Banco de México

Documentos de Investigación

Banco de México

Working Papers

N° 2016-06

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June 2016

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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 role of cross-border banking flows on the transmission of a quality of capital shock in the United States to emerging market economies (EMEs). Banks face a moral hazard problem for borrowing from households. EME's banks might be risky: they can also be constrained to borrow from U.S. banks. A negative quality of capital shock in the United States generates a global financial crisis. EME's macroprudential policy that targets non-core liabilities makes the domestic economy resilient to the volatility of cross-border banking flows and makes EME's households better-off.
Keywords: Global banking, emerging market economies, financial frictions, macroprudential policy
JEL Classification: G28, E44, F42, G21

Resumen: Desarrollamos un modelo de dos países de equilibrio general dinámico y estocástico (DSGE) con bancos globales con el fin de analizar el papel de los flujos bancarios internacionales en la transmisión de un choque a la calidad del capital en Estados Unidos a las economías emergentes (EMEs). Los bancos enfrentan un problema de riesgo moral al tomar prestado de los hogares. Los bancos de la EME pueden ser riesgosos: pueden enfrentar también restricciones al tomar prestado de bancos estadounidenses. Un choque negativo a la calidad del capital en Estados Unidos genera una crisis financiera global. La política macroprudencial en la EME, que se enfoca en los pasivos bancarios no subyacentes, hace que la economía doméstica esté más protegida de la volatilidad en los flujos bancarios internacionales y que los hogares de la EME estén mejor.
Palabras Clave: Bancos globales; economías emergentes; fricciones financieras; política macroprudencial

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1 Introduction

In the last couple of years, scholars and emerging market economies' (EMEs) policy makers have expressed their concern regarding the negative spillovers of advanced economies' (AE) monetary policy through cross-border flows (see Powell, 2013, Rajan, 2014, Sánchez, 2013) and, in particular, cross-border *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 the U.S. monetary policy generates a reduction in credit from domestic global banks to non-financial Mexican firms with consequences on the real economy.

In this paper, we add to this discussion by studying the financial stability effects in EMEs of financial shocks in AEs. We present a stylized two-country model with cross-border banking flows (funds that go from AE banks to EME banks), where banks in the EME might be constrained by how much they borrow from AE banks. We understand the possibility of frictions in the international interbank market as a consequence of banking regulation or structure of the financial system. We refer to the EME banks that face frictions in the global interbank market as risky banks. We propose macro-prudential regulation to mitigate the financial instability effects in the EME of foreign shocks. The novelty of the paper is the interaction between cross-border banking flows and macro-prudential policy. Our results show that a model with cross-border banking flows explains around 25% of the fall in credit in Mexico and Turkey after a financial crisis in the United States. Moreover, the macro-prudential policy makes EME consumers better off.

We propose a two-country (advanced and emerging economies) model with global banks

[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 helps to reduce the volatility generated by international spillovers. Moreover, Cerutti, Claessens, and Laeven (2015), for a large set of countries, show that macro-prudential policies are effective in reducing the growth rates of overall credit, and household and corporate sector credit.

(banks that borrow or lend internationally) 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 (core bank liabilities) 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-border banking flows (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 examine how a country-specific quality of capital shock, that simulates the latest financial crisis, is transmitted internationally. We present VAR evidence to capture the importance of cross-border banking flows on transmitting loses in the AE banking sector to EME credit. We estimate two VARs. The first one includes U.S. and Mexican data and the second one, U.S. and Turkish data. Mexico has had prudential banking regulation in placed since the nineties, while Turkey only implemented it after the latest financial crisis. To an increase in the net charge-offs of U.S. banks, 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. The VAR with Turkish data shows a deeper fall in the domestic credit and the GDP, prompting larger financial instability in the EME.

In terms of the theoretical model, we build a model that replicates the facts from the VAR. 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 to raise deposits, they have to reduce lending to businesses, which further depresses the value of securities and 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. Similar to the VAR exercise, 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. 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. 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 in both cases, however, when there are risky EME banks there is an extra source of friction and the financial instability in the EME is deeper.

Then, we focus on macro-prudential regulation in the EME. The main purpose of the regulation is to smooth the effect of the volatility of cross-border banking flows in the EME financial system, through a levy on non-core bank liabilities. 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 the 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 their consumption less and labor is smoother; EME households are better off. The policy also manages to control the dynamics of the spread. The AE is slightly affected by the EME macro-prudential regulation. 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 the exchange rate, see Shin (2011) for this discussion.

Additionally, we take the net charge-offs of all loans and leases of U.S. banks as an approximation to the quality of capital shock in the AE and simulate the response of different models to this path of shocks for the Great Recession period, 2007Q1-2011Q1. We find that models with safe and risky EME banks do a very good job in replicating the collapse

of domestic bank credit to private non-financial firms for Mexico and Turkey, respectively; especially when we compare them to a model without global banks.

What is new in this framework is the interaction between the cross-border banking flows channel in a DSGE setup, with constrained financial intermediaries in the domestic and international market, with macro-prudential regulation. 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 an international co-movement of asset prices, banks' net worth, and total final demands.[2] Moreover, the macro-prudential regulation protects the EME from shocks propagated by 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 in 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]The co-movement across the two countries that we see in the data and in this paper contrasts with theoretical results of Justiniano and Preston (2010)'s small open economy analysis. The difference comes from the two-country setup with financial openness. Leblebicioglu and Hernandez (2012) have a similar setup to ours but firms borrow from abroad and not banks, so they do not model cross-border banking flows.

2 Historical Background on Macro-Prudential Policy and Empirical Evidence

First, we briefly explain the historical background that brought the macro-prudential policy to the front of the stage. We want to understand why capital flows to EMEs have been very volatile in the last years and why macro-prudential policy carried out by EMEs might help to mitigate the consequences. 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 in the increase in EMEs' credit, and the challenges that this might prompt in EMEs. Then, we show the VAR estimation for two EMEs: Mexico and Turkey. From the VAR, we learn that foreign claims on U.S. banks play a key role in the transmission of a shock to the value of capital in the United States 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 only started to carry it out after the latest financial crisis, such as Turkey: the lack of regulation prompts larger financial instability in the EME.

2.1 Historical Background on Macro-Prudential Policy

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 by 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 result 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, U.S. banks' total foreign

claims on developing economies fell by almost 19% of the level of the end of 2007, almost $100 billion U.S. dollar.

In this setting, AEs, such as the United States, loosened the monetary policy and implemented the so-called "unconventional" monetary policies. These actions 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 a 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 a 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.

In June 2013, the Federal Reserve announced that they would start the tapering of some unconventional policies (in particular quantitative easing) contingent on positive economic data. This news prompted a decrease in the 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 lend-

ing 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 policy-makers 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 recalibrated 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 stability of the financial system as a whole.

Many EMEs implemented prudential regulation at the end of the nineties due to several EMEs crisis. The tools that EMEs have been using are mainly flexible instruments that vary according to 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 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 to follow the same rules and supervisor processes.

Among the prudential regulation measures that Mexico implemented in the nineties are: regulation of 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 nineties helped Mexican banks to be resilient during the global financial crisis. With the financial crisis and the Basel III Agreement, some

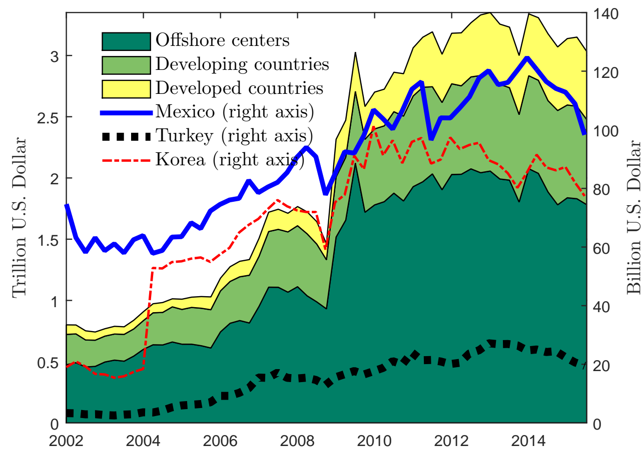

Figure 1. Foreign Claims of U.S. Reporting Banks on Individual Countries, 2001Q4-2015Q3

Source: BIS Consolidated Bank Statistics, Immediate Borrower Basis

new measures were implemented and there is still room for working more on targeting the sources of instability of the financial system.

