Risky Banks and Macroprudential Policy for Emerging Economies

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*Gabriel Cuadra**[*] *Victoria Nuguer*[†‡]

Banco de México *Banco de México*

Abstract

We develop a two-country DSGE model with global banks (financial intermediaries in one country lend to banks in the other country) in order to understand the consequences of cross-border banking flows from the United States to emerging market economies (EME). Moreover, we look at the role of EME' macroprudential policy on mitigating the financial instability that the volatility of cross-border banking flows might cause. Banks in both countries are financially constrained on how much they can borrow from households. EME' banks might also be constrained on how much they can borrow from U.S. banks because EME' banks can be risky. A negative shock to the value of the capital in the United States generates a global financial crisis through the cross-border banking flows with outflows for the EME. Unconventional credit policy helps to mitigate the effects of a financial disruption and causes inflows for the EME. Macroprudential policy targeting non-core liabilities carried out by the EME helps to resilience the domestic economy to cross-border capital flows and makes EME households better off.

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[*]Address: Banco de México, Dirección General de Investigación Económica, Calle 5 de Mayo #18, 06059 Ciudad de México, México; e-mail:gcuadra@banxico.org.mx.

[†]Address: Banco de México, Dirección General de Investigación Económica, Calle 5 de Mayo #18, 06059 Ciudad de México, México; e-mail: vnuguer@banxico.org.mx.

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1 Introduction

Financial liberalization and progress in communication and information technologies have triggered a significant increase in the degree of interconnectedness among financial institutions, investors, and markets at an international level. In principle, these developments have allowed a more efficient allocation of resources and risk across countries and economic agents. However, this increased interdependence process has also led to a faster transmission of financial shocks across economies. In particular, it has increased the exposure of emerging market economies (EMEs) to financial shocks originated in advanced economies. For example, the financial crisis of 2007-2009 originated in the U.S. housing sector and spread to a number of economies that had investments in the United States and also to those that received investment from the United States, such as EMEs. In the aftermath of the global financial crisis, the role of macro-prudential policies as measures to preserve financial stability has been widely discussed among scholars and policy makers in recent years. In this context, we build a two-country model (advanced and emerging economies) to study the role of global financial intermediaries (banks that interact with other banks across international borders) in explaining the international transmission of financial shocks from advanced economies to EMEs. Furthermore, we look at the effects of U.S. unconventional policy for EMEs and how macro-prudential policies help to reduce financial instability in EMEs.

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

It is important to remark that the crisis to EMEs was not only transmitted by global banks. The trade effect was the most important channel of transmission of the financial crisis for these countries, especially because the EMEs' banks did not hold U.S. mortgage backed securities and in general the financial deepness is low in comparison with advanced economies. 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 hadn't implemented macro-prudential until the discussion of the Basel Agreements.

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

In this setting, loose monetary conditions in major advanced economies, such as the United States, contributed to an episode of large capital flows to EMEs. The magnitude and speed at which these financial flows move raised some financial stability concerns in the recipient economies, Sánchez (2013) and Powell (2013). 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, several empirical studies find that episodes of large capital inflows increase the probability of credit booms. There are different channels through which capital inflows may contribute to a credit expansion. There is a direct link between these inflows and credit boom in those cases when financial inflows take the form of bank loans and are intermediated through domestic banks. Hence, some countries experienced growing financial imbalances.

On June 2013, the Federal Reserve announced that they would start the tapering of some of the unconventional policies (in particular quantitative easing) contingent on positive economic data. This news prompted a decrease in U.S. stock markets. Capital started to flight back to advances economies, 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. Therefore, 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. The main concerns are debt (portfolio) flows and cross-border bank lending because they might cause financial instability in EMEs, BIS (2010b).

In light of the exposure of these economies to financial shocks originated in advanced economies, authorities must design and implement policy actions aimed at reducing financial stability risks. In this setting, a key issue concerns the role of macro-prudential policies in addressing these risks. Macro-prudential policies are thought to limit the risk of widespread disruptions to the provision of financial services that have negative consequences for the economy. It focuses on the interactions between the financial and the real sector, and not just individual banks. Macro-prudential instruments are mainly prudential tools that target the sources of systemic risk (FSB, IMF, and BIS, 2011). In principle, these instruments strengthen the resilience of the financial markets and institutions they

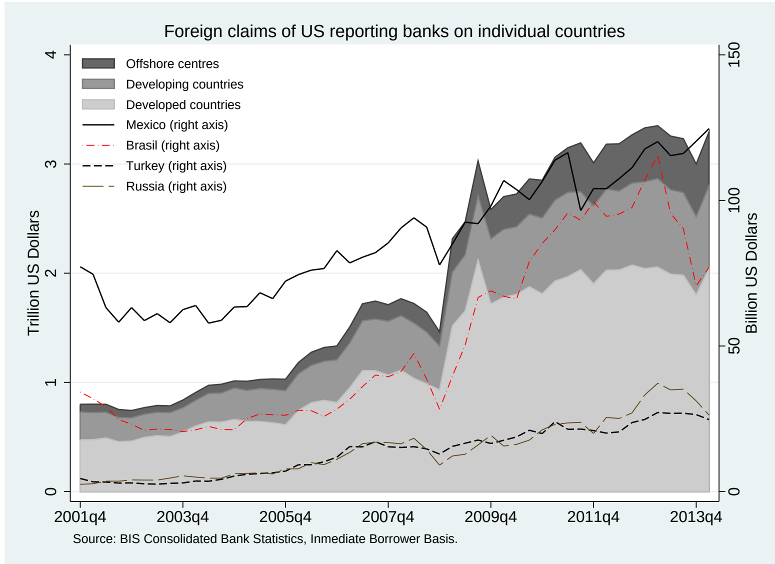

Fig. 1. Foreign Claims of U.S. Reporting Banks on Individual Countries, 1999Q4-2014Q1

target. Although there is no conclusive evidence, the empirical literature supports the effectiveness of macro-prudential tools in dampening procyclicality in financial markets, particularly when those tools target banks. Under this framework macro-prudential policies in EMEs can help to control the financial volatility (and therefore, the real economy volatility) that foreign exposure might cause. That is, EMEs have tools to limit the effects of external shocks on the financial system. Summing up, the financial crisis and the periods of financial turmoil in mid-2013 and early 2014, reminded us that financial instability in EMEs is a risk that policy makers should be aware of and macro-prudential policy is one tool on helping to reduce it.

Figure 1 documents the foreign claims of U.S. banks by EMEs from 2001Q4 until 2014Q1. Developing economies correspond to 26% of the total of foreign claims as an average of the sample. Mexico is the non-advanced economy that receives the most foreign claims from U.S. reporting banks, in terms of Mexican GDP they are on average almost 9% points and they are 5% of the total foreign claims of U.S. banks. The sum of foreign U.S. claims on Brazil, Mexico, Turkey, and Russia is on average 5% of the total GDP of those countries. Foreign claims shows 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 tendency of where the claims of U.S. banks are going, but Mexico, Brazil, Russia, and Turkey show some level of slowdown.

To understand better the transmission through banks of the financial crisis from the United States to EMEs, we estimate a VAR. Figure 2 shows the orthogonalized impulse responses functions from a VAR with one lag with U.S. and two EMEs data: Mexico (solid gray line) and Turkey (dashed blue line). The core VAR consists of six variables: real net charge-offs on all loans and leases of U.S. banks, the S&P500 index, real foreign U.S. banks' claims with EME counterparties, real EME GDP, real EME banks' credit to the private non-financial sector, exchange rate of EME domestic currency per U.S. dollar, and the EME stock market index. For Mexico, the data goes from 2002Q1 to 2013Q4. And for Turkey the data goes from 2001Q3 to 2013Q3.[1] 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.[2]

The VAR exposes the response to a one-standard deviation innovation to the net charge-offs on all loans and leases in bank credit for all U.S. commercial banks. The shock captures one of the initial characteristics of the financial crisis: the decrease in the value of the U.S. banks' loans. The shock suggests a decrease in the S&P 500 index and a decrease in the loans that U.S. banks make to the EME. Then, the crisis is transmitted to the EME, where the GDP, the total loans to the private non-financial sector and the stock market index fall. The exchange rate between EME domestic currency and U.S. dollar increase suggesting a deterioration of the domestic currency because of the loans flying away from the country. The VAR highlights a significant and negative reaction of the EME (real and financial) economy to a decrease in the U.S. banks' net charge-off on all loans and leases. Furthermore, the co-movement of the stock indexes suggests a strong cross-country relation of the asset prices. While U.S. loans go down because of the shock, the decrease on the loans of U.S. banks to the EME emphasizes the co-movement across countries prompting financial instability in the EME. The two EME show similar response to the initial shock. However, the estimated VAR results on a larger impact on the Turkish economy. This highlights how the Turkish economy, one without macro-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-90s. In this paper, we build a dynamic stochastic general equilibrium model (henceforth DSGE) that explains these interactions.

We propose a two-country (advance and emerging economies) model with global banks and financial frictions to examine the international transmission of a financial crisis through the international debt market. The EME is a relatively small country with a small banking sector, such as Mexico or Turkey, while the advance economy (AE) is a big economy with a big banking sector, such as the United States. The model builds on the closed economy

[1] See Appendix for the definition and the sources of the data. we use Mexican banks' credit to the private non-financial sector and not the new loans of Mexican banks because the former starts before. Moreover this data is comparable to the one for Turkish banks.

