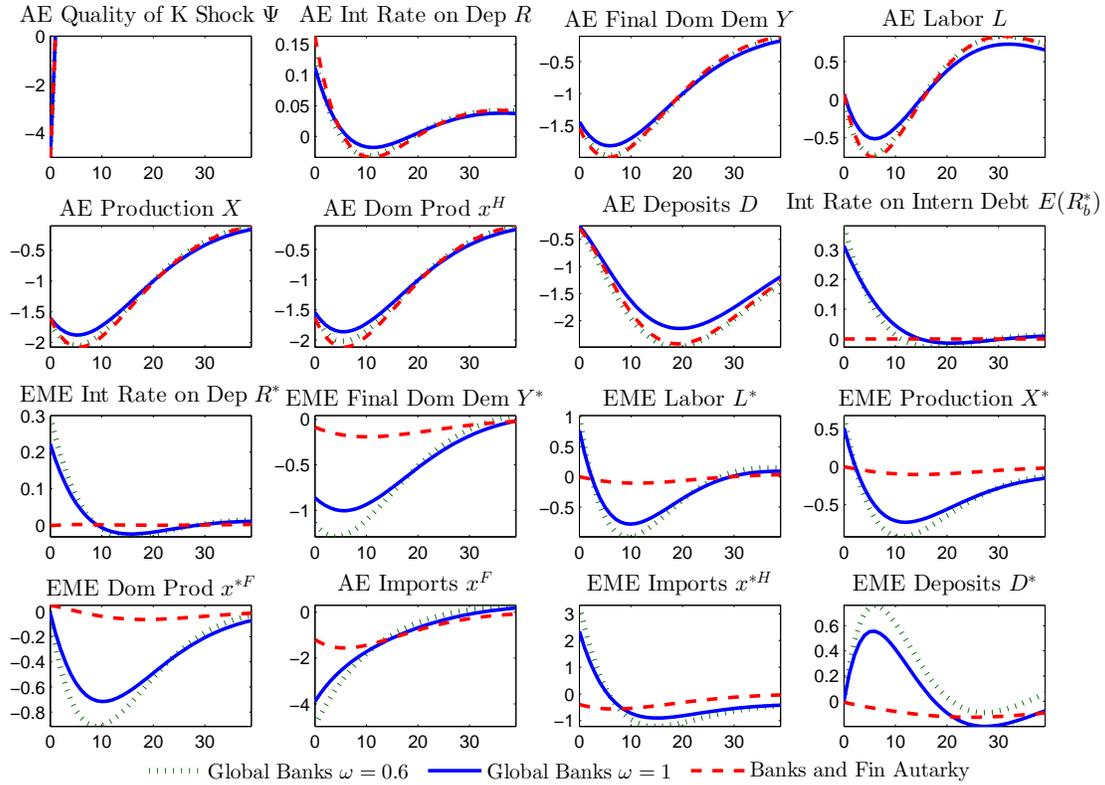*y axis: percentage deviation from steady state; x axis: quarters*

Fig. G.3. Impulse Responses to a 5% Decrease in Ψ_t, Model Comparison with Risky Banks, Large Set of Variables

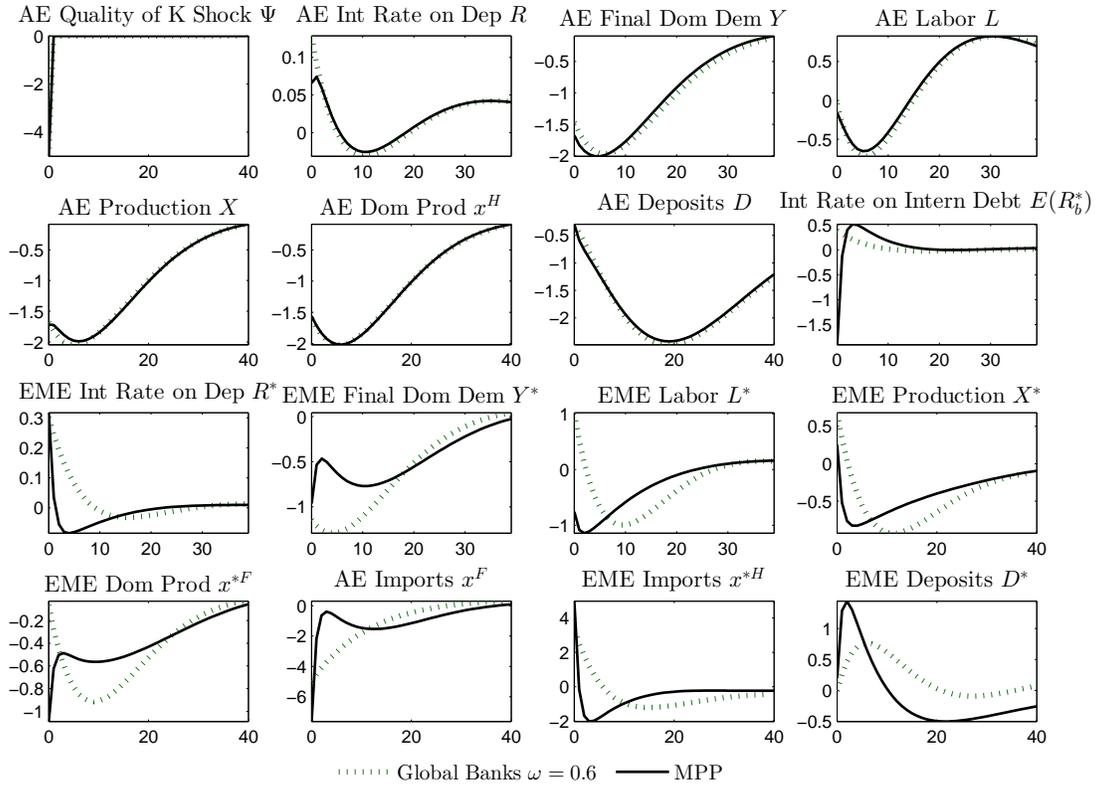*y axis: percentage deviation from steady state; x axis: quarters*

Fig. G.4. Impulse Responses to a 5% Decrease in Ψ_t, Macro-prudential Policy by EME Central Bank, Large Set of Variables

y axis: percentage deviation from steady state; x axis: quarters