2.2 Empirical Evidence

Figure 1 documents the foreign claims of U.S. banks on EMEs from 2001Q4 to 2015Q3. Developing economies correspond to 25% of the total of foreign claims as an average of the sample. Mexico is the non-advanced economy that receives the most foreign claims from U.S. reporting banks; in terms of Mexican GDP they are on average almost 9% and they are 4% of the total foreign claims of U.S. banks. The sum of foreign U.S. claims on Mexico, Turkey, and Korea is on average 6% of the total GDP of those countries. Foreign claims show a positive trend for the sample. There is a clear fall in September 2008, when Lehman Brothers failed and a sharp recovery afterwards, as a consequence of unconventional monetary policy. For the last year of data there is not a clear trend of where the claims of U.S. banks are going, but Mexico, Turkey, and Korea show some level of slowdown.[3]

Lane and McQuade (2014) highlight that behind the divergence between domestic bank

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

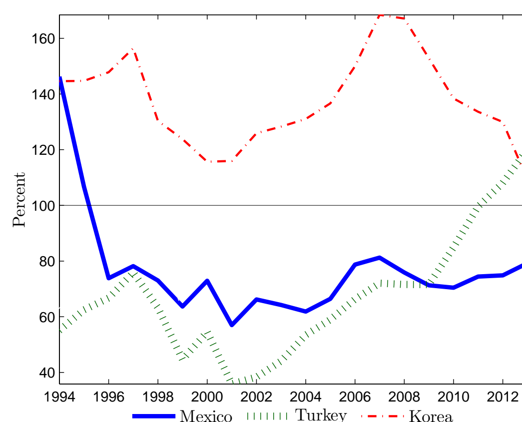

Figure 2. Bank Credit to Bank Deposits for EMEs, 1994-2013

Source: Federal Reserve Bank of St. Louis (FRED)

deposit growth and bank credit growth, banks are using wholesale cross-border funding. Figure 2 shows the ratio between credit and deposits for the three EMEs presented above, from 1994 to 2013. Turkey shows an increasing trend in the ratio with values higher than the equality between credit and deposits for the last years of the sample. This reflects that banks are funding their loans with non-core liabilities, i.e. borrowing short term on the international interbank and money markets and by issuing bonds. This goes in line with the risks that non-core liabilities can prompt in EMEs that are experiencing credit booms, as explained above. Korea shows that its credit is being financed with non-core liabilities but this trend presents a clear slowdown after the financial crisis with the introduction of macro-prudential regulation. Mexico, on the other hand, presents a credit to deposit ratio clearly below the equality after the prudential regulation was in place. 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 was not only transmitted to EMEs by global banks. The trade channel 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, unlike for

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. We compare a VAR model with data from Mexico to one with data from Turkey due to the differences in prudential regulation. In order to be in line with our theoretical model, we follow Lambertini and Uysal (2013) and use shocks to the U.S. commercial banks net charge-off as trigger of the financial crisis. These shocks are equivalent to quality of capital shocks in our model.

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, the exchange rate of EME currency per U.S. dollar, and the EME stock market index. The first two variables want to emphasize the shock and the effect on the financial system of the United States. We use U.S. banks' foreign claims with EME counterparties to model the transmission channel of the shock in the AE to the EME, as we do in our theoretical model. We chose EME banks' credit and the stock market index to model the financial sector. The EME GDP captures the effects on the real side of the economy.

The identifying assumption implicit in the recursive ordering of the VAR implies that U.S net charge-offs shocks have an immediate impact on the other variables. Moreover, we assume that EME variables might influence U.S. series with one lag. We assume this structure and not an exogenous block because we want to be as close as possible to our model which is a two-country one. Nevertheless, the estimated parameters of U.S. series to changes in EME series are smaller than the reaction of EME variables to domestic ones. We have tried 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.

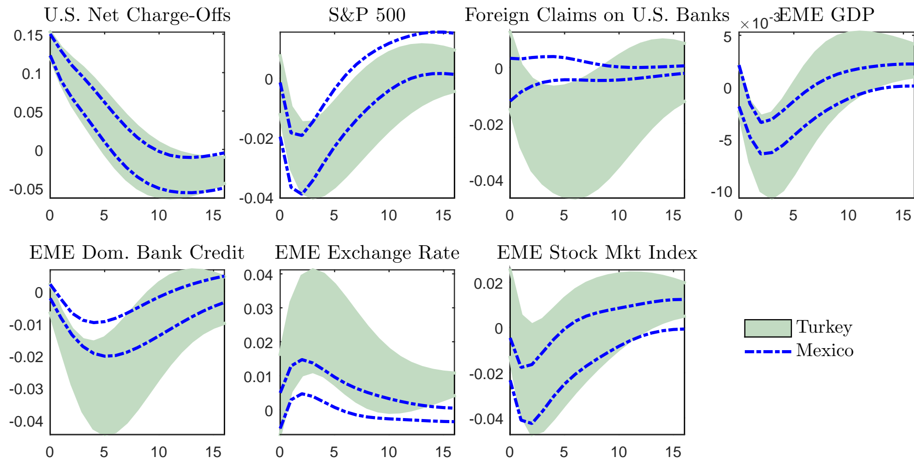

Figure 3. VAR Evidence. Impulse Responses to Cholesky One Standard Deviation Innovation to U.S. Commercial Banks Net Charge-Offs

Note: Mexican VAR (blue dashed lines represent one standard deviation confidence interval) 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 (gray dashed area represents one standard deviation confidence interval) 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.

For Mexico, we estimate our model over the 2002Q1-2013Q4 period. For Turkey, the data goes from 2001Q3 to 2013Q3.[4] 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.[5]

Figure 3 shows the orthogonalized impulse responses functions of the variables to a positive shock to the real net charge-offs on all loans and leases of U.S. banks. The blue-

[4]See Appendix C for the definition and the sources of the data. We use Mexican banks' credit to the private non-financial sector rather than 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 of these countries are mainly financed with domestic bank loans.

[5]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 deposits 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.

dashed lines are the confidence interval for the VAR with U.S. and Mexican data, and the light-green-solid area is the one for Turkey. The results for both EMEs are qualitatively similar. 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 currency and U.S. dollar increases suggesting a deterioration of the EME currency because of the loans flying away from the EME. The VAR highlights a significant and negative reaction of the EME (real and financial) to an increase in the U.S. banks' net charge-offs 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 in 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 a 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 in the reaction of the foreign claims of U.S. banks, in the case of Mexico this movement is not significant. In the next section we build a DSGE model that explains these interactions.

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 on 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 the 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 by how much they borrow from AE banks. EME banks also face a premium on the interest rate paid 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 and EME variables are expressed with an *. We present all equations in Appendix D.

3.1 Physical Setup

There are two countries in the world: the AE and the 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 intermediate good 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},[6]

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

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 are mutually independent and i.i.d. The AE quality of capital shock serves as a trigger of the financial crisis.[7]

As in Heathcote and Perri (2002), there are local perfectly competitive distributor firms (or final good producers) 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,

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

Turning to preferences, households maximize their expected discounted utility

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

[6]Note that we include adjustment costs in the resource constraint, and not in the law of motion of capital. The problems are equivalent.

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

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 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, which 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 household. 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 household, 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 Intermediate 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). I show the problem of these agents in Appendix D. The price of the final AE good is equalized to 1. The gross profits per unit of capital 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 paying all future gross profits to the creditor bank. An intermediate producer will issue new securities at price Q_t to obtain funds to buy 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

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

where P_t is the price of the AE final good and P_t^{H*} the price of the AE good abroad. By the law of one price, $P_t^{H*} \mathit{NER}_t = P_t^H$ with NER_t as the nominal exchange rate. The terms of trade are ToT_t, the price of imports relative to exports. Because of home bias in the final good production, $P_t \neq P_t^* \mathit{NER}_t$; the real exchange rate is defined by $\varepsilon_t = \frac{P_t^* \mathit{NER}_t}{P_t}$. An increase in ToT_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

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

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

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

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 by how much they 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 than that of the EME banks, σ^*. Then, 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, net worth n_t; then, 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 by 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 claims on the future returns on 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,

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

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:

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

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 limited ability of the bank to obtain 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 re-claim 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 bank individually 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,

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

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

We maximize the objective function (13) subject to (12). In Appendix D we show the complete problem. Rewriting the incentive constraint, we define the leverage ratio net of international borrowing as

$$\phi_t = \frac{\vartheta_t}{\theta - \mu_t}, \tag{15}$$

where μ_t is the excess value of a unit of assets relative to deposits, $\mu_t = \frac{\nu_{st}}{Q_t} - \nu_t$. Therefore, the balance sheet of the individual bank is written as

$$Q_t s_t + Q_{bt} b_t = \phi_t n_t. \tag{16}$$

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 fewer assets. When the value of an extra unit of assets increases relative to the cost of holding deposits, the leverage falls, due to the accumulation of assets.