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

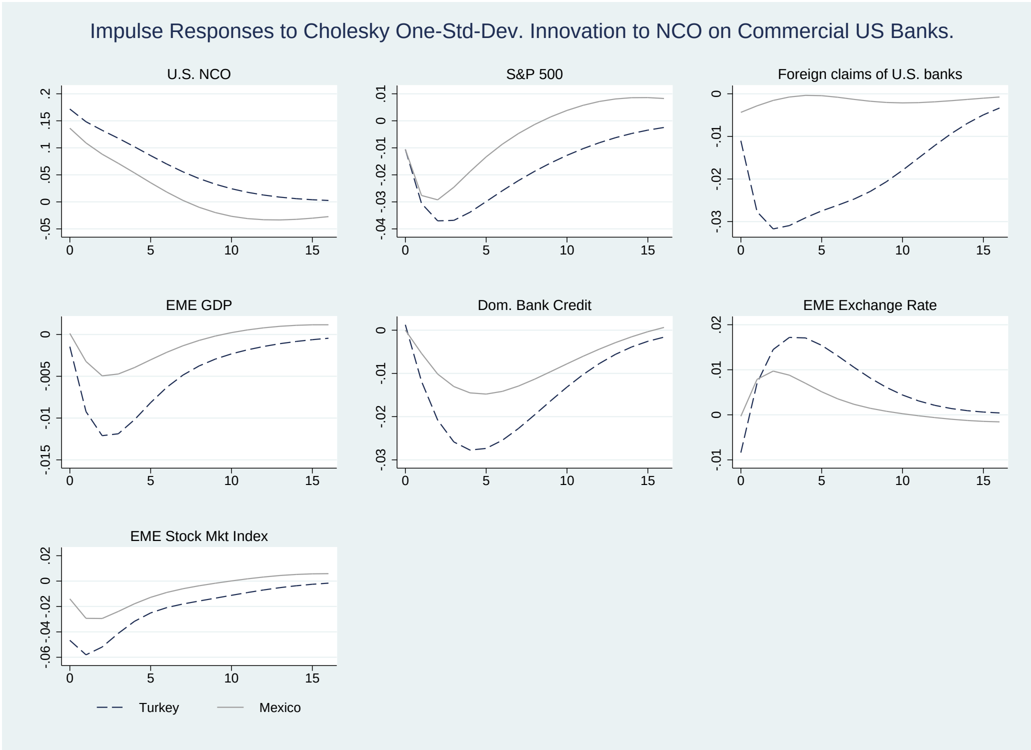

Fig. 2. VAR Evidence

Note: Mexican VAR estimated for 2002Q1 to 2013Q4. The Cholesky ordering is U.S. net charge-offs, S&P500, U.S. banks' foreign claims on Mexican banks, Mexican GDP, Mexican banks credit to the private non-financial sector, exchange rate of Mexican pesos per U.S. dollar and the Mexican stock market index. Turkish VAR estimated for 2001Q3 to 2013Q3. The Cholesky ordering of the variables is similar to the Mexican case. The vertical axis shows the percent deviation from the baseline.[a]

[a] Country VAR estimated with 1 standard deviations confident intervals are available by request. The results are robust to this specification.

models of Gertler and Kiyotaki (2010) and Gertler and Karadi (2011) and the open economy set up of Nuguer (2014). There are advance and emerging banks. They use their net worth and local deposits to finance domestic non-financial business. Although banks can finance local businesses by buying their securities without friction, they face a financing constraint in raising deposit 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 international debt and effectively participate in risky finance in the EME market.

As in the previous literature (Gertler and Kiyotaki (2010), Gertler and Karadi (2011), and Gertler, Kiyotaki, and Queralto (2012)), we simulate the model giving a negative shock to the value of capital, the so-called quality of capital shock. When there is a reduction in the value of capital and securities in the United States, both U.S. and EME banks lose some of their net worth. Because banks are constrained in raising deposits, they have to reduce financing businesses, which further depresses the value of securities and the banks' net worth. EME banks are affected because U.S. banks have to reduce how much they lend to the EME. The EME banks' net worth falls. Then, EME banks have to reduce providing loans to domestic firms because their liability side is shrinking and they are financially constrained. Therefore, the adverse shock in the larger economy leads to a decline in the asset price, investment, and domestic demand in both economies through the international debt.

First, we examine how a country-specific quality of capital shock is transmitted internationally. By looking at different models, we argue that the model with global banks is the only one that is able to replicate the facts shown in the VAR. We compare a model without financial frictions with a model with financial frictions but without global banks, à la Gertler and Kiyotaki (2010). Countries in these two models are in financial autarky. In these models there is very little transmission of the financial crisis which is due to the trade channel. Then, we allow for an international asset, that we call international or foreign debt. When EME banks are allowed to borrow from AE banks, the international asset insures the AE economy against the shock. We study two cases. One in which there are no financial frictions for EME banks to borrow from the AE and the other one in which there is certain level of friction. When there are no financial frictions on borrowing from AE banks, EME banks are considered safe by the AE banks and there is perfect integration of the domestic assets markets. In comparison to the financial autarky case, integration amplifies the transmission of the crisis and prompts a global financial crisis. To a quality of capital shock in the AE, the model shows similar characteristics to the VAR evidence: there is asset price co-movement across countries, AE banks decrease how much they lend to EME banks, and the AE experiences a decrease in the final domestic demand. When there are financial frictions on borrowing from AE banks, there are risky EME banks. The transmission of the financial crisis to the EME is qualitatively similar to the case of safe EME banks, however there is an extra source of friction and the crisis in the EME is deeper in the latest case. Macro-prudential regulation targets this friction.

Next, we turn to policy analysis during a crisis. We focus on macro-prudential regulation in the EME. The main purpose of the regulation is to smooth the effect of external shocks that hit the EME's financial system. Because the transmission mechanism works through the cross-border banking flows, we target the volatility that comes from it. Therefore, the policy targets the ratio of the international asset with respect to banks' capital. EME banks pay a tax when they deviate from the steady state value of the ratio. 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 abroad to the EME, limiting the negative consequences for the small economy. This regulation prompts a cost for the banks to move their foreign liabilities. Therefore, whenever there is a shock the international asset reacts less and the transmission of the shock is mitigated. Banks experience a smoother reaction of their net worth with capital, investment, and asset price falling less. EME households cut less their consumption and labor is smoother; EME households are better off. Because the income from the international asset decreases, EME banks invest more domestically. The policy manages to control the dynamics of the spread too. The AE is not affected by the EME's macro-prudential regulation. EME consumers are better off with the policy than without it.

We also look at the effects of unconventional monetary policy in the AE. In particular, we look at equity injections: provision of direct financing to banks by buying part of their total net worth. The policy prompts a higher price of the domestic asset relaxing the AE banks' constraint. We assume that there is no information asymmetry between the government and the banks, as opposed to the households and the banks. The policy smooths the impact of the shock on the AE and so it also helps the EME on diminishing the effects of the initial shocks by a lower reduction on the price and the quantities of the cross-border banking flows.

What is new in this framework is the study of the international transmission mechanism of a financial crisis through international debt with constrained financial intermediaries and the introduction of a 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 Figure 2. These co-movements are exacerbate by the introduction of a financial friction for EME banks to borrow from AE banks. There is international co-movement of asset prices, the banks' net worth, and total final demands. Moreover, the macro-prudential regulation protects the EME from external shocks.

The rest of the paper is organized as follows. In the next section, we describe in detail the full model. In Section 3, we explain the unconventional credit policy carried out by the AE. In Section 4, we present the macro-prudential policy in the EME. Section 5 studies the effects of the AE quality of capital shock. We examine the model with and without policy response from the AE and the EME and the welfare implications of the EME macro-prudential policy. We conclude in Section 6.

2 The Model

The model builds on the work of Gertler and Kiyotaki (2010) and Nuguer (2014). Our focus as in Nuguer (2014) is on the international transmission of a simulated financial crisis. However, in this paper we look at countries that are net borrowers from the U.S. and face a premium for borrowing from the U.S., such as EME. In particular, we introduce foreign debt and imperfect global integration of the capital markets; they both contribute to the international spillover of the crisis. Then, we look at unconventional monetary policy in the AE and macro-prudential policy in the EME.

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

2.1 Physical Setup

There are two countries in the world: advance economy (AE) and emerging economy (EME). Each country has a continuum of infinitely lived households. In the global economy, there is also a continuum of firms of mass unity. A fraction m corresponds to the AE, while a fraction $1-m$ to the EME. Using an identical Cobb-Douglas production function, each of the firms produces output with domestic capital and labor. Aggregate AE capital, K_t, and aggregate AE labor hours, L_t, are combined to produce an intermediate good X_t in the following way:

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

where A_t is the productivity shock.

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 taking into account the quality of capital shock, Ψ_{t+1},

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

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

As in Heathcote and Perri (2002), there are local perfectly competitive distributor firms that combine domestic and imported goods to produce final goods. 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. The parameter ν is a function of the size of the economy and the degree of openness, λ: $\nu = 1-(1-m)\lambda$ (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

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

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

In Appendix B, we define the competitive equilibrium of the frictionless economy which is the benchmark when comparing the different models with financial frictions. It is a standard international real business cycle model in financial autarky with trade in goods. Next, we add financial frictions.

2.2 Households

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

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

$$C_t + D^h_{t+1} = W_t L_t + R_t D^h_t + \Pi_t - T_t, \tag{7}$$

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

$$L_t: \qquad \tfrac{W_t}{C_t} = \chi L_t^{\gamma} \tag{8}$$

$$D^h_{t+1}: \quad E_t R_{t+1} \beta \tfrac{C_t}{C_{t+1}} = E_t R_{t+1} \Lambda_{t,t+1} = 1 \tag{9}$$

with $\Lambda_{t,t+1}$ as the stochastic discount factor.

2.3 Non-financial firms

2.3.1 Goods producers

Intermediate competitive goods producers operate at a local level with constant returns to scale technology with capital and labor as inputs, given by Equation (1). Wage is defined by

$$W_t = (1-\alpha) P^H_t K^{\alpha}_t L_t{}^{-\alpha} \quad \text{with } P^H_t = \nu^{\frac{1}{\eta}} Y_t^{-1} \left(X^H_t\right)^{-\frac{1}{\eta}}. \tag{10}$$

The price of the final AE good is equalized to 1. The gross profits per unit of capital Z_t are

$$Z_t = \alpha P^H_t L^{1-\alpha}_t K_t{}^{\alpha-1}. \tag{11}$$

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

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

$$X_t = X^H_t + \frac{1-m}{m} X^{H*}_t \tag{12}$$

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

$$X^H_t = \nu \left[\frac{P^H_t}{P_t}\right]^{-\eta} Y_t \tag{13}$$

and

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

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

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

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

2.3.2 Capital producers

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

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

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

$$Q_t = 1 + f\left(\frac{I_t}{I_{t-1}}\right) + \frac{I_t}{I_{t-1}} f'\left(\frac{I_t}{I_{t-1}}\right) - E_t\Lambda_{t,t+1}\left[\frac{I_{t+1}}{I_t}\right]^2 f'\left(\frac{I_{t+1}}{I_t}\right). \tag{14}$$

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

2.4 Banks

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

To motivate cross-border banking flows, we assume that the survival rate of the AE banks σ is higher that of the EME banks σ^*. Then, the AE banks can accumulate more net worth to operate. 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 retain earnings from previous periods which we call net worth n_t; it decides how much to lend to non-financial firms s_t. AE banks also choose how much to lend to EME banks b_t.