We verify the conjecture regarding the form of the value function. For the conjecture to be correct, the cost of deposits and the excess value of bank assets have to satisfy:

$$\vartheta_t = E_t \Lambda_{t,t+1} \Omega_{t+1} R_{t+1} \tag{17}$$

$$\mu_t = E_t \Lambda_{t,t+1} \Omega_{t+1} \left[R_{kt+1} - R_{t+1} \right], \tag{18}$$

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

$$\Omega_{t+1} = (1-\sigma) + \sigma(\vartheta_{t+1} + \phi_{t+1}\mu_{t+1}) \tag{19}$$

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

$$R_{kt+1} = \Psi_{t+1} \frac{Z_{t+1} + Q_{t+1}(1-\delta)}{Q_t}. \tag{20}$$

Regarding the shadow value of net worth, the first term corresponds to the probability of exiting the banking business, and 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 ϑ_{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 (17), 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 (18), 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.

The first order conditions yield that the marginal value of lending in the international market is equal to the marginal value of assets in terms of AE final good,

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

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

$$E_t \Lambda_{t,t+1} \Omega_{t+1} R_{kt+1} = E_t \Lambda_{t,t+1} \Omega_{t+1} R_{bt+1}, \qquad (21)$$

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.

3.4.2 Emerging Market Economy Banks

The problem of EME banks is similar to the one of 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 feature is that EME banks might face two constraints in obtaining funds, instead of one. First, as in the problem of AE banks, EME banks face 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 to 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 bank individually to ensure that a bank does not divert funds,

$$V_t^*(s_t^*, b_t^*, d_t^*) \geq \theta^*(Q_t^* s_t^* - \omega Q_{bt}^* b_t^*) \text{ with } 0 < \omega \leq 1. \tag{22}$$

EME banks maximize its value function, similar to Equation (13), subject to Equation (22). 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

$$\frac{\vartheta_{st}^*}{Q_t^*} = \left[\frac{\vartheta_{bt}^*}{Q_{bt}^*} - (1-\omega)\vartheta_t^*\right]\frac{1}{\omega}. \tag{23}$$

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

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

On the other hand, if $0 < \omega < 1$, the second term inside the brackets in the RHS of Equation (23) 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 $\mu_t^* = \frac{\vartheta_{st}^*}{Q_t^*} - \vartheta_t^*$ and $\mu_{bt}^* = \frac{\vartheta_{bt}^*}{Q_{bt}^*} - \vartheta_t^*$. In terms of excess return on capital and international debt, we can write:

$$\mu_{bt}^* = \omega \mu_t^* \text{ or } \mu_{bt}^* < \mu_t^*. \tag{25}$$

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

$$\mu_t^* \quad = \quad E_t \Lambda_{t,t+1}^* \Omega_{t+1}^* \left[R_{kt+1}^* - R_{t+1}^*\right], \text{ and} \tag{26}$$

$$\mu_{bt}^* \quad = \quad E_t \Lambda_{t,t+1}^* \Omega_{t+1}^* \left[R_{bt+1}^* - R_{t+1}^*\right] \tag{27}$$

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 and they are defined in a similar way as Equation (19) and (20) are for the AE banks.

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 on loans to non-financial EME firms (when $\omega = 1$, Equation (26) transforms into Equation (27) but the result of Equation (26) turns out to be higher than the result of Equation (27) 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 (21). 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 are equalized but there is an extra term, and that is why we call this case imperfect asset market integration; EME banks are risky and face an extra friction.

When there are risky EME banks, AE banks tend to lend less to 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 (16):

$$Q_t S_t + Q_{bt} B_t = \phi_t N_t. \tag{28}$$

Capital letters indicate aggregate variables. The law of motion of the AE banking system's net worth results in

$$N_t = (\sigma + \xi)\left\{R_{k,t} Q_{t-1} S_{t-1} + R_{b,t} Q_{b,t-1} B_{t-1}\right\} - \sigma R_t D_{t-1}. \tag{29}$$

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 banks invested in the EME.

Both loans are scaled by 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

$$N_t^* \;=\; (\sigma^* + \xi^*) R_{k,t}^* Q_{t-1}^* S_{t-1}^* - \sigma^* R_t^* D_{t-1}^* - \sigma^* R_{bt}^* Q_{bt-1}^* B_{t-1}^*, \tag{30}$$

where R_{bt}^* equals R_{kt}^*, from Equation (24). The balance sheet of the aggregate EME banking system can be written as

$$Q_t^* S_t^* - \omega Q_{bt}^* B_t^* = \phi_t^* N_t^*. \tag{31}$$

EME households' deposits are given by

$$D_t^* + (1 - \omega) Q_{bt}^* B_t^* = N_t^* (\phi_t^* - 1). \tag{32}$$

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; then, an international asset market arises.

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 paid by EME banks on the international debt is debt elastic. Specifically, we assume that Equation (21) becomes

$$E_t \Lambda_{t,t+1} \Omega_{t+1} R_{kt+1} = E_t \Lambda_{t,t+1} \Omega_{t+1} R_{bt+1} + \Phi \left[\exp\left(B_t - \bar{B}\right) - 1 \right]. \tag{33}$$

The new term in Equation (33) 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.[8]

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

[8] The reason to change Equation (21) for Equation (33) is that the model without it becomes very volatile when we decrease the size of the EME by reducing m.

to AE firms, R_{kt}, in expected terms plus a risk premium, as in Equation (33); 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 (24) 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 (23), risky EME banks.

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 collateral expressed in foreign currency falls, then AE banks lend less to EME banks, because the risk of running away with AE money is higher (especially 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 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 (22), less binding because EME banks have a lower gain from running away (the RHS 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 different markets need to be in equilibrium. Equation (5) defines the equilibrium for the final goods market for the AE. Then, for the intermediate-competitive goods market, Equation (9) sets the equilibrium. The market for securities is in equilibrium when we combine Equation (2) with Equation (3). The equilibrium in the labor market is given by the standard equations.

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

$$CA_t = 0 = \frac{1-m}{m} X_t^{H*} - \tau_t X_t^F. \tag{34}$$

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

$$CA_t = Q_{b,t} B_t - R_{bt} Q_{b,t-1} B_{t-1} = X_t^{*H} \frac{1-m}{m} \frac{P_t^H}{P_t} - X_t^F \tau_t \frac{P_t^H}{P_t}, \tag{35}$$

with the global asset in zero net supply $B_t = B_t^* \frac{1-m}{m}$. Finally, households find government debt as a perfect substitute of deposits to banks,

$$D_t^h = D_t + \mathcal{D}_{gt}. \tag{36}$$

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

4 Macro-Prudential Policy in the Emerging Market Economy

We allow the EME policy maker to carry out macro-prudential policy. In line with the Korean experience, we incorporate 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 reducing 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,

$$\vartheta^*_{gt} = \left(\frac{\frac{S^*_{t+1}-S^*_t}{S^*_t}}{\frac{D^*_t-D^*_{t-1}}{D^*_{t-1}}} \right)^{\tau^*_g}. \tag{37}$$

How big the tax is has an exogenous (arbitrary) component τ^*_g and an endogenous one that corresponds to the one in 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 (30) 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 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 one and EME banks pay it, and smooths the quantities borrowed from abroad. On the other hand, during periods of financial crisis, the tax works as a subsidy.

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. We include two different calibrations, the first one for the model with safe global banks, that matches certain ratios of the Mexican economy, and the second one for the model with risky global banks, that matches Turkish ratios. Next, we analyze the impulse responses functions to a crisis experiment without a 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 an 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 one time shock to the quality of capital. Second, we assume that the U.S. banks' net charge-offs of all loans and leases that we used in the VAR can be thought of the quality of capital shock in the AE, we use the data as the path of the shock and we compare the different models by looking at the behavior of the credit (loans), investment, and final domestic demand in the EME. Finally, we look at macro-prudential policy carried out by the EME.