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

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

2.4.1 Advance 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 (11).

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 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 reclaim the remained $1-\theta$ fraction of assets. Let $V_t(s_t, b_t, d_t)$ be the maximized value of V_t, given an asset and liability configuration at the end of period t. The following incentive constraint must hold for each individual bank to ensure that the bank does not divert funds:

$$V_t(s_t, b_t, d_t) \geq \theta(Q_t s_t + Q_{bt} b_t). \tag{15}$$

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

$$V(s_{t-1}, b_{t-1}, d_{t-1}) = E_{t-1}\Lambda_{t-1,t}\left\{(1-\sigma)n_t + \sigma\left[\max_{s_t,b_t,d_t} V(s_t, b_t, d_t)\right]\right\}. \tag{16}$$

The problem of the bank is to maximize Equation (16) subject to the borrowing constraint, Equation (15).

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

$$V(s_t, b_t, d_t) = \nu_{st}s_t + \nu_{bt}b_t - \nu_t d_t, \tag{17}$$

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

Maximizing the objective function (16) subject to (15), with λ_t as the constraint multiplier, yields the following first order conditions:

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

Rearranging terms yields:

$$(\nu_{bt} - \nu_t)(1+\lambda_t) = \lambda_t\theta Q_{bt} \tag{18}$$

$$\left(\frac{\nu_{st}}{Q_t} - \frac{\nu_{bt}}{Q_{bt}}\right)(1+\lambda_t) = 0 \tag{19}$$

$$\left[\theta - \left(\frac{\nu_{st}}{Q_t} - \nu_t\right)\right]Q_t s_t + \left[\theta - \left(\frac{\nu_{bt}}{Q_{bt}} - \nu_t\right)\right]Q_{bt}b_t = \nu_t n_t. \tag{20}$$

From Equation (19), we verify that the marginal value of lending in the international market is equal to the marginal value of assets in terms of AE final good. Let μ_t be the excess value of a unit of assets relative to deposits, Equations (18) and (19) yield:

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

Rewriting the incentive constraint (20), we define the leverage ratio net of international borrowing as

$$\phi_t = \frac{\nu_t}{\theta - \mu_t}. \tag{21}$$

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

$$Q_t s_t + Q_{bt} b_t = \phi_t n_t. \tag{22}$$

The last equation establishes how tightly the constraint is binding. The leverage has negative co-movement with the fraction that banks can divert and positive with the excess value of bank assets.

We verify the conjecture regarding the form of the value function using the Bellman equation (16) and the guess (17). For the conjecture to be correct, the cost of deposits and the excess value of bank assets have to satisfy:

$$\nu_t = E_t \Lambda_{t,t+1} \Omega_{t+1} R_{t+1} \tag{23}$$

$$\mu_t = E_t \Lambda_{t,t+1} \Omega_{t+1} \left[R_{kt+1} - R_{t+1} \right], \tag{24}$$

where the shadow value of net worth at $t+1$ is

$$\Omega_{t+1} = (1-\sigma) + \sigma(\nu_{t+1} + \phi_{t+1}\mu_{t+1}) \tag{25}$$

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

$$R_{kt+1} = \Psi_{t+1} \frac{Z_{t+1} + Q_{t+1}(1-\delta)}{Q_t}. \tag{26}$$

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

Then, from Equation (23), 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 (24), the excess value of a unit of assets relative to deposits is the expected value of the product of the augmented stochastic discount factor and the difference between the risky and the risk free rate of return, $R_{kt+1} - R_{t+1}$. The spread is also counter-cyclical.

From Equation (18)

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

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

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

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. Banks are indifferent between providing funds to non-financial AE firms and to EME banks because the expected return on both assets is equalized. Next, we turn to the EME banks problem.

2.4.2 Emerging Market Economy Banks

The problem of the EME banks is similar to the one from the AE banks, except that now the international asset, b_t^*, is a liability,

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

The net worth of the bank can also be thought of in terms of payoffs; then, the total net worth is the payoff from assets funded at $t-1$, net of borrowing costs which include the international loans,

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

EME banks can be riskier for an AE bank because they can divert a fraction $\theta\omega$ of the funds borrowed from the larger economy. If an EME bank runs away, AE banks can recover the fraction $(1-\theta)(1-\omega)$ of international debt. EME banks are also constrained on obtaining funds from EME households. Then, $V_t^*(s_t^*, b_t^*, d_t^*)$ is the maximized value of V_t^*, given an asset and liability configuration at the end of period t. The following incentive constraint must hold for each individual bank to ensure that a bank does not divert funds,

$$V_t^*(s_t^*, b_t^*, d_t^*) \geq \theta^* (Q_t^* s_t^* - \omega Q_{bt}^* b_t^*), \tag{28}$$

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

$$\frac{\nu_{st}^*}{Q_t^*} = \left[\frac{\nu_{bt}^*}{Q_{bt}^*} - (1-\omega) \nu_t^* \right] \frac{1}{\omega}. \tag{29}$$

If $\omega = 1$, EME banks cannot run away with international debt and the second term in brackets in the RHS is zero, therefore there is perfect asset market integration. In terms of returns:

$$E_t \Lambda^*_{t,t+1} \Omega^*_{t+1} R^*_{kt+1} = E_t \Lambda^*_{t,t+1} \Omega^*_{t+1} R^*_{bt+1}. \tag{30}$$

On the other hand if $0 < \omega < 1$, the second term inside the brackets in the RHS of Equation (29) is positive. 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 C, we show that if $\mu^*_t = \frac{\nu^*_{st}}{Q^*_t} - \nu^*_t$ and $\mu^*_{bt} = \frac{\nu^*_{bt}}{Q^*_{bt}} - \nu^*_t$,

$$\mu^*_{bt} = \omega \mu^*_t. \tag{31}$$

Therefore, when $\omega = 1$ ($0 < \omega < 1$) the expected discounted rate of return on international debt is equal to (less than) the expected discounted rate of return of loans to non-financial EME firms. 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 (27). Then, the AE loan market and the EME loan market behave in a similar way. This is the integration of the asset markets. When $0 < \omega < 1$, the rates equalized but there is an extra term, and that is why we call this case imperfect asset market integration; EME banks face an extra friction.

With Ω^*_{t+1} as the shadow value of net worth at date $t+1$, and R^*_{kt+1} as the gross rate of return on bank assets, after verifying the conjecture of the value function:

$$\nu^*_t = E_t \Lambda^*_{t,t+1} \Omega^*_{t+1} R^*_{t+1}, \tag{32}$$

$$\mu^*_t = E_t \Lambda^*_{t,t+1} \Omega^*_{t+1} \left[R^*_{kt+1} - R^*_{t+1} \right], \text{ and} \tag{33}$$

$$\mu^*_{bt} = E_t \Lambda^*_{t,t+1} \Omega^*_{t+1} \left[R^*_{bt+1} - R^*_{t+1} \right] \tag{34}$$

with

$$\Omega^*_{t+1} = 1 - \sigma^* + \sigma^* \left(\nu^*_{t+1} + \phi^*_{t+1} \mu^*_{t+1} \right),$$

$$R^*_{kt+1} = \Psi^*_{t+1} \frac{Z^*_{t+1} + Q^*_{t+1}(1-\delta)}{Q^*_t}, \text{ and} \tag{35}$$

$$R^*_{bt+1} = \frac{Z^*_{t+1} + Q^*_{bt+1}(1-\delta)}{Q^*_{bt}}. \tag{36}$$

2.4.3 Aggregate Bank Net Worth

Finally, aggregating across AE banks, from Equation (22):

$$Q_t S_t + Q_{bt} B_t = \phi_t N_t. \tag{37}$$

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

$$D_t = N_t(\phi_t - 1). \tag{38}$$

Furthermore,

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

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

For EME banks, the aggregation yields

$$N_t^* = (\sigma^* + \xi^*)R_{k,t}^*Q_{t-1}^*S_{t-1}^* - \sigma^* R_t^* D_{t-1}^* - \sigma^* R_{bt}^* Q_{bt-1}^* B_{t-1}^*, \tag{40}$$

where R_{bt}^* equals R_{kt}^*, from Equation (30). The balance sheet of the aggregate EME banking system can be written as

$$Q_t^* S_t^* - \omega Q_{bt}^* B_t^* = \phi_t^* N_t^*. \tag{41}$$

EME households deposits are given by

$$D_t^* + (1-\omega)Q_{bt}^* B_t^* = N_t^*(\phi_t^* - 1). \tag{42}$$

2.4.4 Cross-border banking flows

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

The small economy is an EME, therefore we assume that EME banks need to pay a premium on borrowing from AE banks. Following Schmitt-Grohé and Uribe (2003), the interest rate payed by EME banks on the international debt is debt elastic. Specifically, Equation (27) becomes

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

The new term in Equation (43) 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.

Regarding the interest rate, the return on loans to EME banks made by AE banks is $E_t(R_{bt+1}) = E_t(R_{bt+1}^* \frac{\varepsilon_{t+1}}{\varepsilon_t})$. The rate on international debt is equalized to the return on loans to AE firms, R_{kt}, in expected terms plus a risk premium, as in Equation (43); 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 (30) 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 (29).