5.1 Calibration

The calibration is specified in Table 1. We use two different calibrations: one for $\omega = 1$, and another one for $\omega = 0.6$. They are important when matching macro variables ratios for Mexico and for Turkey, respectively; the model and data are in Table 2. The calibrations for the EMEs prompt a good fit between the deterministic steady state of the model and the two standard deviations' confidence interval of the data.

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, equals 0.1. We use the relative weight of labor in the utility function, χ, to match the consumption to GDP ratio in the EMEs. The capital share in the production of the intermediate good, α, is 0.33, as is standard in the literature. The parameter

Table 1. Calibration

		GB $\omega = 1$		GB $0 < \omega < 1$	
		AE	EME	AE	EME
β	discount factor	0.9900	0.9900	0.9900	0.9900
γ	inverse elasticity of labor supply	0.1000	0.1000	0.1000	0.1000
χ	relative utility weight of labor	2.0000	2.0000	2.0000	2.0000
α	effective capital share	0.3300	0.3300	0.3300	0.3300
κ	adjustment cost parameter	1.0000	5.0000	1.0000	4.0000
δ	depreciation	0.0180	0.0230	0.0160	0.0230
ν	home bias	0.7750	0.9750	0.7750	0.9750
η	elasticity of substitution	1.5556	1.5556	1.5556	1.5556
m	size of the countries	0.9000	0.1000	0.9000	0.1000
ξ	start-up fraction assets	0.0018	0.0018	0.0018	0.0018
θ	fraction of div assets	0.4459	0.4077	0.4459	0.4068
σ	survival rate	0.9740	0.9720	0.9740	0.9720
$\bar{g}$	steady state gov expenditure	0.1961	0.1109	0.1961	0.1055

in the adjustment cost in investment, κ, equals 1 for the AE, but is higher in the EME; we use it to control the reaction of investment when the economies are hit by a shock. The depreciation rate of capital is different across models to match the ratio of investment to GDP in the EME, and the ratio of cross-border banking flows to domestic deposits in the EME.

With respect to the parameters that enter into the CES aggregator, we choose ν (and λ) to match the ratios between the U.S. and the EME GDP. The size of the AE is set to be clearly bigger than the EME, 0.9 and 0.1, respectively. The home bias, ν, is defined by the size of the AE and the degree of openness, λ: $\nu = 1 - (1 - m)\lambda$. 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; we choose it to control the net exports.

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 it is a rough approximation of the different spreads for the pre-2007 period, and is taken from Gertler and Kiyotaki (2010). For the EME it is higher than for the AE because it is riskier to invest there, however it is still very low in comparison to the average bank lending deposit spread that was 460 basis point for Mexico.[9] 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, 0.974 for AE banks and 0.972 for EME banks. On average, AE banks survive 9 years, while EME banks survive around 8 years and a half. These parameters help to match the cross-border banking flows to deposit ratios of the model with the data. We assume a negative i.i.d. quality of capital 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 it 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 it 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 green-dotted line. The comparison of these models shows how the transmission mechanism across countries changes given the different assumptions. In the first model, 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.[10]

[9] If we calibrate an interest rate spread that high, then the capital in that economy is very small and the macro ratios of the model do not fit the data.

[10] In Appendix H, we show a complete of impulse responses functions. In Appendix G, we show the results for another calibration. We also present another model comparison where we include a framework without financial frictions.

Table 2. Deterministic Steady State, Model and Data

	Global Banks $\omega = 1$			Global Banks $\omega = 0.6$		
	Model	Data CI 2sd		Model	Data CI 2sd	
Advanced Economy: United States						
Consumption/GDP	0.6115	0.6753	0.6820	0.6728	0.6753	0.6820
Investment/GDP	0.1924	0.1558	0.1774	0.1980	0.1558	0.1774
Government spending /GDP	0.1961	0.1909	0.2013	0.1961	0.1909	0.2013
Emerging Market Economy:		*Mexico*			*Turkey*	
Consumption/GDP	0.6771	0.6576	0.6682	0.6817	0.6782	0.6969
Investment/GDP	0.2120	0.2083	0.2193	0.2128	0.2158	0.2453
Government spending /GDP	0.1109	0.1094	0.1124	0.1055	0.1022	0.1087
Exports/GDP	0.2465	0.2749	0.3008	0.2479	0.2436	0.2570
Imports/GDP	0.2301	0.2722	0.3025	0.2339	0.2573	0.2852
Cross-border bnk fl/Deposits	0.0196	0.0105	0.0273	0.0670	0.0082	0.0793

Source: own calculations with data from FRED 2002q1 - 2014q4. For Mexico, the cross-border banking flows to deposits ratio is the ratio between deposits from financial institutions from abroad and deposits from households for the period 2004q2-2015q2, CF445, Bank of Mexico. For Turkey, it is the ratio between total deposits from financial foreign institutions and total deposits from households in TRY for the same time period, Central Bank of Turkey.

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 by how much they can borrow, there is a fire-sale 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 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 fewer advanced goods and they are relatively more expensive, the terms of trade slightly improve for the AE. EME

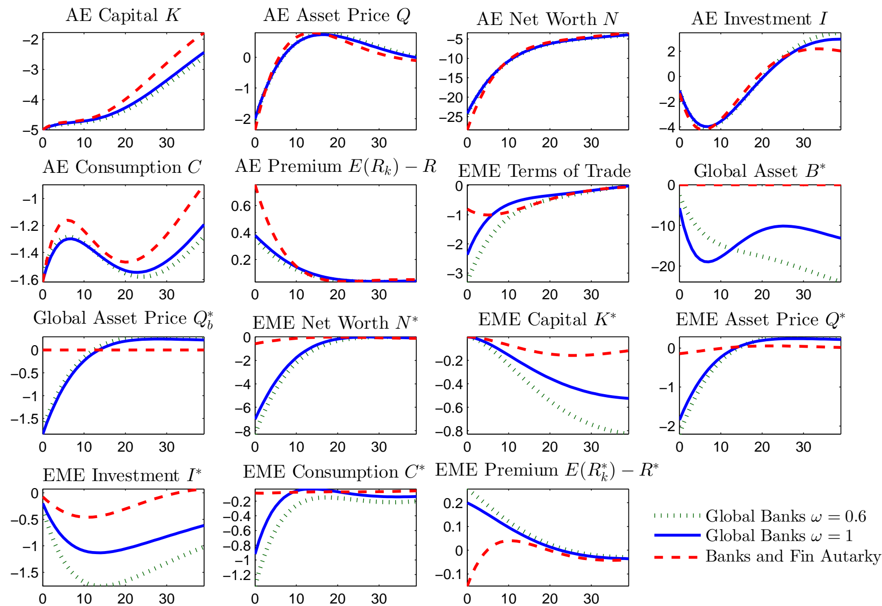

Figure 4. Impulse Responses to a 5% Decrease in Ψ_t, Model Comparison with Global Banks

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

goods are cheaper and their production increases. However, the depreciation of the EME currency makes 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. 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 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, as a result 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.

In the model with global banks and financial frictions, 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. The AE banks' lending to EME banks does not imply a risk for the AE.

When we allow for risky EME banks, $0 < \omega < 1$, the shock hits harder the EME because AE banks reduce more loans to EME banks. The possibility of running away with money from AE banks prompts a difference in the perception of risk of lending to EME banks when a shock hits. This is also reflected in how the interest rate spread of the EME reacts to the shock. The macro-prudential regulation analyzed in the next section targets the cross-border banking flows for the case of risky EME banks.

The AE variables show a deeper crisis when EME banks are riskier. At the steady state, AE lend more to EME because of a higher return (in comparison to $\omega = 1$, remember Equation (25)). However, when the shock hits, a lower ω prompts a more abrupt reaction on cutting down on lending to EME banks, and there is more financial instability in the EME.

The qualitative behavior of the model matches the VAR evidence shown in Figure 3. In the data, a decrease in U.S. loans prompts a decrease in 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 AE banks.

We understand the difference between safe and risky EME banks as having or not having prudential regulation in place before the Great Recession, like Mexico and Turkey, respectively.

5.3 The Great Recession

We evaluate how well the different models manage to replicate some empirical facts from Mexico and Turkey after fitting in with the path of the quality of capital shock in the United States. We focus on credit in the EME, because it is the most important variable when generating financial instability in the small economy, and on investment and final domestic demand, to show the effects on the real 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. Turkish data are the dashed-dotted-green line, and Mexican data correspond to the blue-solid-thin line. The results are in Figure 5. The data are in log and HP filtered, and have been normalized to zero in 2007Q1.

By fitting the net charge-offs, we give a much bigger shock than 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, the models with global banks fit better the data. For the case of safe global banks, $\omega = 1$, the model explains around 28% of the path of the Mexican credit at the end of 2009 and beginning of 2010, the deepest moment of the crisis. For the case of risky global banks, $\omega = 0.6$, the model explains 24% of the fall in the Turkish credit. The simulated

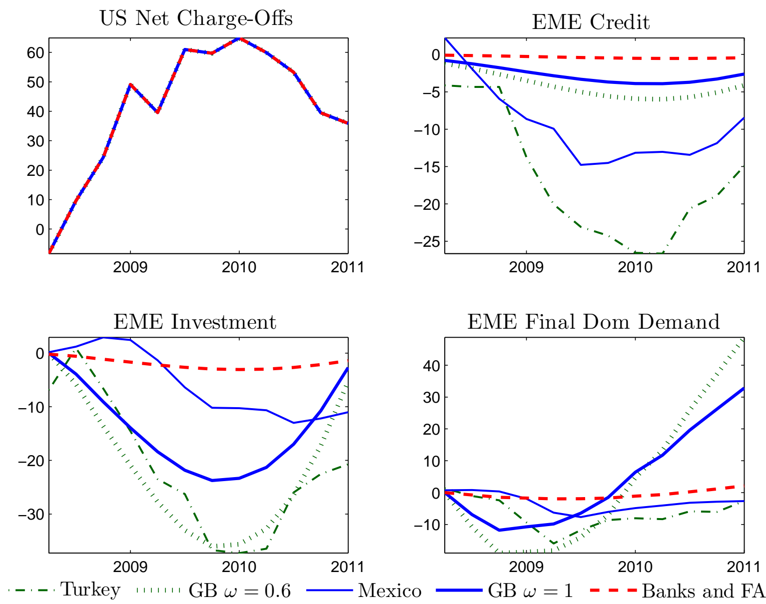

Figure 5. The Great Recession and EME banks' credit

model does a better job on explaining the path of investment. The model overestimates the fall for Mexico but it replicates very well the Turkish data. The simulated series manage to capture the hump shape of the data.

Despite the good performance in terms of credit and investment in the EME, the model over-predicts the reaction of real variables in the EME. The final domestic demand, last plot in the Figure, reacts earlier and with more volatility in the model than in the data; this is a consequence of not having any type of nominal friction in the model. Nevertheless, the model with $\omega = 0.6$ presents a deeper fall in the domestic demand than the model of $\omega = 1$; this goes in line with the data.

5.4 Policy Response

5.4.1 IRF: Macro-prudential Policy in the EME

We introduce EME macro-prudential policy. 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

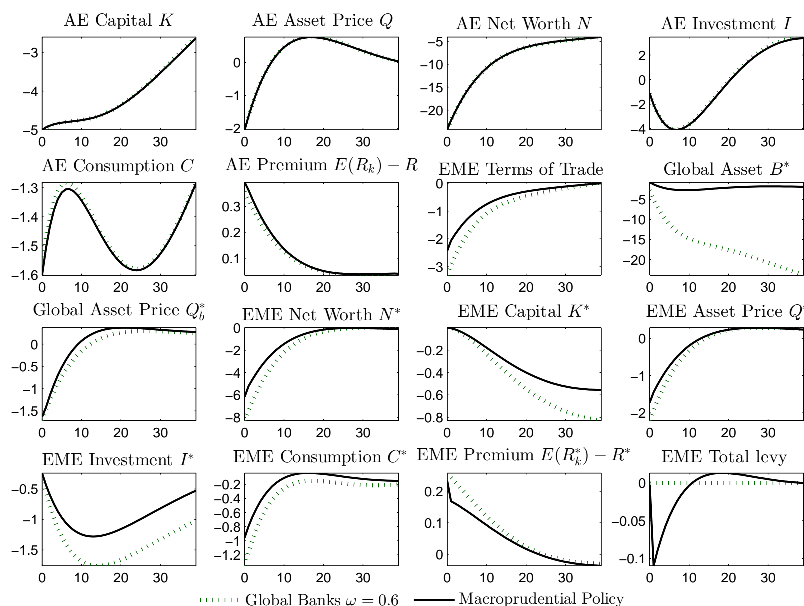

Figure 6. Impulse Responses to a 5% Decrease in Ψ_t, Macro-prudential Policy by the EME Central Bank

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

tax on them; the opposite is valid when deposits are growing faster than credit. When there is a financial crisis, deposits grow faster than credit and so the tax is a subsidy and EME banks adjust non-core liabilities much more than without the levy.

Figure 6 shows a small set of variables with two models.[11] The dotted-green line is the same model without policy and with risky banks shown in previous figures. The solid-black line is a model with the quality of capital shock in the AE and macro-prudential policy in the EME.[12]

The net worth of 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 also displays a better scenario. Note that the effect on the AE of having the levy is small.

So far, we have studied the first order approximation of the model. This is useful when

[11]In Appendix H, we show the rest of the variables.

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

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 by looking at the second order approximation of the model.

5.5 Welfare Analysis

We look at the advanced and emerging consumers' welfare given 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

$$Welf_t = U(C_t, L_t) + \beta E_t Welf_{t+1}, \tag{38}$$

where the utility function comes from Equation (6). Welfare is defined as the lifetime utility of consumers. We compare the different interventions using the consumption equivalent, i.e. the fraction of household's 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. We use Schmitt-Grohé and Uribe (2007)'s definition of consumption equivalent.

We define the stochastic steady state as the ergodic mean in the absence of shocks.[13] We follow Carrillo, Peersman, and Wauters (2013) on the way to calculate it: it is the place where the model stands after 2500 periods, given the deterministic steady state as starting point and the policy functions approximated up to a second order (see Kim and Kim, 2003, Schmitt-Grohé and Uribe, 2004). We do not give shocks in the process of going from the deterministic to the stochastic steady state but the variance of the perturbations are taken into account in the solution of the model.

Figure 7 shows the consumption equivalent of the AE and the EME for different intensity

[13] This is the definition used by Fernández-Villaverde, Guerrón-Quintana, Rubio-Ramírez, and Uribe (2011) and Born and Pfeifer (2014): "the point of the state space where, in absence of shocks in that period, agents would choose to remain although they are taking future volatility into account" (Born and Pfeifer, 2014, footnote 2).

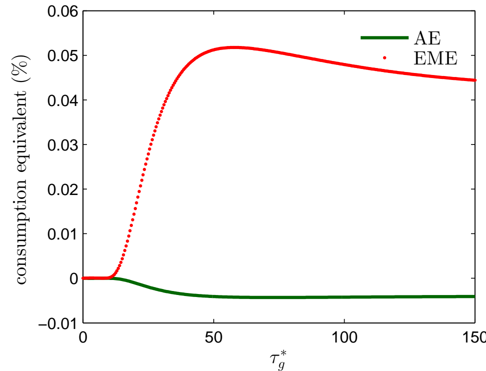

Figure 7. Consumption Equivalent under different intensity of macro-prudential intervention and $\sigma_\Psi = 0.0005$

levels of macro-prudential intervention by the EME.[14] It turns out that for τ_g^* between 0 and 150, the EME is better off with the policy. The gains for EME consumers are approximately 10 times larger than the losses of 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 $\tau_g^* = 58$. This corresponds to a tax of 0.00958% on the volatility of non-core liabilities. The results show that the macro-prudential intervention always makes EME consumers better off. 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.

6 Concluding Remarks

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 to obtain funds from households. The AE can invest in the EME through banks using a global asset (or cross-

[14]We do this exercise with a two variations in the calibration for $\omega = 0.6$, due to indeterminance problems. The adjustment costs at the EME are set to 1.5, lower than the baseline calibration, but higher than the ones for the AE; and the weight on labor for both economies is set to 5.013, the value used in Gertler and Kiyotaki (2010).

border banking flows). EME banks might also be constrained by how much they borrow from AE banks. The return on 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 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 by 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.