2.5 Equilibrium

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

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

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

Then for the intermediate-competitive goods market,

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

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

$$\chi L_t^{\gamma} = (1-\alpha)\frac{X_t}{L_tC_t} \quad \text{and} \quad \chi L_t^{*\gamma} = (1-\alpha)\frac{X_t^*}{L_t^*C_t^*}. \tag{47}$$

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

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

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

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

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

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

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

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

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

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

3 Unconventional Policy

In 2008, the Fed started to intervene in different markets as lender of last resort to increase credit flows in the economy. The measures were taken under an extraordinary setting, namely, the financial crisis. From among the policies that the Fed carried out, We focus on equity injections in the banking system. The Treasury provided capital facilities to Bear Stearns, JPMorgan Chase, Maiden Lane LLC, American International Group (AIG), Bank of America, and Citigroup. The facilities were under the Troubled Assets Relief Program (TARP) and started after the collapse of Lehman Brothers in September 2008.

In this section, we introduce an interventions carried out by the AE central bank. The policy provides capital directly to banks and corresponds to equity injections; this policy can be related to the TARP program that the Treasury put in action. We build the modeling of the policy on Gertler and Karadi (2011), Gertler and Kiyotaki (2010), Gertler, Kiyotaki, and Queralto (2012), and Dedola, Karadi, and Lombardo (2013).

The extend to which the central bank intervenes is determined endogenously. The level of intervention follows the difference between the spread of the expected return on capital and the deposit rate, and their stochastic steady state level under no-policy:

$$\varphi_t = \nu_g \tau_{gt} \left[E_t(R_{k,t+1} - R_{t+1}) - \left(R_k^{SSS} - R^{SSS} \right) \right], \tag{52}$$

where ν_g is a policy instrument; τ_{gt} follows an AR(1) process when there is a quality of capital shock in the AE; otherwise, it equals zero. This specification contrasts with the policy proposed in the previous literature in two dimensions. First, we target the stochastic steady state premium instead of the deterministic one. The spread is where banks accumulate earnings; by targeting the deterministic steady state, the net worth takes longer to return to its steady state value. In this sense, Kiyotaki (2013) suggests targeting the mean of the ergodic distribution of the variables taking into account the distribution of the shocks. Second, the policy is only active when there is a quality of capital shock in the AE, while in the other papers the policy is active when the premium is different from its deterministic steady state, even if it is coming from a productivity shock.

We assume that $\tau_{gt} = \rho_{\tau_g}\tau_{gt-1} + \varepsilon_{\Psi,t}$, where $\varepsilon_{\Psi,t}$ is the same exogenous variable that drives the AE quality of capital shock.

The policies are carried out only by the policy maker of the country directly hit by the shock. Next, we describe the policy.

3.1 Equity Injection

Under this policy, the central bank gives funds to AE banks and the banks then decide how to allocate these extra resources optimally. The quantity of funds that the government provides is a fraction of the total assets of AE banks, $\mathcal{N}_{gt} = \varphi_t Q_t S_t$. The net worth of the AE banking system is set to be

$$N_t = (\sigma + \xi)\left[Z_t + (1-\delta)Q_t\right]K_t - \sigma R_t D_{t-1} - \sigma R_{bt} Q_{bt-1} B_{t-1} - \sigma R_{gt} \mathcal{N}_{g,t-1}.$$

Redefining Equation (37) yields

$$Q_t S_t = \phi_t N_t + \mathcal{N}_{gt} + Q_{bt} B_t. \tag{53}$$

The interest rate paid to the government is equal to the interest rate on capital.

3.2 Government

Consolidating monetary and fiscal policy, total government expenditure is the sum of consumption, G_t, loans to firms, $\mathcal{S}_{gt}$ (or total intervention), and debt issued last period, $R_t\mathcal{D}_{gt-1}$. Government resources are lump sum taxes, T_t, new debt issued, $\mathcal{D}_{gt}$, and the return on the intervention that the government made last period. The budget constraint of the consolidated government is

$$G_t + \mathcal{N}_{gt} + R_t \mathcal{D}_{gt-1} = T_t + \mathcal{D}_{gt} + \sigma R_{gt} \mathcal{N}_{g,t-1}.$$

The debt that government issues is a perfect substitute of the deposits to banks, therefore, the rate that they pay is the same and households are indifferent between lending to banks and to the government. Government expenditure includes a constant fraction of total output and a cost for each unit of intervention issued,

$$G_t = \tau_{1S}\mathcal{N}_{gt} + \tau_{2S}\mathcal{N}_{gt}^2 + \bar{g}Y.$$

The efficiency cost are quadratic on the intervention of the central bank, as in Gertler, Kiyotaki, and Queralto (2012).

4 Macro-prudential Policy

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

Many EME implemented macro-prudential regulation at the end of the 90s due to several EME crisis. The tools that EME have been using are mainly of the type (2) of the IMF, i.e. flexible instruments that vary according to the different systemic risks, Castillo, Quispe, Contreras, and Rojas (2011). EMEs have strengthening the regulatory framework with respect to maturity mistmatches on the balance sheets of financial institutions, limit short-term foreign borrowing, and strengthening 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 macro-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 the same rules and supervisor processes.

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

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 foreign currency liabilities). The levy rates varies according to the maturity of the liability. The effects contributed to reduce banks' foreign borrowings and improving their maturity structures. (Kim, 2014 and Shin, 2010)

In this section, we introduce one possible macro-prudential tool in line with the Korean experience. 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 international asset.

Moreover, the international contagion is deeper when there is a friction for EME banks on obtaining funds from AE banks because the former can run away with part of the international asset, i.e. $0 < \omega < 1$. This is exactly the friction that the macro-prudential policy targets because is the source of financial instability for the EME.

The policy is a tax on deviations from the steady state of the ratio of the global asset with the EME banks' capital,

$$\vartheta^*_{gt} \quad = \quad \tau^*_g \left(\frac{Q^*_{bt} B^*_t}{N^*_t} - \frac{Q^*_b B^*}{N^*} \right)^2 . \tag{54}$$

How big the tax is has an exogenous (arbitrary) component τ^*_g and an endogenous one that corresponds to the brackets. In Section 5.4 we do a welfare analysis for the different levels of τ^*_g. The tax goes directly into the incentive compatibility constraint, Equation (28), changing the perception of how risky EME banks are for AE banks. Therefore, the constraint with the policy becomes

$$V_t(s^*_t, b^*_t, d^*_t) \geq \theta^* \left[Q^*_t s^*_t - (1 + \vartheta^*_{gt}) \omega Q^*_{bt} b^*_t \right]. \tag{55}$$

When the value of the ratio moves away from its steady state, the tax becomes positive and banks are perceived as with a lower friction because of the macro-prudential policy. No matter in which direction, EME banks are perceived as safer due to the policy. Quantities move smoother with the policy because of this adjustment cost.

The net worth of EME banks becomes

$$N^*_t = (\sigma^* + \xi^*) R^*_{kt} Q^*_{t-1} S^*_{t-1} - \sigma^* \left[R^*_t D^*_{t-1} + (1 + \vartheta^*_{gt}) R^*_{bt} Q^*_{b,t-1} B^*_{t-1} \right].$$

Finally, the government budget constraint of the EME is

$$G^*_t = T^*_t + \mathcal{D}^*_{gt} + \vartheta^*_{gt} Q^*_{bt} B^*_t.$$

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

5 Crisis experiment

In this section, we present numerical experiments to show how the model captures key aspects of the international transmission of a financial crisis. First, we present the calibration; next, we analyze a crisis experiment without response from the government and we highlight the role of the foreign debt in the transmission of the crisis and how it works as insurance for the economy that is hit by a shock. Next, we study how credit market intervention by the AE central bank can mitigate the effects of the crisis. Finally, we look at macro-prudential policy carried out by the EME and its combination with the unconventional monetary policy of the AE.

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

Tab. 1. Calibration

5.1 Calibration

The calibration is specified in Table 1. The parameters that correspond to the non-financial part of the model, i.e. households and non-financial firms, follow the literature. The discount factor, β is set to 0.99, resulting in a risk free interest rate of 1.01% at the steady state. The inverse of the Frisch elasticity of labor supply, γ, and the relative weight of labor in the utility faction, χ, are equal to 0.1 and 5.584, respectively. The capital share in the production of the intermediate good, α, is 0.33 and the parameter in the adjustment cost in investment, κ, equals 3. The depreciation rate of capital is 2.5% quarterly.

With respect to the parameters that enter into the CES aggregator, we choose η and we calibrate ν to match the Mexican data. The elasticity of substitution between the AE and the EME goods in the production of the final good, η, is set to be greater than one. This implies substitutability between domestic and foreign goods. The home bias, ν, is defined by the size of the AE and the degree of openness. We calibrate them to match the ratio of U.S. exports to Mexico with Mexican final domestic demand as an average between 1999Q4 and 2013Q4.

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

5.2 No policy response

5.2.1 Safety EME Banks $\omega = 1$

Figure 3 shows the impulse responses to a decline in the AE quality of capital of 5% in period t comparing three models. The first model is one without financial frictions and in financial autarky and is the green thick dash-dotted line. The second model has financial frictions but no trade in assets, and is the blue solid line. The financial frictions are à la Gertler and Kiyotaki (2010). The third model is with financial frictions and an international debt market (financial openness) with no further EME frictions ($\omega = 1$); it is the red thin dashed line. The comparison of these models shows how the transmission mechanism across countries changes given the different assumptions. In the first two models, there is only international spillover due to the trade of intermediate goods. In the third model, we add the international financial mechanism. The comparison helps us understanding the insurance and the transmission role of the international debt market. In Appendix D, we show the complete set of impulse responses functions: AE and EME variables are in Figure 8.

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

The AE cuts back not only the demand for local goods, X_t^H, but also imports, X_t^F. There are fewer AE goods in the economy because of the shock. As a result, every unit of AE good is more expensive and the terms of trade slightly improve (deteriorate) for the AE (EME). The trade balance is defined by Equation (48) and equals zero in every period because there is no international borrowing/lending.

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

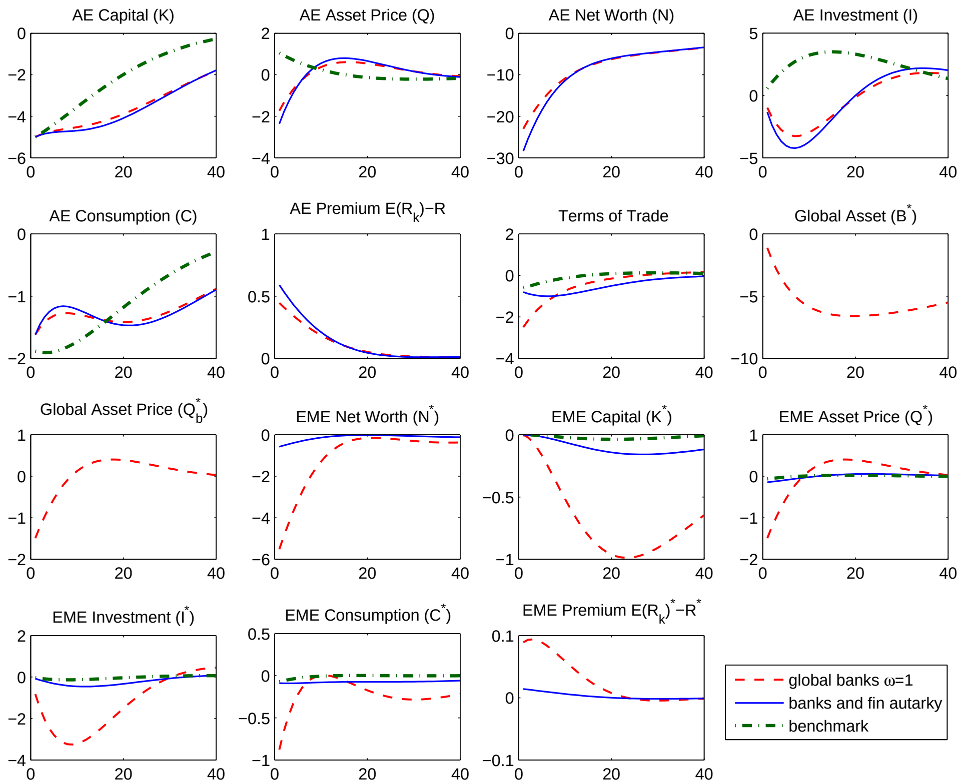

Fig. 3. Impulse Responses to a 5% Decrease in Ψ_t, Model Comparison with Global Banks
y axis: percentage deviation from steady state; x axis: quarters

prices or in production. However, there is co-movement in total demand and consumption, while the terms of trade deteriorate for the AE.

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

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

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

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

The decrease in the value of assets and securities in the AE prompts AE banks to be more financially constrained. The reaction is similar to the model without global banks and is shown by the solid-blue and the thick dashed-red line in Figure 3. The mechanism that takes place for the AE variables is the same in both models with financial frictions. However, final domestic demand is less affected by the shock when there are global banks because the AE can partially pool the country specific shock.

In this model $\omega = 1$, the return on EME assets equalizes the return on EME debt. EME banks face a reduction in their net worth because of a country specific shock in the AE. EME financial intermediaries are more financially constrained and reduce lending to domestic businesses. Investment and the price of capital shrink. The global banks transmit the crisis from the AE to the EME.

Two types of spillovers disturb the EME: the demand and the international debt effects. The demand effect prompts an increase in production because the exchange rate is depreciating. The international debt effect generates a tightening of the EME borrowing constraint because there is a decrease in the value of international lending. The international debt effect predominates and the net worth of EME banks falls and households cut down on consumption. The effect on production vanishes after 3 periods. Global banks imply financial openness, the current account is now defined in Equation (49).

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

5.2.2 Risky EME banks $0 < \omega < 1$

In Figure 4 we compare two models. They differ on the level of riskiness of EME banks with respect to the international asset. The red dashed line is the same model as in Figure 3, the AE banks perceive the EME banks as safe, $\omega = 1$. The black full line is a model in which EME banks are riskier, $0 < \omega < 1$. Given that the small economy is an EME, it is plausible to assume that EME banks are riskier. Figure 9 in Appendix D shows the complete set of AE and EME variables.

The economies show a similar reaction in both cases to an AE quality of capital shock. However, when EME banks can run away with money from AE banks (when EME banks are

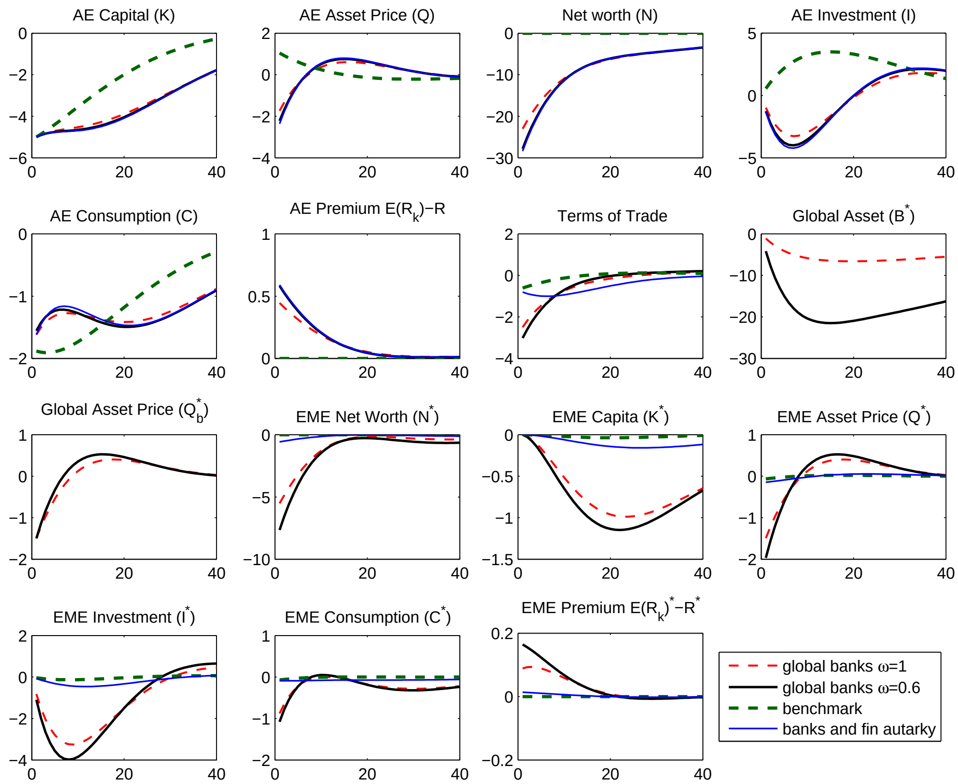

Fig. 4. Impulse Responses to a 5% Decrease in Ψ_t, Model Comparison with Risky Banks
y axis: percentage deviation from steady state; x axis: quarters

riskier) the shock hits harder the EME economy. EME banks are restricted on borrowing from AE banks. This difference in the possibility of running away with money from AE banks prompts a difference in the perception of risk of the EME banks that is also reflected on how the spread on the interest rates of the EME reacts to the shock. The macro-prudential regulation analyzed in the next section targets this new friction of the model.

The AE variables also show a deeper crisis when EME banks are riskier. This is the case because even if the AE does not lend much to the EME, the perception of being riskier hurts the AE.

The qualitative behavior of the model matches the VAR evidence shown in Figure 2. In the data, a decrease in the U.S. loans prompts a decrease in the international debt that is then transmitted to the EME. Total final demand, foreign U.S. dollars denominated loans, credit in the EME, and asset prices fall.

The EME has a larger co-movement with the AE in a framework with financial openness than without it. The EME experiences a crisis because of the quality of capital shock abroad, as shown by the VAR evidence and the model. Moreover, through the international debt market, the AE manages to partially insure itself against the shock. The EME experiences a deeper financial crisis when domestic banks can run away with resources from the AE banks.

5.3 Policy response

5.3.1 Unconventional Monetary Policy

We analyze equity injections. The policy are carried out only by the AE central bank. One of the reasons that motivated the Fed to intervene was the abnormal credit spread in several markets. In this sense, the central bank determines the fraction of private credit to intermediate by following the difference between the risky and the risk free interest rate and its stochastic steady state value, as in Equation (52).

Figure 5 shows a small set of variables with the results; Figure 10 in Appendix D shows more variables. The solid black line is the model with financial frictions and financial openness without policy with risky banks, the same as in the previous figure. The dashed blue line is the model with equity injections. The policy parameter ν_g^* is set to be 10000 and $\rho_{\tau_g^*} = 0.66$. The costs of issuing government loans follow Gertler, Kiyotaki, and Queralto (2012) and the fraction of government expenditure at the steady state matches the data for the United States and Mexico.

The central bank intervention prompts a higher price of the domestic asset than under no intervention. The initial intervention is around 3% of total AE assets. Higher asset price implies that AE banks are less financially constrained. The AE banks' net worth falls almost 10% less than under no-policy. The asset price is also the price of investment, therefore, investment contraction is lower with the policy. Consumers pay the cost of the policy.

Because of some level of asset market integration, the price of the global asset also falls less. EME banks are less financially constrained than under no policy, the net worth of EME banks drops only 3% on impact. Banks lend more to domestic firms; as a result, the EME asset price decreases by less with the AE policy and the fall in investment is smoothed.

In conclusion, with AE equity injections the advanced and the emerging economies get a smoother impact of the crisis. Although EME banks do not have direct access to the policy, the EME profits through the higher prices in the interbank market. EME consumption and total demand drop less than under no-policy.