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, an *ex ante* 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 resilient financial system is the 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 in EMEs. Moreover, 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 and 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.

Acknowledgments

Any views expressed herein are those of the authors and do not necessarily reflect those of Banco de México. We are grateful to Julio Carrillo for his advice and guidance. We also thank Ana María Aguilar and Jessica Roldán for their time to discuss and Cristina Arellano, Luca Dedola, Andrés Fernández Martin, Patrick Fève, Gabriel Tenorio, and Martín Tobal for their helpful comments. María del Carmen Hernández Ruiz provided excellent research assistance. We thank seminar participants at the Brownbag Seminar at Bank of Mexico, XVIII Workshop in International Economics and Finance, Sixth BIS CCA Research Conference, Spring 2015 Midwest Macro Conference, 21st International Conference on Computing in Economics and Finance, IBEFA Day-Ahead Conference Summer 2015, and 2nd ITAM-Pier Conference on Macroeconomics. All remaining errors are our own.

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A Funding of Commercial Banks, for Mexico and Turkey

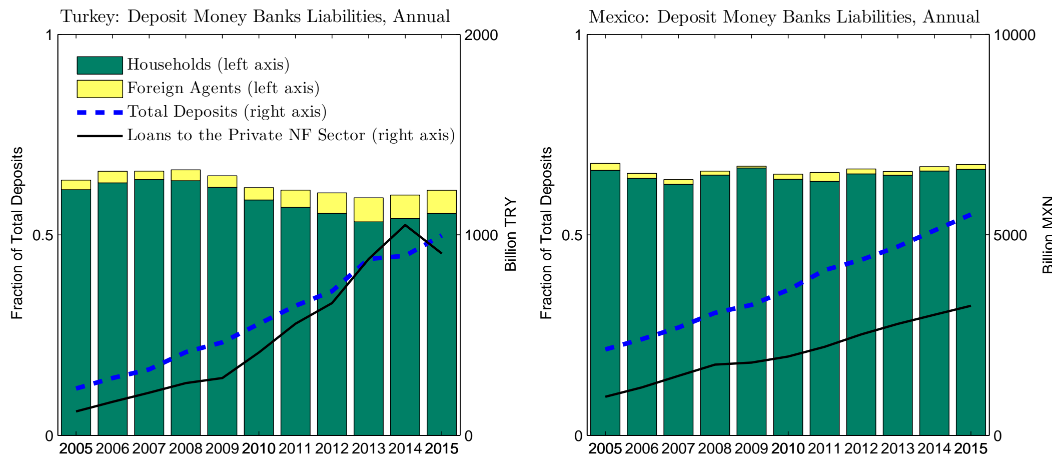

Figure A.1. Mexico and Turkey: Deposits Money Banks Liabilities, 2005-2015

Source: Turkish Central Bank and Bank of Mexico

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 in transmitting shocks from abroad, but they represent a small share of total liabilities. Moreover, as we explain in the paper, Mexican banks are subject to prudential regulation that restricts how much they can borrow from abroad; then, we expect Mexican banks' liabilities from foreign banks to be smaller than for Turkish banks. We show these characteristics in Figure A.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 ratio of 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 right 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 Funding of Private Non-Financial Firms, for Mexico

In this part we document how Mexican private non-financial firms get their funding. We want to show that these firms get funding mainly from the domestic banking system.

For the case of Mexican non-financial firms, in Figure B.1 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 other domestic 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). 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.

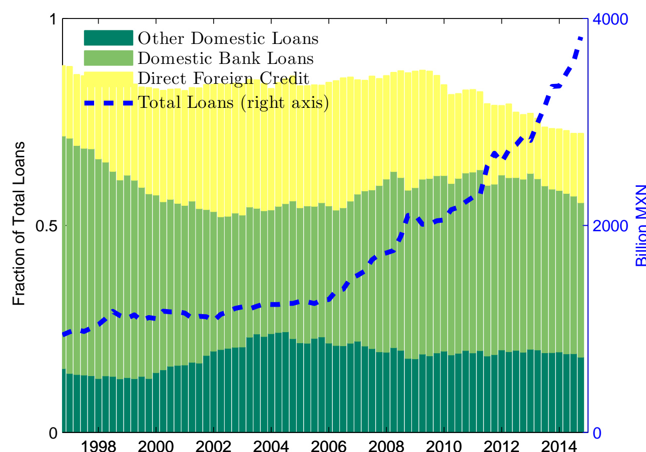

Figure B.1. Mexico: Non-Financial Private Firms Liabilities, 1996Q4-2014Q4

Source: Bank of Mexico

C 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 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: Bank of Mexico. Turkish stock market index (not seasonally adjusted). Source: Turkish Central Bank.

D Equations of the Model

D.1 Physical Setup

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

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

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

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

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

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

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

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

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

Households maximize their expected discounted utility

$$U(C_t, L_t) = E_t \sum_{t=0}^{\infty} \beta^t \Big[\ln C_t - \frac{\chi}{1+\gamma} L_t^{1+\gamma} \Big]$$
$$\text{s.t} \quad C_t + D_{t+1}^h = W_t L_t + R_t D_t^h + \Pi_t - T_t,$$

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 Intermediate Goods Producers

Good producers maximize their expected discounted dividends,

$$\max_{K_{t+1}, L_t} E_t q_t + d_t = d_t + E_t \textstyle\sum_{s=t+1}^{\infty} \frac{d_s}{\Pi_{v=t+1}^{s} R_v}$$
$$\text{s.t.} \;\; d_t = A_t K_t^{\alpha} L_t^{1-\alpha} P_t^H - W_t L_t - Q_t \left[\frac{K_{t+1}}{\Psi_{t+1}} + (1-\delta) K_t \right]$$

Then, the first order conditions are

$$L_t : \quad W_t = (1-\alpha) A_t K_t^{\alpha} P_t^H L_t^{-\alpha} \tag{D.13}$$

$$K_{t+1} : \quad R_{t+1} = \Psi_{t+1} \frac{[Q_{t+1}(1-\delta) + Z_{t+1}]}{Q_t}, \tag{D.14}$$

where I define the capital gross return

$$Z_t = \alpha P_t^H {L_t}^{1-\alpha} {K_t}^{\alpha-1} \tag{D.15}$$

From the optimization problem of the final good producers, the demand for domestic goods is

$$X_t^H = \nu \left[\frac{P_t^H}{P_t}\right]^{-\eta} Y_t \tag{D.16}$$

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

where prices are defined by

$$P_t^H = \nu^{\frac{1}{\eta}} Y_t^{-1} \left(X_t^H\right)^{-\frac{1}{\eta}} \tag{D.18}$$

$$P_t = 1 = \left[\nu (P_t^H)^{1-\eta} + (1-\nu)(P_t^F)^{1-\eta}\right]^{\frac{1}{1-\eta}} \tag{D.19}$$

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

Wages and profits for the EME are

$$W_t^* = (1-\alpha) P_t^{*F} K_t^{*\alpha} L_t^{*-\alpha} \tag{D.21}$$

$$Z_t^* = \alpha P_t^{*F} L_t^{*1-\alpha} K_t^{*\alpha-1}. \tag{D.22}$$

D.2.2 Capital Producers

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

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

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

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 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 solving and rearranging are

$$\phi_t = \frac{\nu_t}{\theta - \mu_t} \tag{D.25}$$

$$\nu_t = E_t \Lambda_{t,t+1} \Omega_{t+1} R_{t+1} \tag{D.26}$$

$$\mu_t = E_t \Lambda_{t,t+1} \Omega_{t+1} \left[R_{kt+1} - R_{t+1} \right] \tag{D.27}$$

$$\Omega_{t+1} = (1 - \sigma) + \sigma(\nu_{t+1} + \phi_{t+1} \mu_{t+1}) \tag{D.28}$$

$$R_{kt+1} = \Psi_{t+1} \frac{Z_{t+1} + Q_{t+1}(1 - \delta)}{Q_t}. \tag{D.29}$$

D.3.2 Emerging Market Economy Banks

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

$$\nu_t^* = E_t \Lambda_{t,t+1}^* \Omega_{t+1}^* R_{t+1}^* \tag{D.30}$$

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

$$\Omega_{t+1}^* = 1 - \sigma^* + \sigma^* \left(\nu_{t+1}^* + \phi_{t+1}^* \mu_{t+1}^* \right) \tag{D.32}$$