5.3.2 Macro-prudential Policy

In this part, we analyze the effects of the EME macro-prudential policy. In particular, we look at three models. Figure 6 shows a small set of variable. The black solid line is the same model without policy with risky banks shown in previous figures. The magenta dashed line is a model with the quality of capital shock in the AE and macro-prudential

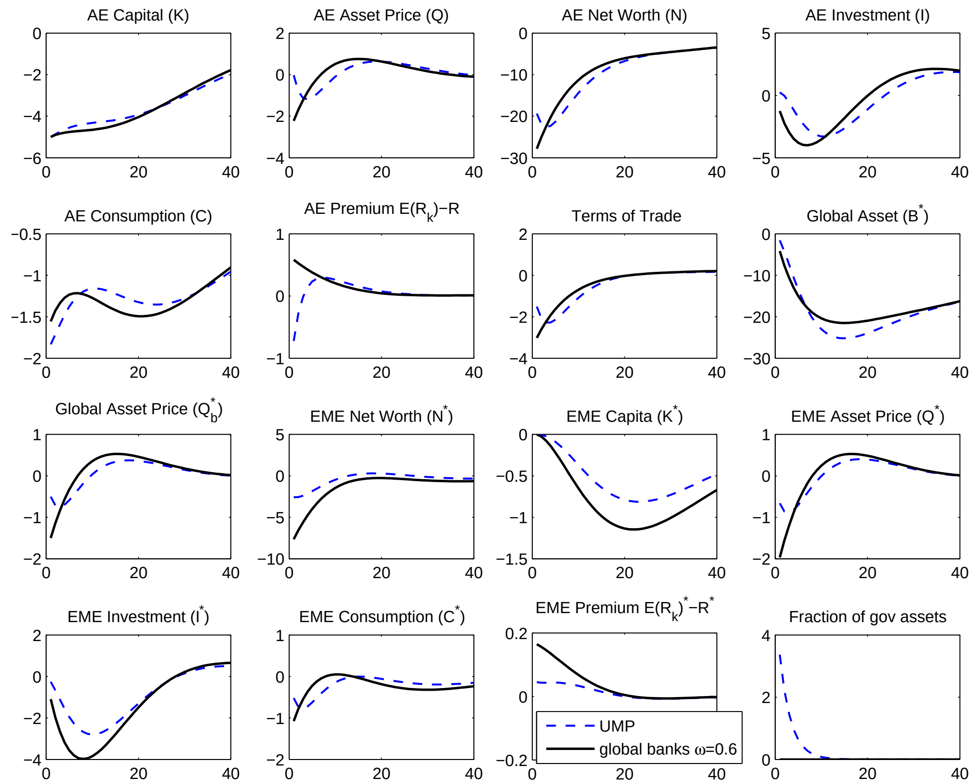

Fig. 5. Impulse Responses to a 5% Decrease in Ψ_t, Unconventional Policies by AE Central Bank
y axis: percentage deviation from steady state; x axis: quarters

policy in the EME. The green dotted-dashed line is the model with macro-prudential policy carried out by the EME and unconventional policy (equity injections) carried out by the AE. The parameters of the unconventional policy are the same as in the previous exercise. For the macro-prudential policy, the calibrated parameter is set to 2000. In Appendix D, Figure 11 we show the rest of the variables.

The macro-prudential intervention targets the ratio between the holdings of cross-border banking flows by EME banks (the non-core liabilities) and the EME banks' capital. The fact of having the tax makes the AE banks perceived EME banks as safer; moreover there is a cost on moving away from the steady state, so the international asset quantities react much less with the macro-prudential policy than without it.

If the EME implements the macro-prudential policy (the magenta dashed line) the global asset is costly to move and so the transmission of the external shock is smaller. Moreover, the net worth of the domestic banks fall less, which prompts loans and capital to be cut by less. The price of the capital doesn't fall as much and so investment moves in a smoother way. Even the household's consumption shows a smaller reaction. The interest

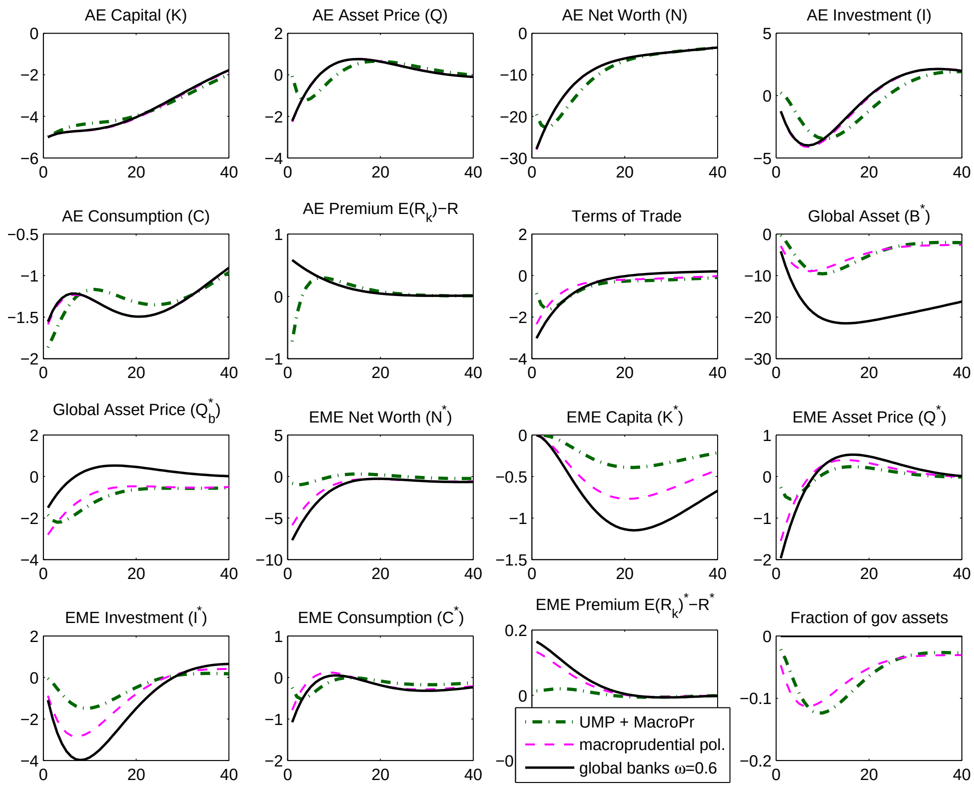

Fig. 6. Impulse Responses to a 5% Decrease in Ψ_t, Macro-prudential Policy by the EME Central Bank with and without Unconventional Policy by the AE Central Bank
y axis: percentage deviation from steady state; x axis: quarters

rate premium also presents a better scenario.

When the AE carries out equity injections and the EME has the macro-prudential policy at work, the transmission of the financial crisis to the EME is even smoother. Equity injections help the EME through a lower fall of the global asset price and a lower fall of the global asset (as we showed in the previous exercise). Having the macro-prudential policy at work allows the EME to reduce even more the effects of the negative external shock by this cost on moving away the global asset from its steady state.

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

5.4 Welfare analysis

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

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

$$Welf_t = U(C_t, L_t) + \beta E_t Welf_{t+1}, \tag{56}$$

where the utility function comes from Equation (6). Welfare is defined as the lifetime utility of the consumers. We compare the different calibrations using the consumption equivalent, i.e. the fraction of household consumption that would be needed to equate the welfare of the deterministic steady state to the welfare under policy, in the case of the macro-prudential intervention.

The stochastic steady state is defined as the place where the model stands after 500 periods given the deterministic steady state as starting point. The approximation of the model is of the second order. We don't give shocks in the process of going through the deterministic to the stochastic steady state but the variance of the perturbations are taken into account in the solution of the model. We follow Carrillo, Peersman, and Wauters (2013) on the way to calculate the stochastic steady state and Schmitt-Grohé and Uribe (2007) for the definition of consumption equivalent.

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

The different levels of ω reveal that to quality of capital shocks in the AE, EME consumers are better off because they do not get the impact of the shock directly. AE consumers decrease there consumption much more than the decrease in labor. Moreover, a higher exposure to cross-border banking flows (higher ω) makes EME consumers worse off. This is the case because the EME is more exposed to foreign debt when EME banks are less risky (higher ω). Therefore, the terms of trade get worsen with higher values of ω due to the shock and EME households have to work more. On the other hand, the depreciation of the terms of trade for the EME implies an appreciation for the AE, so the households of the latter are better off with higher level of riskiness of EME banks. When the EME banks have very little risk for the AE banks, AE households are better off with domestic quality of

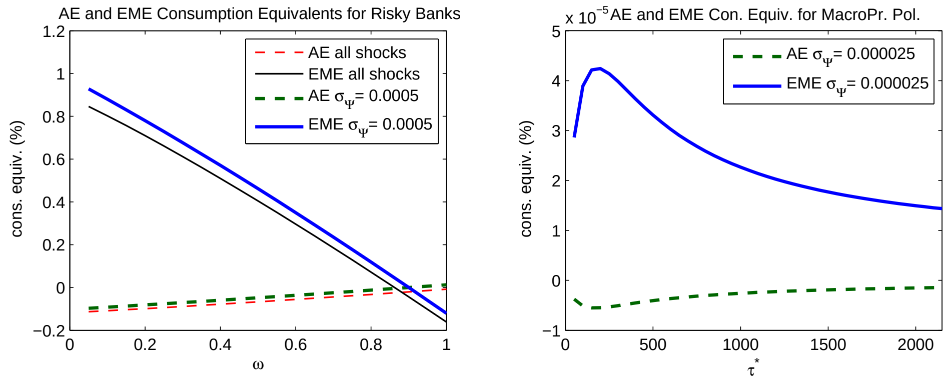

Fig. 7. Consumption Equivalent for different level of risky EME banks, ω -left panel- and different intensity of macro-prudential intervention for $\omega = 0.6$ -right panel-

capital shocks because they can share almost perfectly the risk of domestic perturbations. The results hold for the case in which there are more shocks and they also occur in the EME.

The right hand side panel of Figure 7 shows the consumption equivalent of the advanced and the emerging economies for different intensity of macro-prudential intervention by the EME. It turns out that for τ^* between 0 and 2200, the EME is always better off with the macro-prudential intervention than without it and the AE is always worse off. The gains for the EME consumers are approximately 6 times larger than the looses of the AE households; this highlights the fact that the policy doesn't have much impact on the AE. Furthermore, there is a maximum for the EME households' consumption equivalent when $\tau^* = 350$. 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. Actually, we are using a very small shock because otherwise, the higher order terms are relevant and the model doesn't have a solution.

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

6 Conclusion

We have presented a two-country DSGE model with financial intermediaries that captures part of the international transmission mechanism of the latest financial crisis to EMEs. Banks in the AE and in the EME are borrowing constrained on obtaining funds from households. The AE can invest in the EME through banks using a global asset. EME banks might be constrained on how much they borrow from AE banks. The return of the international asset is related to the return on capital of the foreign economy.

Comparing a model with financial frictions and in financial autarky with one with a global interbank market suggests that the latter generates a higher co-movement of the crisis that 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 does the quantities. EME banks face a reduction in their liabilities and they are more constrained to lend to domestic non-financial firms. The price of EME domestic assets drops prompting a fall in investment, consumption, and total demand. When EME are also constrained on how much they can borrow from AE banks, the crisis is deeper in the EME in comparison to the case in which there is no friction on borrowing AE banks.