$$R_{kt+1}^* = \Psi_{t+1}^* \frac{Z_{t+1}^* + Q_{t+1}^*(1 - \delta)}{Q_t^*}. \tag{D.33}$$

$$\phi_t^* = \frac{\nu_t^*}{\theta^* - \mu_t^*} \tag{D.34}$$

$$\mu_{bt}^* = E_t \Lambda_{t,t+1}^* \Omega_{t+1}^* \left[R_{bt+1}^* - R_{t+1}^* \right] \tag{D.35}$$

$$\phi_{bt}^* = \frac{\nu_t^*}{\theta^* \omega - \mu_{bt}^*} \tag{D.36}$$

$$\mu_{bt}^* = \mu_t \omega \tag{D.37}$$

D.3.3 Aggregate Bank Net Worth

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

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

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

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

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

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

D.3.4 Global Interbank Market

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

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

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

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

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

Then, for the intermediate-competitive goods market

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

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

The markets for securities are in equilibrium when

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

The conditions for the labor market are

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

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

$$CA_t = 0 = \frac{1-m}{m} X_t^{H*} - \tau_t X_t^F, \tag{D.50}$$

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

$$CA_t = Q_{b,t}B_t - R_{bt}Q_{b,t-1}B_{t-1} = X_t^{*H}\frac{1-m}{m}\frac{P_t^H}{P_t} - X_t^F \tau_t \frac{P_t^H}{P_t}. \tag{D.51}$$

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

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

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

$$D_t^h = D_t + \mathcal{D}_{gt} \quad \text{and} \quad D_t^{h*} = D_t^* + \mathcal{D}_{gt}^*. \tag{D.53}$$

E 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.24), (D.33) and (D.29), and (D.46) - (D.50).

Economy with Financial Frictions The competitive banking equilibrium without government intervention is defined as a solution to the problem that involves choosing the same twenty two quantities as in the frictionless economy (Y_t, X_t, L_t, C_t, I_t, X_t^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.49), (D.51), and (D.52).

F EME Banks' Optimization Problem

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

$$V_t^*(s_t^*, b_t^*, d_t^*) \geq \theta^*(Q_t^* s_t^* - \omega Q_{bt}^* b_t^*), \tag{F.54}$$

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

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

$$V_t^*(s_{t-1}^*, b_{t-1}^*, d_{t-1}^*) = E_{t-1}\Lambda_{t-1,t}^* \left\{ (1-\sigma^*)n_t^* + \sigma^* \left[\max_{s_t^*, b_t^*, d_t^*} V^*(s_t^*, b_t^*, d_t^*) \right] \right\}. \tag{F.55}$$

The problem of the bank is to maximize Equation (F.55) subject to the borrowing constraint, Equation (F.54).

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

$$V(s_t^*, b_t^*, d_t^*) = \nu_{st}^* s_t^* - \nu_{bt}^* b_t^* - \nu_t^* d_t^*, \tag{F.56}$$

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.55) with respect to (F.54), with λ_t^* as the constraint multiplier, yields similar first-order conditions to the ones from the AE; those are

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

Rearranging terms yields:

$$\left(\frac{\nu_{bt}^*}{Q_{bt}^*} - \nu_t^*\right)(1+\lambda_t^*) = \lambda_t^* \theta^* \omega \tag{F.57}$$

$$\left(\frac{\nu_{st}^*}{Q_t^*} - \frac{\nu_{bt}^*}{Q_{bt}^*}\right)(1+\lambda_t^*) = \lambda_t^* \theta^* (1-\omega) \tag{F.58}$$

$$\left[\theta^* - \left(\frac{\nu_{st}^*}{Q_t^*} - \nu_t^*\right)\right] Q_t^* s_t^* - \left[\theta^* \omega - \left(\frac{\nu_{bt}^*}{Q_{bt}^*} - \nu_t^*\right)\right] Q_{bt}^* b_t^* = \nu_t^* n_t^*. \tag{F.59}$$

Combining Equation (F.57) with Equation (F.58) results in

$$
\begin{aligned}
\left(\frac{\nu_{bt}^*}{Q_{bt}^*} - \nu_t^*\right)\frac{1}{\omega} &= \left(\frac{\nu_{st}^*}{Q_t^*} - \frac{\nu_{bt}^*}{Q_{bt}^*}\right)\frac{1}{1-\omega} \\
\mu_{bt}^* &= \left(\mu_t^* - \mu_{bt}^*\right)\frac{\omega}{1-\omega} \\
\mu_{bt}^* &= \mu_t^* \omega, \qquad \text{(F.60)}
\end{aligned}
$$

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

Rewriting Equation (F.59) and defining $\phi_t^* = \frac{\theta^* - \mu_t^*}{\nu_t^*}$ and $\phi_{bt}^* = \frac{\theta^* \omega - \mu_{bt}^*}{\nu_t^*}$ yields

$$n_t^* = \frac{1}{\phi_t^*} Q_t^* s_t^* - \frac{1}{\phi_{bt}^*} Q_{bt}^* b_t^*. \tag{F.61}$$

Now expressing the guess of the value function, Equation (F.56), in terms of the net worth and international debt,

$$
\begin{aligned}
V(s_t^*, b_t^*, d_t^*) &= \frac{\nu_{st}^*}{Q_t^*} Q_t^* s_t^* - \frac{\nu_{bt}^*}{Q_{bt}^*} Q_{bt}^* b_t^* - \nu_t^* d_t^* \\
&= \left(\phi_t^* \mu_t^* + \nu_t^*\right) n_t^* + \left(\frac{\phi_t^* \mu_t^*}{\phi_{bt}^*} - \mu_{bt}^*\right) Q_{bt}^* b_t^*. \qquad \text{(F.62)}
\end{aligned}
$$

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

G Safe vs. Risky EME

In this section we compare a set of models to analyze the effects of including the cross-border banking flows channel. We use a standard calibration, similar to the one used previously in the related literature, to evaluate the changes of the spillovers when there are safe EME banks and when there are risky EME banks. The only difference in the calibration between the two models is the parameter ω, 1 and 0.6, respectively. Second, we describe the impulse response functions.

G.1 Calibration

The calibration is specified in Table G.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 function, χ, are equal to 0.1 and 5.013, respectively. The capital share in the production of the intermediate good, α, is 0.33 and the parameter in the adjustment cost in investment, κ, equals 1. The quarterly depreciation rate of capital is 2.5%.

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 AE and 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 to 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.

Table G.1. Calibration

		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	5.0130	5.0130
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	0.9740	0.9720
ω	friction on EME banks		0.6000
$\bar{g}$	steady state gov expenditure	0.1240	0.2000

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 it is a rough approximation of the different spreads for the pre-2007 period. For the EME it is higher than for 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 9 years, while EME banks survive around 8 years and a half. 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 from U.S. banks to Mexican counterparties from the year 1999Q4

to 2013Q4, and constitutes 7.8% of Mexican banks' total assets. We assume a negative i.i.d. quality of capital shock that occurs in the AE.

G.2 Impulse Response Functions

Figure G.1 shows the impulse responses to a decline in the AE quality of capital of 5% in period t comparing four models, using the calibration presented above. 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 third model is one with financial frictions and an international debt market (financial openness) with no further EME frictions ($\omega = 1$); it is the blue-solid line. The fourth model is one with financial frictions and risky EME banks ($\omega = 0.6$) and is the green-dotted 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 last two models, we add the international financial mechanism and we study safe vs. risky banks. The comparison helps us to understand the insurance and the transmission role of the international debt market. In Figure G.2, we show the rest of the impulse responses functions.

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

The AE cuts back not only the demand for local goods, X_t^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 (D.50) and equals zero in every period because there is no international borrowing/lending.