Banks that intermediate funds across borders and in different currencies entail relevant challenges in terms of policy and regulation. For EMEs capital flows volatility have a particular interest. 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 variables volatility that cross-border bank capital might prompt. The policy is effective on smoothing the impact of external shock because it targets directly one of the frictions that makes the transmission deeper, i.e. the likelihood of EME banks running away with loans from AE banks. Moreover, the policy makes EME consumers better off. The macro-prudential policy is also effective on reducing the volatility of EME variables when the AE carries out unconventional monetary policy, in particular equity injections.

The paper focuses on one aspect of the transmission mechanism of the financial crisis for EMEs: the cross-border bank capital. Banks that intermediate funds across borders and in different currencies imply relevant challenges in terms of policy and regulation, especially for EMEs. One tool that these economies have to create a resilience financial system is macro-prudential policy. In future research, we are planning to extend the model to agency problems when banks lend to non-financial firms, with particular interest on EMEs. Moreover, the macro-prudential policy has many possible instruments that haven't been studied in this paper and that are of relevance for policy makers.

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

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

B Appendix: Definition of Equilibria

Frictionless Economy In a model without financial frictions, the competitive equilibrium is defined as a solution to the problem that involves choosing twenty two quantities (Y_t, X_t, L_t, C_t, I_t, X_t^H, X_t^{H*}, K_{t+1}, W_t, Z_t, S_t, Y_t^*, X_t^*, L_t^*, C_t^*, I_t^*, K_{t+1}^*, X_t^F, X_t^{F*}, W_t^*, Z_t^*, S_t^*), two interest rates (R_t, R_t^*), and five prices (Q_t, 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 twenty nine variables and twenty nine equations: Eq. (1)-(5), (8) - (14), and Eq. (26) for the AE, where Eq. (10) has two equations, and equivalent for the EME, and for Eq. (48) which is unique.

Economy with Financial Frictions The competitive banking equilibrium without government intervention and with $\omega = 1$ 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 fourteen 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^*), 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 seven variables and forty seven equations. Eq. (1)-(5), (8)-(14), for the AE, where Eq. (10) has two equations, and equivalent for the EME. Eq. (21), (23)-(26), (37)-(39) and similar for the EME; and Eq. (30), (36), (43), (49), and (50).

C Appendix: EME Banks' Optimization Problem

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

$$V_t^*(s_t^*, b_t^*, d_t^*) \geq \theta^*(Q_t^* s_t^* - \omega Q_{bt}^* b_t^*), \tag{C.1}$$

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

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

$$V_t^*(s_{t-1}^*, b_{t-1}^*, d_{t-1}^*) = E_{t-1}\Lambda_{t-1,t}^* \left\{(1-\sigma^*)n_t^* + \sigma^* \left[\max_{s_t^*, b_t^*, d_t^*} V^*(s_t^*, b_t^*, d_t^*)\right]\right\}. \tag{C.2}$$

The problem of the bank is to maximize Equation (C.2) subject to the borrowing constraint, Equation (C.1).

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

$$V(s_t^*, b_t^*, d_t^*) = \nu_{st}^* s_t^* - \nu_{bt}^* b_t^* - \nu_t^* d_t^*, \tag{C.3}$$

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 (C.2) with respect to (C.1), with λ_t^* as the constraint multiplier, yields similar first-order conditions to the ones from the AE; those are

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

Rearranging terms yields:

$$\left(\frac{\nu_{bt}^*}{Q_{bt}^*} - \nu_t^*\right)(1+\lambda_t^*) = \lambda_t^*\theta^*\omega \tag{C.4}$$

$$\left(\frac{\nu_{st}^*}{Q_t^*} - \frac{\nu_{bt}^*}{Q_{bt}^*}\right)(1+\lambda_t^*) = \lambda_t^*\theta^*(1-\omega) \tag{C.5}$$

$$\left[\theta^* - \left(\frac{\nu_{st}^*}{Q_t^*} - \nu_t^*\right)\right] Q_t^* s_t^* - \left[\theta^*\omega - \left(\frac{\nu_{bt}^*}{Q_{bt}^*} - \nu_t^*\right)\right] Q_{bt}^* b_t^* = \nu_t^* n_t^*. \tag{C.6}$$

Combining Equation (C.4) with Equation (C.5) results in

$$\begin{aligned}
\left(\frac{\nu_{bt}^*}{Q_{bt}^*}-\nu_t^*\right)\frac{1}{\omega} &= \left(\frac{\nu_{st}^*}{Q_t^*}-\frac{\nu_{bt}^*}{Q_{bt}^*}\right)\frac{1}{1-\omega} \\
\mu_{bt}^* &= \left(\mu_t^*-\mu_{bt}^*\right)\frac{\omega}{1-\omega} \\
\mu_{bt}^* &= \mu_t^*\omega,
\end{aligned} \tag{C.7}$$

where from the first to the second step we am using the definition of μ_{bt}^* and μ_t^* given in the text in Equations (33) and (34), respectively.

Rewriting Equation (C.6) and defining $\phi_t^*=\frac{\theta^*-\mu_t^*}{\nu_t^*}$ and $\phi_{bt}^*=\frac{\theta^*\omega-\mu_{bt}^*}{\nu_t^*}$ yields

$$n_t^*=\frac{1}{\phi_t^*}Q_t^*s_t^*-\frac{1}{\phi_{bt}^*}Q_{bt}^*b_t^*. \tag{C.8}$$

Now expressing the guess of the value function, Equation (C.3), in terms of the net worth and international debt,

$$\begin{aligned}
V(s_t^*,b_t^*,d_t^*) &= \frac{\nu_{st}^*}{Q_t^*}Q_t^*s_t^*-\frac{\nu_{bt}^*}{Q_{bt}^*}Q_{bt}^*b_t^*-\nu_t^*d_t^* \\
&= \left(\phi_t^*\mu_t^*+\nu_t^*\right)n_t^*+\left(\frac{\phi_t^*\mu_t^*}{\phi_{bt}^*}-\mu_{bt}^*\right)Q_{bt}^*b_t^*.
\end{aligned} \tag{C.9}$$

With this information I can verify the value function that corresponds to Equations (32), (33), and (34).

D Appendix: Additional Graphs

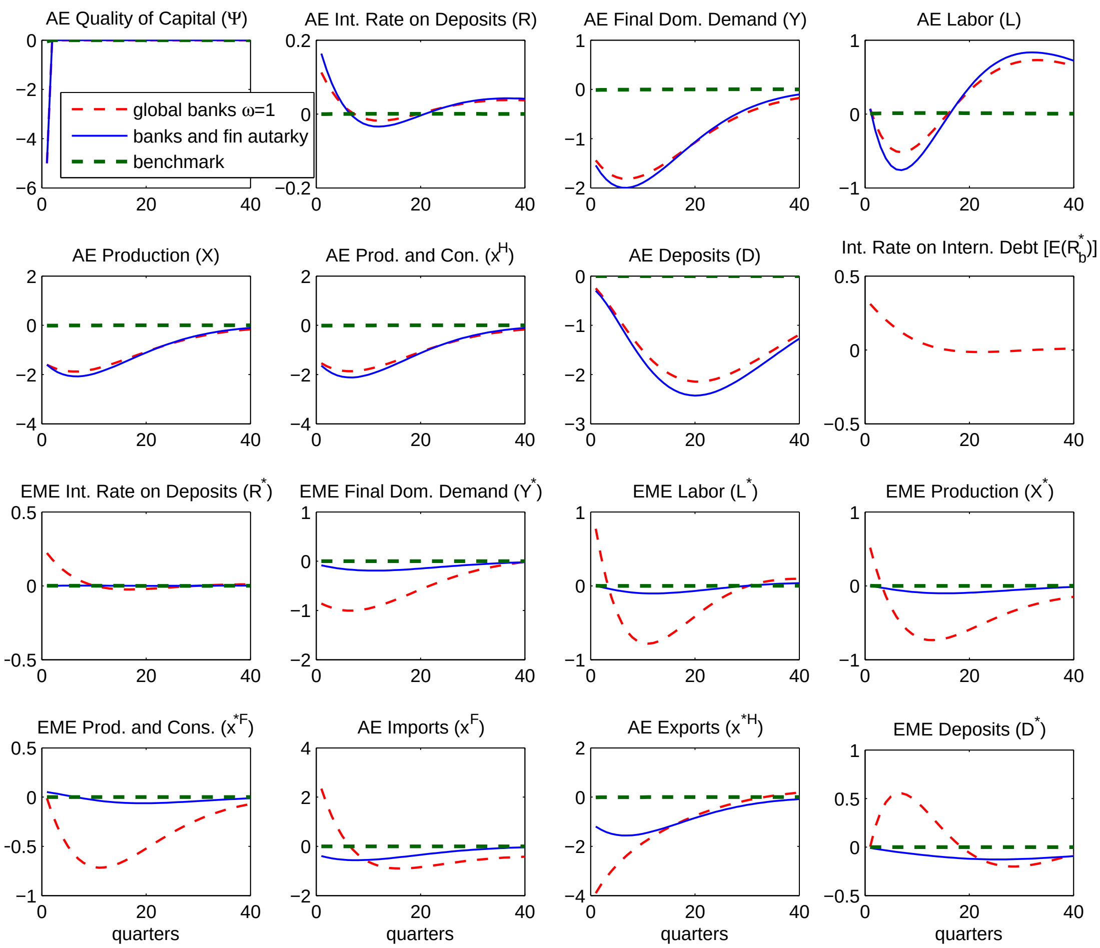

Fig. 8. Impulse Responses to a 5% Decrease in Ψ_t, Model Comparison with Global Banks, Large Set of Variables