The AE demand for EME goods decreases but the EME starts demanding more domes-

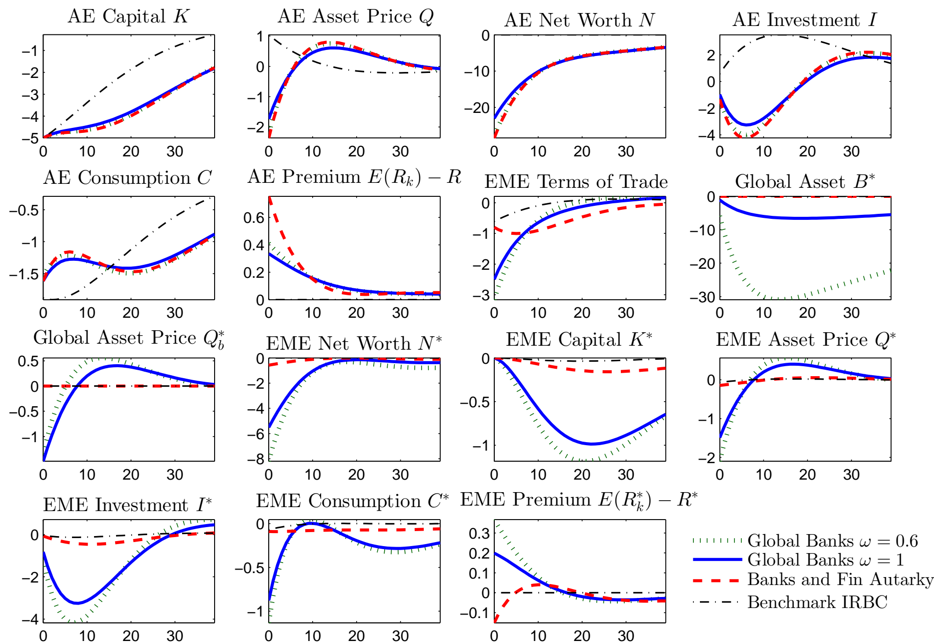

Figure G.1. Impulse Responses to a 5% Decrease in Ψ_t, Model Comparison with Global Banks

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

tic 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 model similar 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 by how much they can borrow, there is a fire-sale 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 characteristic of the crisis period. The expected rate of return on capital increases because of the fall in capital.

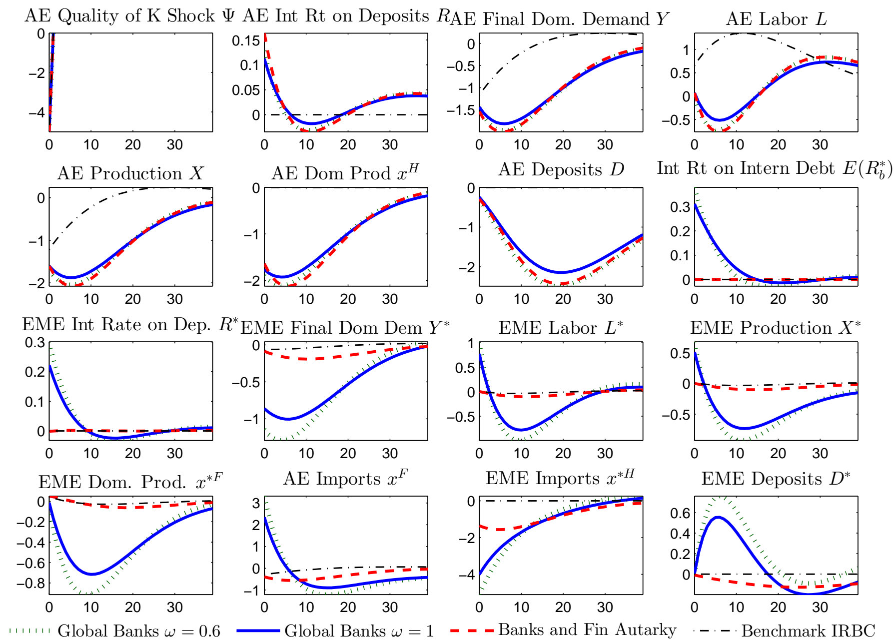

Figure G.2. Impulse Responses to a 5% Decrease in Ψ_t, Model Comparison with Global Banks, Large Set of Variables

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

The AE production and consumption shrink. There are fewer 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 EME households to cut down on consumption which prompt a decrease in EME capital, net worth of the banks, and sset 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.

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. 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. 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 (D.51).

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 implies a country-specific premium, but it does not imply a risk.

The last model that we include in the Figure is the one with risky EME banks. The only difference in the calibration between this model and the previous one is ω. The transmission mechanism works in the same fashion to the model with global banks and $\omega = 1$, however, we have an additional friction. EME banks might run away with funds from AE banks. Then, after the shock, AE banks reduce lending to the EME more than in the previous case. This constrains more EME banks and their net worth drops more, following a further decrease in the domestic credit and the asset price. The spread widens even more than in the previous framework and households cut more their consumption. The financial instability is larger in the model with risky banks than in the one with safe banks.

H Additional Graphs

H.1 No Policy Response

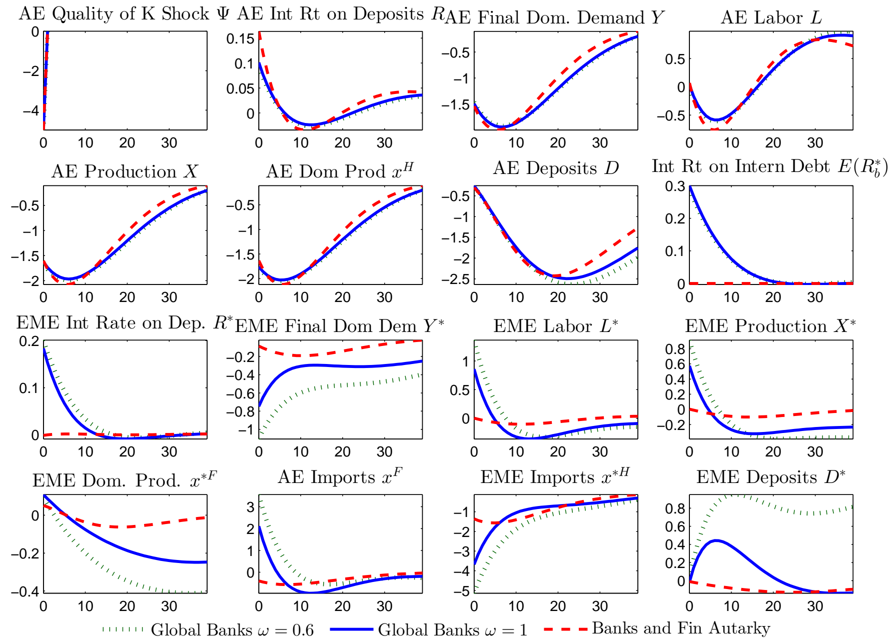

Figure H.1. Impulse Responses to a 5% Decrease in Ψ_t, Model Comparison with Risky Banks, Large Set of Variables

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

H.2 Policy Response

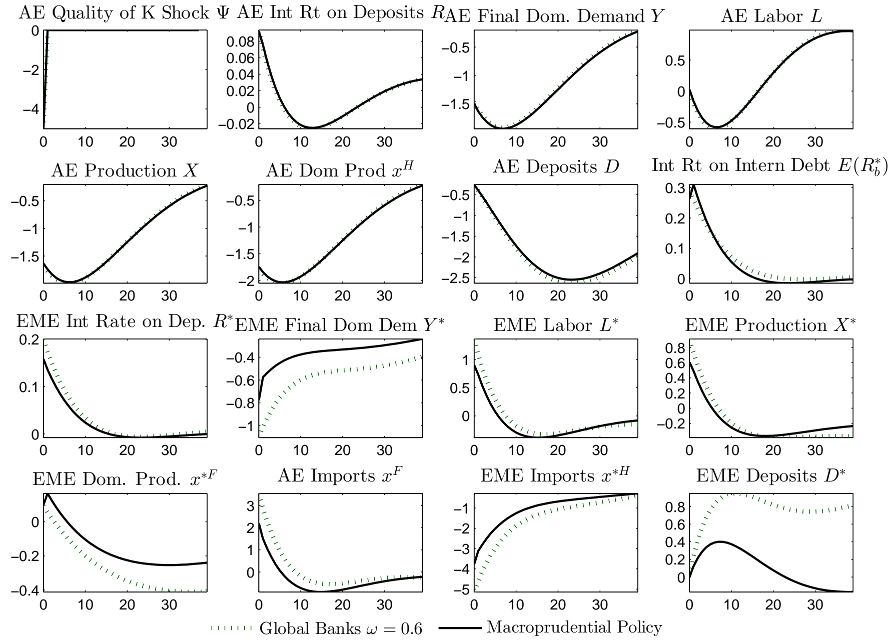

Figure H.2. Impulse Responses to a 5% Decrease in Ψ_t, Macro-prudential Policy by EME Central Bank, Large Set of Variables

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