y axis: percentage deviation from steady state

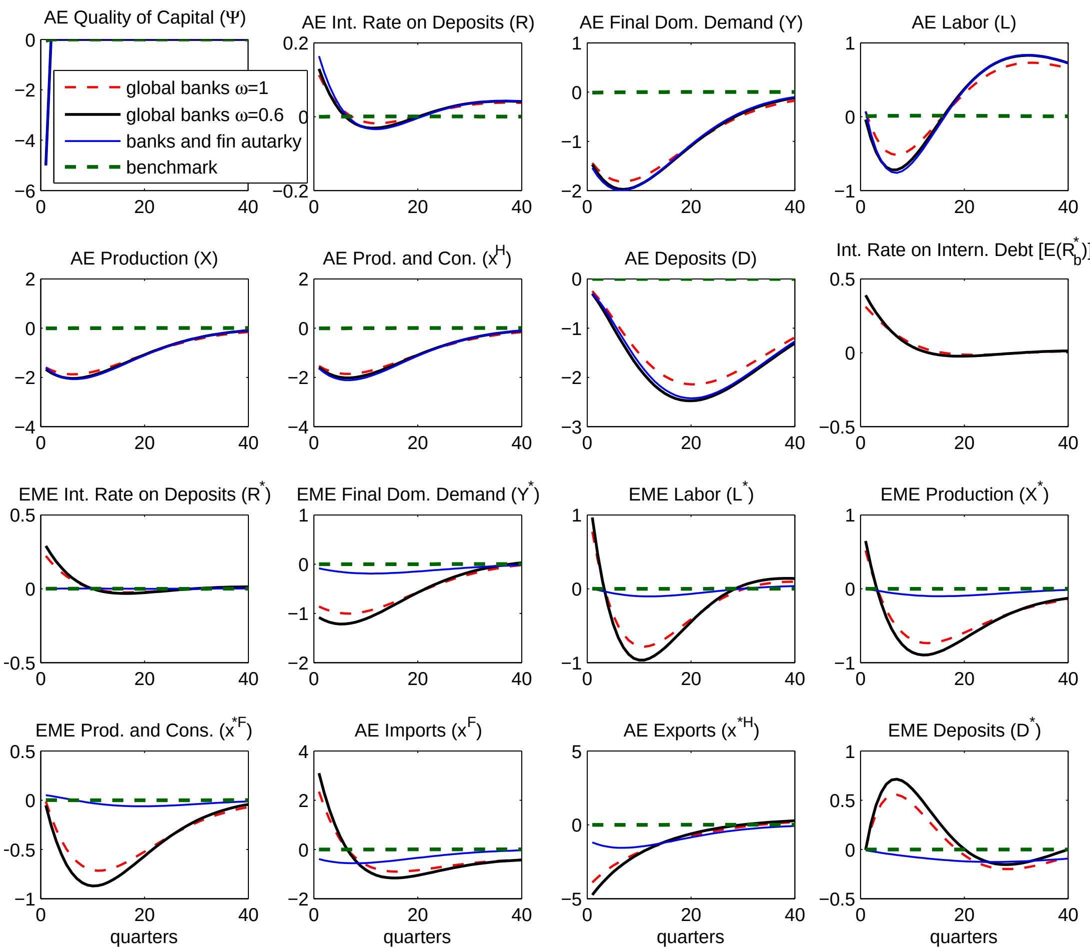

Fig. 9. Impulse Responses to a 5% Decrease in Ψ_t, Model Comparison with Risky Banks, Large Set of Variables
y axis: percentage deviation from steady state

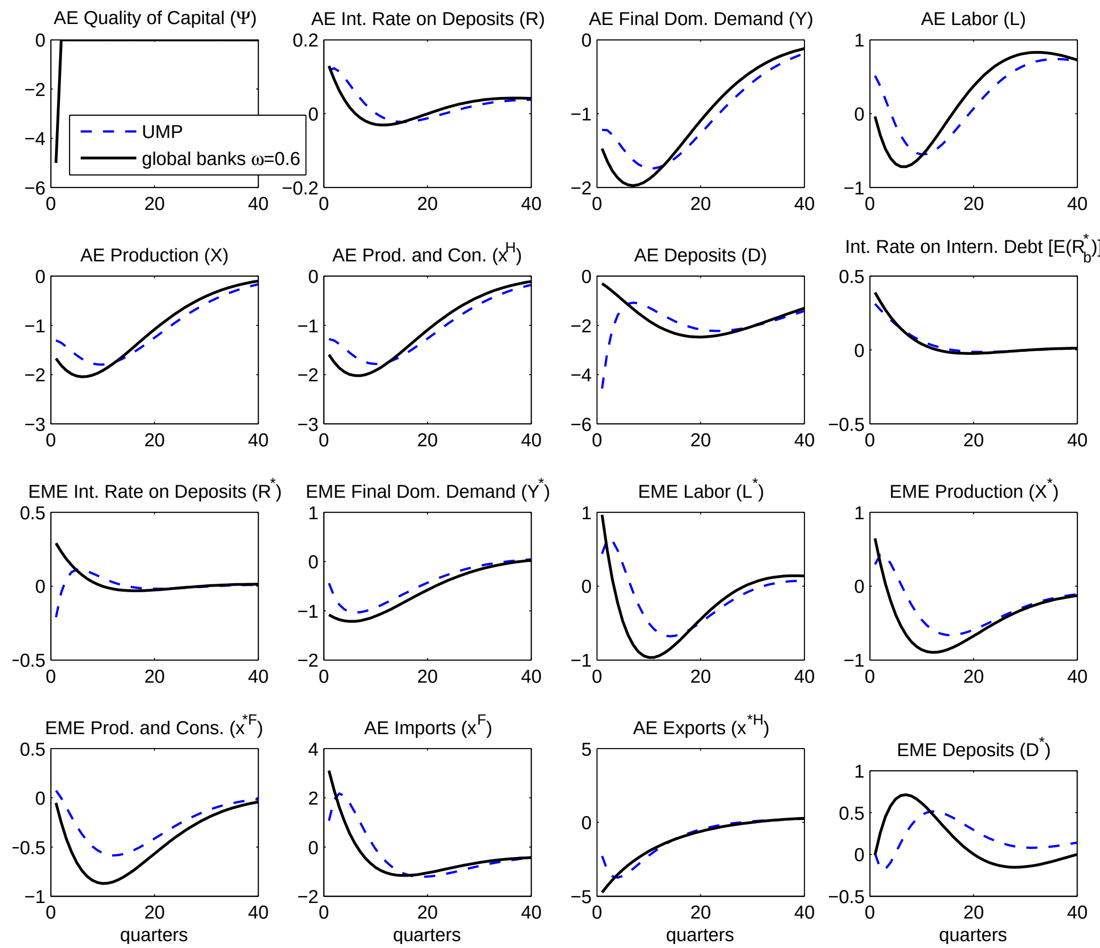

Fig. 10. Impulse Responses to a 5% Decrease in Ψ_t, Unconventional Policies by AE Central Bank, Large Set of Variables
y axis: percentage deviation from steady state

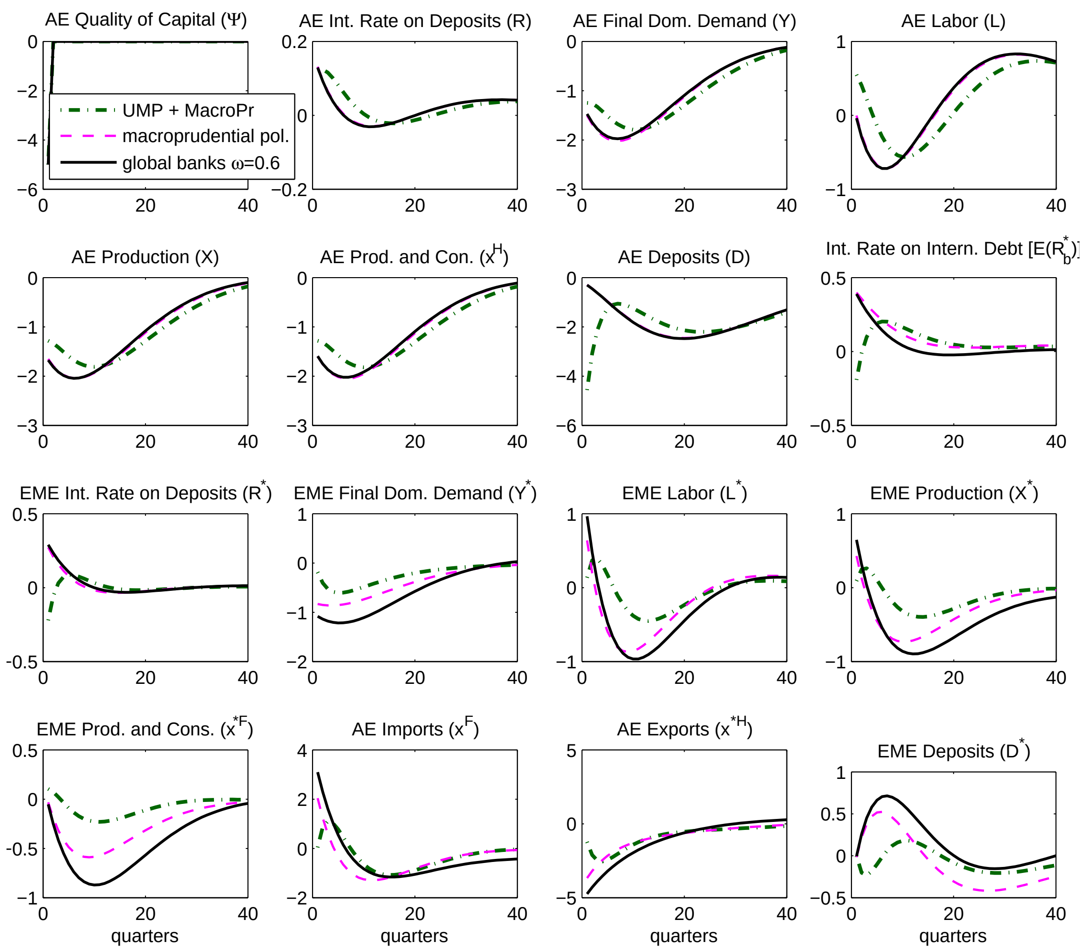

Fig. 11. Impulse Responses to a 5% Decrease in Ψ_t, Macro-prudential Policy by the EME Central Bank with and without Unconventional Policy by the AE Central Bank, Large Set of Variables
y axis: percentage deviation from steady state